SCOTTISH HOSPITALS INQUIRY

Bundle of Documents for the Oral Hearing Commencing 12 June 2023 in relation to the Queen Elizabeth University Hospital and the Royal Hospital for Children, Glasgow

Bundle 7 - Written Reports prepared by Health Protection Scotland (HPS), Health Facilities Scotland (HFS) and Antimicrobial Resistance and Healthcare Associated Infection (ARHAI)

Table of Contents

Initial report on the findings of the NHS Greater Glasgow and Clyde: Queen Elizabeth University Hospital/Royal Hospital for Children water contamination incident and recommendations for NHS Scotland

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Contents

Executive summary

NHS Greater Glasgow and Clyde (NHSGGC) are currently investigating a potentially contaminated water system across the Queen Elizabeth University Hospital (QEUH) and Royal Hospital for Children (RHC) with possible linked cases of bloodstream infections associated with ward 2A RHC.

Ward 2A RHC is a haemato-oncology unit, also known as Schiehallion, and houses the National Bone Marrow Transplant Unit. In 2016 a patient within ward 2A RHC was identified as having a blood stream infection (BSI) as a result of *Cupriavidus pauculus*. NHSGGC investigations included water samples from outlets within the aseptic suite of the pharmacy department where the parenteral nutrition was made that the child had received. *Cupriavidus pauculus* was isolated from water samples taken from a tap on a wash hand basin within this area. The wash hand basin was subsequently removed as a result. A further single case of *Cupriavidus pauculus* was identified in September 2017 however no environmental or water sampling was undertaken at this time.

Between the period of 29th January and 3rd April 2018 7 cases of blood stream infections (3 different organisms) with potential links to water contamination were identified. As a result widespread testing of the water supply was undertaken across both hospital sites. This testing identified widespread contamination of the water system. Control measures implemented included sanitisation of the water supply to ward 2A, the use of point of use filters in wash hand basins and showers in ward 2A and other areas where patients were considered high risk. There have been no new linked cases identified since the implementation of the control measures and whilst the investigation remains ongoing the clinical incident has been declared over with a full debrief held on 15th May 2018.

NHSGGC requested support from HPS with this incident on 16th March 2018 and Scottish Government invoked the national support framework on 20th March 2018 which requires HPS to lead an investigation and provide board support. This report is an initial summary of the findings from this investigation. A detailed technical report will be produced for NHSGGC by 31st July 2018

Introduction

NHS Greater Glasgow and Clyde (NHSGGC) are currently investigating a potentially contaminated water system across the Queen Elizabeth University Hospital (QEUH) and Royal Hospital for Children (RHC) with possible linked cases of bloodstream infections associated with ward 2A RHC. NHSGGC requested support from HPS with this incident on 16th March 2018 and Scottish Government invoked the national support framework[1] on 20th March 2018 which requires HPS to lead an investigation and provide board support. This report is an initial summary of the findings from this investigation. A detailed technical report will be produced for NHSGGC by 31st July 2018.

Background

NHS Greater Glasgow and Clyde's (NHSGGC) Queen Elizabeth University hospital (QEUH) is a 1109 bedded hospital with 100% en suite single side rooms which was handed over to the Board on 26th January 2015 with patient migration commencing from 24th April 2015 until 7th June 2015. The adjoining Royal Hospital for Children (RHC) is a 256 bedded childrens hospital which was handed over to the Board on 26th January 2015 with migration of patients occurring between 10th and 14th June 2015. The QEUH and RHC were both fully occupied from 15th June 2015 There are a number of additional healthcare facilities in the surrounding grounds including the maternity unit, neurosurgical unit, elderly care unit and the national spinal injuries unit.

Ward 2A RHC is a haemato-oncology unit, also known as Shiehallion, and houses the National Bone Marrow Transplant Unit. In February 2016 a patient within ward 2A RHC was identified as having a bloodstream infection (BSI) as a result of *Cupriavidus pauculus*. NHSGGC investigations included water samples from outlets within the aseptic suite of the pharmacy department where the parenteral nutrition was made that the child had received. *Cupriavidus pauculus* was isolated from water samples taken from a tap on a wash hand basin within this area. The wash hand basin was subsequently removed as a result. A further single case of *Cupriavidus pauculus* was identified in September 2017 however no environmental or water sampling was undertaken at this time. Appendix 1 details all incidents reported to Health Protection Scotland under the Healthcare associated incident investigation tool[2] related to ward 2A since 1st January 2016.

On 29th January 2018 *Cupriavidus pauculus* was identified from a bloodstream infection (BSI) in a patient in ward 2A. A series of investigations were undertaken including water sampling from outlets within the ward area. On 21st February *Pseudomonas* was identified from a BSI and between 11th and 16th March 2018 4 cases of *Stenotrophomonas maltophilia* were identified from patients in ward 2A and 1 patient in Paediatric ICU. *Cupriavidus, Pseudomonas and Stenotrophomonas* (amongst other gram negative bacillus and fungi) were identified. This led to enhanced control measures being applied within ward 2A and an extensive investigation into the potentially contaminated water system across the QEUH and RHC. Testing of the organisms in this incident has not provided an exact link to the patient cases and the water system. Testing in an incident like this can be difficult and should only be used to include cases rather than exclude. To attain appropriate representation of the bacteria within the water would require significant sampling of each organism identified to ensure a representation of strains was identified. A timeline of the patients with infections included in this incident is detailed in Appendix 2. A further case of *Stenotrophomonas* bacteraemia presented on admission to 2A on 3rd April 2018. Due to previous ward contact before implementation of control measures this case was included.

This report is an overview report of this investigation due to the large volume of data and complexities associated with this incident. A second more detailed and technical report is currently being produced which will cover more technical details and will be issued to Scottish Government and NHS GGC by end of July 2018. The longer timescale for this report is as a result of this incident being an ongoing live situation and covers information from the design and commissioning of the hospitals to the current position. HPS worked with

the support of Health Facilities Scotland (HFS) as the technical engineering experts to support this investigation and report production.

Organisms linked to cases of infection in this incident

Details on the 3 organisms (*Cupriavidas, Stenotrophomonas and Pseudomonas*) that are linked to patient cases in this current investigation are covered in appendix 3.

The role of biofilm

Biofilm is a group of microorganisms in which the cells adhere to each other and often to a surface. These cells then become embedded within a slimy substance and can be prevalent in natural, industrial and hospital settings. There is a multitude of information in the published literature which directly links biofillm production/biofilm producing organisms to water source related outbreaks. In addition, 3 recent review articles focussed on the role of water in healthcare associated infections, with specific mention of biofilm formation as a key mechanism for sustained contamination of water systems.[3-5] Biofilm formation has been described for *Cupriavidus* species and *Pseudomonas spp*, particularly in association with water systems. Biofilm formation with *Stenotrophomonas* on a variety of surfaces has also been demonstrated.[6] As a specific example; an *S maltophilia* biofilm was found to be formed within a flexible tube running from a carbon filter to a chiller, which was connected to a tap in a kitchen sink, used to supply patients with drinking water.[6]

Initial findings

HPS, HFS and NHS GGC initiated a detailed investigation into the contaminated water system within QEUH/RHC. This includes reviewing commission, installation and maintenance records provided by the contractor. This has proved challenging due to the archiving of data and the fact that there are very few members of the initial project team available who are technically qualified to retrieve data and provide verbal clarification.

Results from ongoing water testing are being reviewed on a weekly basis and would appear to confirm that there continues to be regressional seeding of contamination and supports the theory that a whole system remedial approach is required. In addition to the 3 organisms associated with the clinical incident, numerous additional gram negative bacilli and fungal species have been identified from samples.

A technical and epidemiological report is currently being produced which will include details of this investigation. Initial preliminary findings have identified that prior to handover from the contractor there were a number of water samples taken that produced results with high level of total viable counts (TVCs). TVCs are indicators that there are hygiene issues within the water system and are quantified as a generic indicator for microbial contamination. Specific microorganisms which can be tested for include: Coliforms, *Escherichia coli (*including O157), *Pseudomonas aeruginosa, Salmonella spp*, *Campylobacter spp* and Environmental Mycobacteria. Testing for these is not conducted as standard within current guidance and typically occurs in response to a suspected or confirmed outbreak, or due to identification of a series of sequential cases.

Commissioning and design of the hospital system

As part of the normal water system commissioning water samples were obtained. Some samples yielded high TVCs. In response to the high levels of TVCs NHSGGC did not accept the handover of the hospital at this time sanitisation of the water supply was undertaken prior to handover, with some impact and a reduction in TVCs in most areas, however there are a number of reports which indicate that there may still have been a number of areas with higher than normally acceptable levels of TVCs however work is still ongoing with this.

Evidence has been requested from NHS GG&C in relation to the infection control sign off of results and the system at commissioning/handover. Work continues to locate appropriate documentation and will be discussed in the final report. Water was first placed on the Infection prevention and control (IPCT) risk register in 2018.

The design and construct of wash hand basins, showers and taps in this hospital were agreed with NHS GGC in line with the Scottish Health Technical Memorandum (SHTM) in place at the point the hospital was designed, this included the installation of taps with flow regulators. HFS and HPS were involved in this decision making process as was NHSGGC Infection Control team. The SHTM (SHTM 04-01)[7] was revised in 2015 and no longer supports the use of flow regulators in clinical wash hand basins.

Biofilm formation in flow straighteners has been identified in a previous published outbreak.[8] The manufacturers of the taps/flow regulators recommend regular removal of the flow straighteners for cleaning/decontamination. Any records relating to decontamination of the flow straighteners will be reviewed in the wider review being undertaken.

The taps in place across all clinical wash hand basins in the hospital are not compatible with silver hydrogen peroxide, a product used during commission stage to sanitise the water system in view of the high TVC results. It is unclear whether this has caused any degradation of the taps, however NHS GGC have sent taps removed from the installation for metallurgical testing. In addition a tap was deconstructed and examined for the presence of biofilm, in addition to microbiological sampling. The presence of high levels of gram negative bacteria and fungus in the water system suggests that temperature control required has not always been achieved. This will be reviewed as part of the wider review being undertaken. In line with the national guidance there is a water safety group (WSG), and local Sector/Hospital Water Safety Groups. The Board Water Safety Group is a sub group of the Board Infection Control Group .Water Safety is a standing agenda item for the infection Control Team Senior Managers Team meeting.

There is a flushing regime in place across both hospitals however it is unclear whether the flushing process is adequate and all outlets are being flushed, including little used outlets, water coolers, baths etc. Due to the size of the system this is extremely difficult to assess. The wider report will review this.

Current management of situation

Point of use filters

Point of use (POU) filters were installed as one of the main control measures initially in high risk areas (wash hand basins and showers) to ensure a safe water supply at the point of use. These filters have been installed across all areas within QEUH and RHC where there are likely to be immunocompromised patients or in identified clinically higher risk areas. POU filters require to be changed every 30 days and are a costly approach. However, in the interim until the water contamination can be addressed, is the only feasible approach to ensure safe delivery of water. A number of studies found that installation of point of use filters reduced either infection rates in associated healthcare settings[9; 10] or pathogen counts within tested water samples.[11]

Water treatment

It is well recognised that drinking water distribution systems contain a diverse range of microorganisms.[12-14] The presence of microorganisms is affected by various factors including; the disinfection processes employed, the location and age of the system as well as pipe material.[15]

There are a number of options to be explored for longer term water treatment and NHS GGC are preparing a feasibility report on the most appropriate solution: these options include

Chlorine dioxide

A number of studies were identified which utilised chlorine dioxide systems within hospital settings, and use of these was found to reduce bacterial numbers. [14;16;17]

Various advantages and limitations associated with use of chlorine dioxide are known, with the most relevant summarised below.[18;19]

Advantages: Known to be effective against a wide range of bacteria, viruses and some protozoa including Giardia.

Limitations: Production of disinfection by- products (DBP's). Although potential production of DBP's always needs to be considered, the efficacy of water disinfection should not be compromised in trying to eliminate these. [19]

UV light

A number of drinking-water treatment technologies are available which employ UV light radiation to inactivate microorganisms.[19]

As with chlorine dioxide, various advantages and limitations associated with use UV are known, with the most relevant summarised below. [18-20]

Advantages: Bacteria, fungi and protozoa (considered to be more effective at killing Cryptosporidium than chlorine dioxide) are readily inactivated at low UV doses, with higher doses required for virus inactivation. In addition, UV disinfection does not result in the formation of DBP's like chlorine dioxide.

Limitations: UV disinfection does not leave any residual compound in treated water and therefore does not offer protection against possible microbial re-growth in distribution pipe-work.

Thermal disinfection

Very limited information was identified in the published literature in relation to advantages and limitations of thermal disinfection.

One study found that heat shock treatment at 80˚C reduced Gram negative bacteria in a hospital water system but did not lead to complete eradication.[21]

A risk benefit analysis of each option will be undertaken as part of the wider report. An additional approach for sanitisation which will also be reviewed is copper silver ionisation.

Hypothesis

There are a number of workable hypotheses being explored; it is currently considered the most likely cause of the widespread contamination is a combination of hypothesis B and C

A: Ingress contamination

A small low level number of micro-organisms may have been present in the water supply at the point of entry. Lack of temperature or chemical control may have enabled biofilm formation. Due to the increasing biofilm throughout the system this may have allowed any subsequent micro-organisms present at point of entry an opportunity to flourish and cause widespread contamination of the system.

B: Regressional contamination

This may have occurred due to contamination occurring at the taps/outlets or flow straighteners and contamination has regressed backwards throughout the system causing widespread contamination. The widespread positive results and array of bacteria point to contaminated outlets at installation or contamination of high risk components in the tap from ingress as opposed to the patient contact route.

C: Contamination at installation/commissioning

Contamination may have occurred due to presence of contaminated pipework or outlets. Prior to handover the system required to be sanitised due to high TVC counts. It is unclear if a robust flushing regime was in place from installation to handover and from handover to occupancy to prevent contamination.

Summary

There have been no new reported cases since 3rd April 2018 and the clinical aspect of this incident has been closed. This will be reopened if any new cases are identified. Control measures are in place to mitigate the risk however further work to address the widespread contamination is required. HPS will continue to liaise with HFS and NHSGGC and co-ordinate and produce a detailed technical report for NHSGGC and Scottish government which will include the review of installation, commission and maintenance and the risk/benefits of remedial approaches such as water dosing and tap replacement. This report will be prepared by July 2018.

Recommendations:

- Point of use filters will continue to be in place in ward 2A and other areas identified by the IMT until the risk to patients from the current situation of water contamination has been minimised.
- HPS will continue to liaise with HFS and NHSGGC and co-ordinate a wider technical report by 31st July 2018
- HPS via the existing Infection Control Built environment programme will, in conjunction with HFS:
    A. Prioritise water safety and undertake a review of NHS Scotland current approach to water safety
    B. Review existing national and international guidance relating to water safety and consider robust requirements for building handover requirements in relation to the water systems.
    C. Establish a risk based approach to water testing and any remedial action required, including roles and responsibilities.

Appendix 1 - NHSScotland Incident and Outbreak Summary Ward 2a RHC (January 2016- April 2018).

NHS Greater Glasgow and Clyde have reported a total of 10 outbreaks and incidents for the clinical setting paediatric haemato-oncology. Of the 10 incidents and outbreaks HIIAT assessed; 4 were Red, 2 were Amber and 4 were Green. The data is displayed in the tables below providing a breakdown of the outbreaks reported by annual period with exception of the current period to date for 2018 and HIIAT Green in 2016 following introduction of mandatory report (non Norovirus) from April. Comparative data for this setting within NHSScotland identified no reported incidents or outbreaks out with NHS Greater Glasgow and Clyde.

2018:

Table 1 NHS Greater Glasgow & Clyde, RHC haemato-oncology (ward 2A), HIIAT RED 2018 ± Total (1)			
Date reported	**Organism**	**Infection Category**	**Summary**
01/03/2018	*Pseudomonas aeruginosa* or *Cupriavidus pauculus*	BSI	**Current ongoing** incident following initial reporting water system contamination with Cupriavidus pauculus/ Pseudomonas aeruginosa within ward 2A (haemato-oncology ward) at the Royal Hospital for Sick Children following 2 confirmed cases, 1 with *Cupriavidus pauculus* bacteraemia, 1 with *Pseudomonas aeruginosa* bacteraemia resulting in invokement of the national framework by Scottish Government on 21/3/18.

Table 2 NHS Greater Glasgow & Clyde, RHC haemato-oncology (ward 2A), HIIAT AMBER 2018 ± Total (1)			
Date reported	**Organism**	**Infection Category**	**Summary**
10/04/2018	Astrovirus	Respiratory	12 patient cases identified with Astrovirus

2017:

Table 3 NHS Greater Glasgow & Clyde, RHC haemato-oncology (ward 2A), HIIAT GREEN 2017 ± Total (3)			
Date reported	**Organism**	**Infection Category**	**Summary**
03/03/2017	*Elizabethkingia miricola*	BSI	Three cases BSI infection since September 2016. Action plan - focus on the environment
03/03/2017	Mixed	BSI	IPCT and clinical team noted a general increase in the number of blood cultures over January and February
31/5/2017	Norovirus	GI	3 cases, 2 of which HAI (some cases amongst parents within the unit)

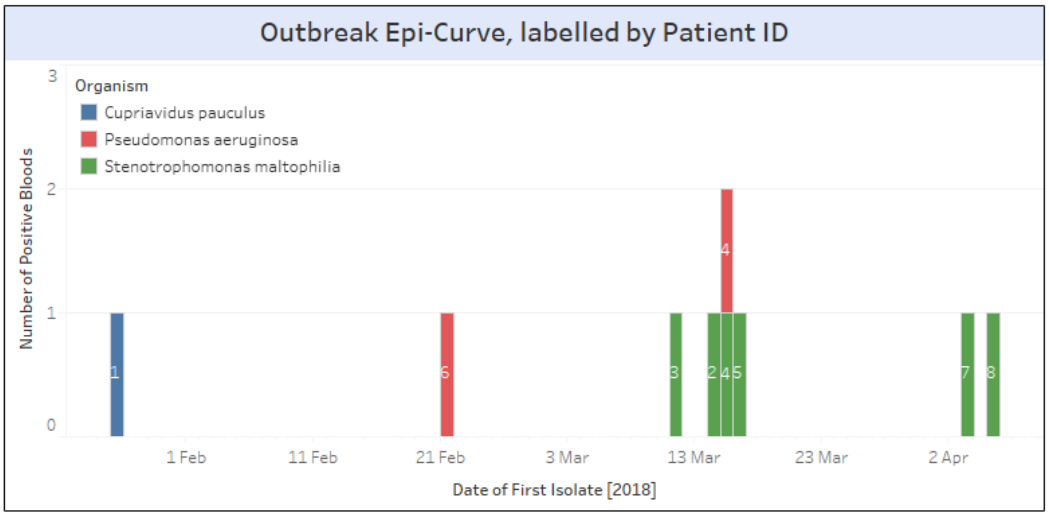
Table 4 NHS Greater Glasgow & Clyde, RHC haemato-oncology (ward 2A), HIIAT RED 2017 ± Total (3)			
Date reported	**Organism**	**Infection Category**	**Summary**
7/3/2017	*Aspergillus fumigatus*	Airborne	A higher than expected incidence of Aspergillus in this patient population since June 2016. Three patients met the case definition of probable Aspergillosis
13/04/2017	Rotavirus	GI	5 patient cases of VRE 3 of which have rotavirus. 2 staff members confirmed rotavirus
26/7/2017	Stenotrophomonas	BSI	Two patients with positive Stenotrophomonas bacteraemia within 8 days. Both cases considered to be HAI. Control measures in place

2016:

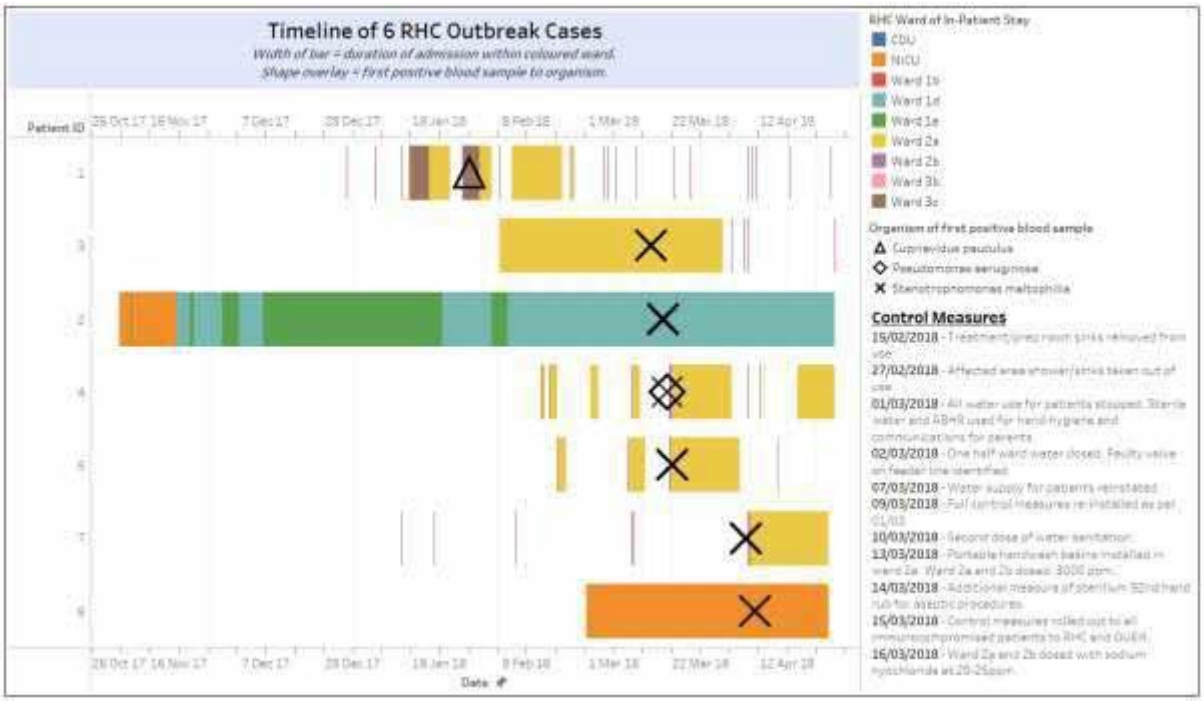
Table 5 NHS Greater Glasgow & Clyde, RHC haemato-oncology (ward 2A), HIIAT GREEN 2016- Total (1)			
Date reported	**Organism**	**Infection Category**	**Summary**
04/08/2016	Vancomycin Resistant *Enterococci*	GI	Increase in VRE

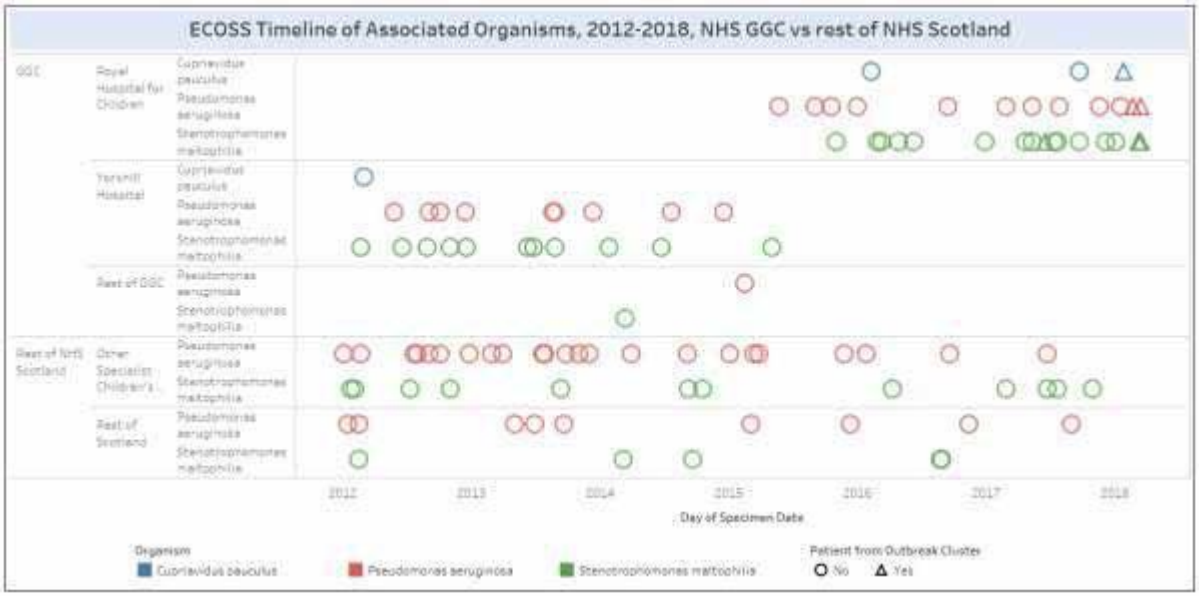
Table 6 NHS Greater Glasgow & Clyde, RHC haemato-oncology (ward 2A), HIIAT AMBER 2016- Total (1)			
Date reported to HPS	**Organism**	**Infection Category**	**Summary**
05/08/2016	Aspergillus	Respiratory	Two cases: one confirmed and one probable Neither giving cause for clinical concern specific to Aspergillus. Possible contributing environmental factors for cross transmission.

Appendix 2 Timeline of cases



The epi-curve demonstrates that only one case of *Cupriavidus pauculus* was reported from 26th January 2018, with the other associated cases being *Stenotrophomonas maltophilia* and/or *Pseudomonas aeruginosa* positive between 21st February 2018 and 5th April 2018.




ECOSS Timeline of Associated Organisms, 2012-2018, NHS GGC vs rest of NHS Scotland
GGC
Royal Hospital for Children
Cupriavidus pauculus
Pseudomonas aeruginosa
Stenotrophomonas maltophilia
Yorkhill Hospital
Cupriavidus pauculus
Pseudomonas aeruginosa
Stenotrophomonas maltophilia
Rest of GGC
Pseudomonas aeruginosa
Stenotrophomonas maltophilia
Rest of NHS Scotland
Other Specialist Children's
Pseudomonas aeruginosa
Stenotrophomonas maltophilia
Rest of Scotland
Pseudomonas aeruginosa
Stenotrophomonas maltophilia
2012
2013
2014
2015
2016
2017
2018
Day of Specimen Date
Organism
Cupriavidus pauculus
Pseudomonas aeruginosa
Stenotrophomonas maltophilia
Patient from Outbreak Cluster
No
Yes

Appendix 3 - *Cupriavidus, Stenotrophomonas, Pseudomonas*

Cupriavidus pauculus

1. Background

Cupriavidus species are Gram-negative, aerobic, non-spore-forming, motile bacilli.[22]

Various naming conventions have previously been associated with this organism (formerly known as *Ralstonia paucula*, *Wautersia paucula* and CDC group IVc-2)[22-24]

a. Reservoir/s
C. pauculus and other *Cupriavidus* species are considered to be environmental organisms,[24;25] (although negative environmental screening when investigating incidents/outbreaks has occasionally been reported[26;27]). More specifically, water is known to be a potential source of infection, including drinking water.[24;28-30]

b. Mode/s of transmission
Very limited information on the mode of transmission of the organism is available. Contact with the environment has been proposed as the primary mode of transmission.[25-27] Person-to-person spread has been considered, but has not been proven.[31] In addition, other modes of transmission, including following a cat bite[32] have also been reported.

c. Biofilm formation
Biofilm formation has been described for *Cupriavidus* species, particularly in association with water systems.[26;30;33-35]

2. Summary of published incidents/outbreaks

There are numerous case reports of infections caused by *C. pauculus* within the published literature. Many of these occurred in Europe, [31;32;36-42] but to date, there have been no case reports of infection in Scotland, or the UK.

The majority of case reports identified one affected patient[23;25;27;32;36-38;40-50] therefore it may be most appropriate to considered these as 'incidents' rather than true outbreaks.

A number of the reports[23;31;38;43;44;47;49] considered infections to be nosocomial, although many of the patients had prolonged/intermittent hospital stays and it was therefore difficult to accurately establish healthcare versus community acquisition.

The majority of reports were associated with immunocompromised patients, [27;31;38;39;41-43;48;50] or those with various co-morbidities, with or without known immunosupression. [23;37;40;44;46;47]

A significant number of reports were associated with neonates, or paediatric patients. [23;25;31;36;44-46;48]

Various types of infections were described, the majority of reports described bacteraemia/septicaemia.[23;25;37;41-45;47;49;50] Other presentations included pneumonia,[36-38;46] meningitis,[25] peritonitis,[40] and osteomyelitis/septic arthritis.[43] In addition, catheter associated infections were also reported.[27;42] A number of patient deaths

occurred, [37;44;46;48] but in most cases it was difficult to determine whether these were directly due to infection with the organism, or other factors associated with patient immunosupression /chronic disease.

Water as a source[23;27;29;43;44;47] was suspected in a number of reports, but no source was determined in the majority of cases.

In addition, two pseudo-outbreaks were reported, due likely environmental contamination by this organism of specimen swabs[29] and blood culture bottles.[26]

Stenotrophomonas maltophilia

1. Background

Stenotrophomonas maltophilia is a non-lactose fermenting Gram-negative aerobic bacillus, previously known as *Xanthomonas maltophilia* and *Pseudomonas maltophilia.* The organism has been implicated in causing outbreaks since the 1970's.[51]

a. Reservoir/s
The organism is found in a variety of environments, including water, sewage and soil. Specifically within healthcare settings, *S. maltophilia* has been isolated from various reservoirs including taps, humidifiers, nebulizers, and ventilation equipment.[51] In addition, the organism has been isolated from bottled water.[52]

b. Mode/s of transmission
Although numerous outbreaks associated with this organism have been reported, the source and mode of transmission it often difficult to establish. Typically, direct or indirect contact with a contaminated healthcare environment/equipment has been reported. Human carriage has also been noted in a number of studies, and therefore gives rise to the potential for person-to-person transmission.[51]

c. Biofilm formation
Biofilm formation on a variety of surfaces has been demonstrated.[6] As a specific example; an *S maltophilia* biofilm was found to be formed within a flexible tube running from a carbon filter to a chiller, which was connected to a tap in a kitchen sink, used to supply patients with drinking water.[53]

Under laboratory conditions, optimum temperature for growth is considered to be 37ÛC, although environmental isolates tend to have a propensity for growth at lower temperatures (20-30ÛC). The organism is also known to survive in temperatures as low as 4˚C for significant periods of time.[54] In addition, it has been indicated that biofilm formation is temperature dependent, with one study citing optimum biofilm formation at 32˚C (in comparison to 18 and 37°C).[55]

2. Summary of published incidents/outbreaks

There are numerous published case reports and outbreak studies describing nosocomial infection and/or colonisation. One of these referred to an outbreak which occurred in the UK. [53]

The majority of studies were associated with immunocompromised patients, [56-60] or those with various co-morbidities, with or without known immunosupression.[53;61-66]

25% (4 out of 16) of identified studies were associated with neonates, or paediatric patients.[62;64;66;67]

Various types of infections were described; predominantly bacteraemia/septicaemia.[56-61;64;66;67] Other presentations included endopthalmitis,[68] as well as respiratory,[53;62;63;69] soft tissue[58] and catheter associated infections.[59] In addition, a number of studies described cases of both colonisation and infection[53;60;63;64] and one described colonisation alone.[70]

Various sources of infection were reported including taps/tap water[53;58;64;70;71] and related environments (wash-hand basins[62;65] and a shower outlet[60]), medical solutions, [56;68] and various medical equipment;[61;63;66;69;71-73] predominantly bronchoscopes (N.B all bronchoscope related outbreaks were found to be pseudo-outbreaks).

Limited information was provided on the mode of transmission but most studies considered this to be contact with the healthcare environment, relating to the sources described above. Two outbreaks stipulated that person-to-person transmission from colonised healthcare workers may have occurred.[66;67]

In addition, a number of reports described co-infections; primarily with other Gram negative organisms.[71-74]

Pseudomonas spp

Biofilm formation

Pseudomonas spp are known to form biofilms both within the environment and in patient infections (i.e. on implanted biomaterials).[75]

P. aeruginosa is known to survive a range of temperatures; typically 4-42° C, with optimum growth occurring at 37°C.[76] Biofilm formation has been shown to be temperature dependent, with one experimental study citing optimum biofilm formation at 37°C (in comparison to 28, 33 and 42°C).[3]

Further specific information in relation to biofilm formation associated with water sources can be found in '*Are biofilms associated with water source related transmission with healthcare settings?*' below.

Summary of published incidents/outbreaks

A multitude of nosocomial *Pseudomonas spp* outbreaks have been reported in the published literature. The summary below includes outbreaks occurring in the last 10 years only.

Outbreaks were reported internationally, with four of these occurring in the UK.[4;5;9;10]

The majority of studies were associated with immunocompromised patients, [56;77-89] or those with various co-morbidities, with or without known immunosupression.[4;9;10;90-118]

9% (7 out of 63) of identified studies were associated with neonates, or paediatric patients.[77;79;99;101;106;110;114] A recent systematic review outlines risk factors and environmental sources associated *with P. aeruginosa* outbreaks in neonatal intensive care settings.[119]

Various types of infections were described; predominantly bacteraemia/septicaemia.[11;56;78-81;83;85;88;89;94;98-101;107;109;113;114;118;120-122] Other presentations included endopthalmitis,[123-126] endocarditis[127] as well as respiratory,[10;69;78;80;89;96;105;109;112;113;118;128] surgical site[88;89;115;118;129] and urinary tract infections.[80;88;95;109;118;120;122;128;130;131] In addition, a number of studies described cases of both colonisation and infection. [78-81;93;94;97;99;104;110;111;114;116;128]

Various sources of infection were reported including bottled water,[91;99] taps/tap water, [5-77;82;97;101] as well as wider wash-hand basin environments [4;90;110;113;116] including a soap dispenser.[80] In addition, a further study demonstrated isolation of *P. aeruginosa* from various water fittings in intensive care rooms, in the absence of a recognised outbreak.[132] Outbreaks have also been associated with various medical solutions,[56;96;121;124;126;127] and medical equipment, including various types of endoscopes, [69;81;93;120;130;133] arthroscopic shavers,[129] a urodynamic transducer[122] and a transesophageal echocardiogram probe.[94]

Limited information was provided on the mode of transmission but most studies considered this to be contact with the healthcare environment, relating to the sources described above. A number of outbreak reports stipulated that person-to-person transmission from colonised healthcare workers/patients may have occurred. [11;79;84;92;95;98;102;104;112;114]

The majority of outbreaks were associated with *P. aeruginosa* but other species were also reported including *P. putida* [56;100;93], *P. fulva*[93] and *P. fluorescens*.[107]

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Health Protection Scotland

NHS National Services Scotland

Summary of Incident and Findings of the NHS Greater Glasgow and Clyde: Queen Elizabeth University Hospital/Royal Hospital for Children water contamination incident and recommendations for NHSScotland

Date: 20/12/18

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Contents

Executive summary

NHS Greater Glasgow and Clyde (NHSGGC) are currently investigating and managing a contaminated water system across the Queen Elizabeth University Hospital (QEUH) and Royal Hospital for Children (RHC) with probable linked cases of bloodstream infections associated with wards 2A/2B RHC.

Wards 2A/2B RHC is a haemato-oncology unit, also known as Schiehallion, and houses the National Bone Marrow Transplant Unit. In 2016 a patient within ward 2A RHC was identified as having a blood stream infection (BSI) as a result of *Cupriavidus pauculus*. NHSGGC investigations included water samples from outlets within the aseptic suite of the pharmacy department where the parenteral nutrition received by the child was prepared. *Cupriavidus pauculus* was isolated from water samples taken from a tap on a wash hand basin within this area. The wash hand basin was subsequently removed as a result. A further single case of *Cupriavidus pauculus* was identified in September 2017 however no environmental or water sampling was undertaken at this time.

Between the period of 29 h January and 26th September 2018, 23 cases of blood stream infections (11 different organisms) with organisms potentially linked to water contamination were identified. As a result further testing of the water supply was undertaken across both hospital sites early in the investigation. This testing identified widespread contamination of the water system. Control measures implemented included sanitisation of the water supply to ward 2A, installation of the use of point of use filters in wash hand basins and showers in ward 2A/B and other areas where patients were considered high risk. Drain decontamination was undertaken and on 26th September 2018 wards 2A/B were closed and patients decanted to ward 6A QEUH and 4B QEUH. There have been no new linked cases identified since the decant of the patients.

NHSGGC requested support from Health Protection Scotland (HPS) with this incident on 16th March 2018 and Scottish Government invoked the national support framework on 20th March 2018 which requires HPS to lead an investigation and provide board support. This report is a summary of the findings from this ongoing investigation for the period of 29th January 2018 – 26th September 2018. Further technical work is being undertaken for NHSGGC by Health Facilities Scotland (HFS).

Background

Health Protection Scotland

HPS plan and deliver effective and specialist national services which co-ordinate, strengthen and support activities aimed at protecting the people of Scotland from infectious and environmental hazards.

They do this by providing advice, support and information to health professionals, national and local government, the general public and a number of other bodies that play a part in protecting health.

HPS is a division of NHS National Services Scotland which works at the very heart of the health service across Scotland, delivering services critical to frontline patient care and supporting the efficient and effective operation of NHS Scotland. The specialist group involved in supporting NHSGGC in this investigation is the antimicrobial resistance and healthcare associated infection (ARHAI) group. The lead from HPS in this investigation and author of this report is a Consultant Nurse in Infection Prevention and Control with a specialist qualification in water and ventilation and is also the national HAI built environment and decontamination lead. HPS have been supporting NHSGGC with this incident since 16th March 2018. This report has been produced with full support from colleagues across NSS.

National Support Framework

The National Support Framework[1] is a structure that sets out the roles and responsibilities of organisations in the event that a healthcare infection outbreak/incident, is deemed to require additional expert support. The National Support Framework may be invoked by the Scottish Government HAI/AMR Policy Unit or by the NHS Board to optimise patient safety during or following any healthcare incident/outbreak(s)/data exceedance or Healthcare Environment Inspectorate (HEI) visit/report. Scottish Government invoked the national support framework[1] on 20th March 2018

NHS Greater Glasgow and Clyde

NHSGGC is the largest health board in Scotland serving a population of approximately 1.2 million people and employ circa 38,000 staff. The main hospital sites covered by this NHS Board are:

- Inverclyde hospitals campus
- Royal Alexandra campus
- Gartnavel campus
- West Glasgow ambulatory care Campus
- Glasgow Royal Campus
- New Victoria Hospital
- Stobhill campus
- Vale of Leven
- Queen Elizabeth University Hospitals Campus

Queen Elizabeth University Hospital (QEUH)/Royal Hospital for Children (RHC)

NHS Greater Glasgow and Clyde's (NHSGGC) Queen Elizabeth University hospital (QEUH) is a 1109 bedded hospital with 100% ensuite single side room. Construction commenced on the £842 million hospital in 2011 which was handed over to the Board on 26th January 2015 with patient migration commencing from 24th April 2015 until 7th June 2015. The adjoining Royal Hospital for Children (RHC) is a 256 bedded childrens hospital which was handed over to the Board on 26 h January 2015 with migration of patients occurring between 10th and 14th June 2015. The QEUH and RHC were both fully occupied from 15th June 2015. There are a number of additional healthcare facilities in the surrounding grounds including the maternity unit, neurosurgical unit, elderly care unit and the national spinal injuries unit. The QEUH/RHC is Scotland's largest hospital and replaced a number of existing hospitals from the NHSGGC area including:

- Southern General Hospital
- Victoria Infirmary
- Mansionhouse Unit
- Western Infirmary
- Royal Hospital for Sick Children (Yorkhill)

Introduction

NHS Greater Glasgow and Clyde (NHSGGC) are currently investigating and managing a contaminated water system across the Queen Elizabeth University Hospital (QEUH) and Royal Hospital for Children (RHC) with 23 probable linked cases of bloodstream infections associated with wards 2A /2B RHC. NHSGGC requested support from HPS with this incident on 16th March 2018 and Scottish Government invoked the national support framework[1] on 20th March 2018 which requires HPS to lead an investigation and provide NHS board support. It is recognised that this investigation and remedial action is still underway and may be ongoing for a considerable period, therefore this report is a summary of the findings from this investigation and includes cases and findings for the period 29th January – 26th September 2018.

An initial report was produced by HPS and submitted to Scottish Government (SG) and NHSGGC on 31st May 2018. Due to the ongoing and complex nature of this incident and investigation a further report was requested. This report is a summary overview of this investigation however due to the large volume of data and complexities associated with this incident further technical work is being undertaken by HFS. HPS worked with the support of HFS as the technical engineering experts to support this investigation and report production. In addition the HAI Policy Unit Scottish Government (HAIPU) has requested a separate detailed review of wards 2A/B to be undertaken. This is currently underway and will form a separate report for HAIPU and NHSGGC.

Summary of clinical cases associated with this incident

Case definition

The case definition in place since January 2018 is:

"*any child linked to wards 2A/B RHC with a blood stream infection (BSI) caused by a gram negative bacillus that had been identified from organisms identified within the water system"*

Ward 2A RHC is a haemato-oncology unit, also known as Schiehallion, and houses the National Bone Marrow Transplant Unit and teenage cancer trust. Ward 2B is the day care component of ward 2A. In total there have been 23 cases identified during the period 29th January and 26th September 2018.

2016-2017

In February 2016 a patient within ward 2A RHC was identified as having a bloodstream infection (BSI) as a result of *Cupriavidus pauculus*. NHSGGC investigations included water samples from outlets within the aseptic suite of the pharmacy department where the parenteral nutrition was made that the child had received. *Cupriavidus pauculus* was isolated from water samples taken from a tap on a wash hand basin within this area. Typing by Colindale reference laboratory confirmed the isolate from the washhand basin and the patient were the same. The wash hand basin was subsequently removed as a result. A further single case of *Cupriavidus pauculus* was identified in September 2017. NHSGGC reported that a second hand hygiene sink was found to be positive but following assessment was unable to be removed. Silver hydrogen peroxide treatment was undertaken and repeat testing resulted in zero total viable counts from this outlet.

2018

On 29th January 2018 *Cupriavidus pauculus* was again identified from a bloodstream infection (BSI) in a patient in ward 2A. Following identification of this case a series of investigations were undertaken including water sampling from outlets within the ward area. On 21st February *Pseudomonas fluorescens* was identified from a BSI and between 11th and 16th March 2018, 3 cases of *Stenotrophomonas maltophilia* were identified from patients in ward 2A. On 7th April a further case of *Stenotrophomonas maltophilia* was identified. *Cupriavidas*, *pseudomonas* and *stenotrophomonas* (amongst other gram negative bacillus and fungi) were identified from water samples obtained within wards 2A/B and therefore all cases considered to be linked to the water system. No further cases were reported until April, when between April and June, a further 10 cases were reported: 5 *Enterobacter cloacae*, 3 mixed gram negative bacilli, 2 S*tenotrophomonas maltophilia*. This cluster of mixed organisms, which were present from drain samples prompted the investigation in to the drains within ward 2A/B. Following drain sanitisation and environmental decontamination using hydrogen peroxide vapour, no further cases were reported until 2nd August and between the period 2nd August and 20th September 6 further cases were identified: 1 *Chryseomonas indologenes/Stenotrophomonas maltophilia*, 1 *Serratia marsescens*, 1 *Klebsiella oxytoca*, 2 S*tenotrophomonas maltophilia,* 1 *Enterobacter cloacae.* This latest cluster resulted in immediate further drain decontamination and a temporary decant facility for wards 2A/B being identified, with the patients transferred to wards 6A and 4B on 26th September to allow for investigative and remedial works to be undertaken in wards 2A/B.

In total there have been 23 patient cases identified. A number of patients have multiple organisms so the organism total is greater than the case number.

The organisms linked to cases include:

- *Cupriavidus pauculus* (1)
- *Pseudomonas fluorescens (1)*
- *Pseudomonas aeruginosa* (3)
- *Stenotrophomonas maltophilia* (12)
- *Acinetobacter ursingii* (2)
- *Enterobacter cloacae* (7)
- *Klebsiella oxytoca* (1)
- *Serratia marcescens* (1)
- *Pseudomonas putida* (1)
- *Pantoea sp* (1)
- *Klebsiella pneumonia* (1)
- *Chryseomonas indologenes*(1)

In addition to the organisms detailed above there is evidence of fungal growth in the water system however there have been no associated clinical cases reported.

A timeline of cases is detailed in Appendix 1. This incident has resulted in a number of children requiring additional intervention and some delays in chemotherapy treatment, however, there has been no associated mortality. There have been no associated cases since the temporary closure of wards 2A/B and the decant of the patients to ward 6A QEUH on 26th September 2018.

The clinical component of this incident is considered as occurring within two phases:

- Phase one relates to the water contamination and the clinical cases associated at that time relating to the water system. Following installation of point of use filters, the water system was acknowledged as being of suitable quality for use by patients and staff. Whilst work was ongoing to investigate and manage the water contamination incident the clinical component of this phase was considered over with a debrief held on 15th May 2018

- Phase two relates to the environmental contamination and subsequent associated clinical cases occurring as a result of the contaminated drains and the impact caused by the fitting of point of use filters. Phase two is currently ongoing and will remain open until wards 2A/B have re-opened

Summary of initial findings

Following identification of the potentially contaminated water system in wards 2A/B and the resultant possible linked cases in March 2018, NHSGGC considered the decant of these 2 wards to allow for a full investigation of the source of water contamination in wards 2A/B and consider remedial action. At that time ward 4B QEUH was being prepared for the transfer of adult BMT patients from the Beatson oncology unit. Water sampling was undertaken in this ward prior to decant as a precautionary measure. Results identified the presence of *Cupriavidus pauculus* (and other gram negative bacilli) in water outlets within this ward and was the initial suggestion that there may be widespread contamination of the water system that serves both QEUH and RHC. Further testing across the site provided confirmation of this, with positive samples being identified in a number of areas across both sites at both outlet level and within the water system in the basement level (risers). Within the same timeframe staff within wards 2A/B also reported they had witnessed “black effluent” around the rim of the drain in some wash hand basins. Following visual inspection and laboratory testing, this was considered to be biofilm and sampling identified significant contamination of the drains with microorganisms and fungi. Drain contamination is not unexpected however the level of biofilm evident was not in keeping with a water system of less than four years old.

In an attempt to establish the extent of the water system contamination and any causative factor NHSGGC, supported by HFS and HPS initiated a detailed investigation into the contaminated water system within QEUH/RHC. Support was also requested from a number of external companies experienced in water incident management: These included Leegionella, Public Health England (PHE), water solutions group and Makin & Makin. The detailed investigations led by NHSGGC and supported by HFS/HPS included reviewing commission, installation and maintenance records provided by the contractor. This proved to be challenging due to the archiving of data and there were very few members of the initial project team available who are technically qualified to retrieve data and provide verbal clarification. The detailed findings from these records are included within the technical review.

Results from ongoing water testing were reviewed on a weekly basis and highlighted there was evidence of regressional seeding of contamination which supported NHSGGCs view that a whole system remedial approach was required.

Commissioning and design of the hospital water system

As part of the normal water system commissioning water samples were obtained. Initial preliminary findings have identified that prior to handover from the contractor there were a number of water samples taken that produced results with high level of total viable counts (TVCs). TVCs are indicators that there are hygiene issues within the water system and are quantified as a generic indicator for microbial contamination. Specific microorganisms which can be tested for include: Coliforms, *Escherichia coli (*including O157), *Pseudomonas aeruginosa, Salmonella spp*, *Campylobacter spp* and Environmental Mycobacteria. Testing for these is not conducted as standard within current guidance and typically occurs in response to a suspected or confirmed outbreak, or due to identification of a series of sequential cases.

In response to the high levels of TVCs found as part of the pre handover commissioning sanitisation of the water supply was undertaken by the contractor, with some impact and a reduction in TVCs in most areas, however there are a number of reports which indicate that

there may still have been a number of areas with higher than normally acceptable levels of TVCs.

Design and installation of taps and clinical wash hand basins

The design and construct of wash hand basins, showers and taps in these hospitals were agreed with NHSGGC in line with the Scottish Health Technical Memorandum (SHTM) in place at the point the hospitals were designed (commencing 2009), this included the installation of taps with flow regulators. HFS and HPS were involved in this decision making process as were NHSGGC Infection Control team. The SHTM (SHTM 04-01)[2] was revised in 2015 and no longer supports the use of flow regulators in clinical wash hand basins.

Biofilm formation in flow regulators has been identified in a previously published outbreak.[3] The manufacturers of the taps/flow regulators in place across the QEUH/RHC recommend regular removal of the flow regulators for cleaning/decontamination however do not offer more specific guidance on frequency of decontamination of the flow regulators. The flow regulators in use have a number of components and potentially create ideal conditions for the development of biofilm.

NHSGGC provided an external company (Intertek) with some flow regulators to carry out microbiological testing. This confirmed that flow regulators have the ability to harbour a significant number of micro-organisms with the presence of biofilm being detected on all flow regulators tested and 50% showing high levels of contamination. It is also worthy of note that biofilm was present on some flow regulators which was not immediately obvious on visual inspection.

The taps in place across all clinical wash hand basins in both hospitals are also reported to be non compatible with silver hydrogen peroxide, a product which was used during commission stage to sanitise the water system in view of the high TVC results. It is unclear whether this has caused any degradation of the taps. A tap was deconstructed by NHSGGC and examined for the presence of biofilm, in addition to microbiological sampling. Several components of the tap exhibited microbiological contamination.

The presence of high levels of gram negative bacteria and fungus in the water system may indicate that temperature control required has not always been achieved. Temperature control is included as part of the wider technical review being undertaken for NHSGGC by HFS.

Other aspects discussed in the detailed technical review include:

- Flushing
- Contract/project team
- Roles/responsibilities
- Design and construction
- Guidance and specifications
- Specification of water system
- Flexible hoses
- System description

- Pipe work
- Post handover and maintenance

There are a number of local and national recommendations within this review for both NHSGGC and Nationally. The key NHSGGC and National recommendations from the technical review are included within the recommendation section of this report.

Infection Control at design commissioning and handover

HAI-SCRIBE

Healthcare Associated Infection System for Controlling Risk in the Built Environment (HAI-SCRIBE) [4], reference has been designed as an effective tool for the identification and assessment of potential hazards in the built environment and the management of these risks. HAI-SCRIBE (2007) was in place during the construction and handover of both buildings.

Implementation of HAI-SCRIBE should be the responsibility of a multidisciplinary team of specialists with appropriate skills.

Compliance with HAI-SCRIBE requires an accurate record of the process of hazard assessment and risk management which is essential ‘due diligence’ information.

Evidence has been reviewed in relation to the infection control sign-off of results and the system at commissioning/handover. Whilst there is evidence of involvement with initial results and sanitisation there is no evidence of ongoing input or sign off from the Infection Prevention and Control Team (IPCT). It is noted that there is lack of clarity in current national guidance relating to roles and responsibilities of the IPCT in the commissioning, design and handover of new or refurbished builds. Water was first placed on the Infection prevention and control (IPCT) risk register in 2018. The IPC risk register is reviewed on an annual basis with risks considered and prioritised using a risk scoring system. Water safety was added to the risk register in 2018 in response to the emerging evidence of potential issues associated with this incident. Prior to 2018 water safety did not feature in the IPC risk priorities when scored.

NHSGGC employed a robust approach to the design stage of the hospital project by means of a dedicated Infection Prevention and Control Nurse (IPCN) seconded as part of the project team to support the IPCT aspect of the design stage, commissioning and handover stage.

Whilst there was dedicated resource allocated to the project team, there is no documented evidence of NHSGGC Infection Prevention and Control Team involvement in the commissioning or handover process of the project. However NHSGGC has provided a statement from the Lead Infection Control doctor at the time to confirm that they were involved in reviewing some aspects of the initial water testing methodology and the results for QEUH and RHC during commissioning and handover. The Lead ICD has confirmed being involved in:

- Quality assurance of the water testing methodology used by the commissioning engineers.
- Liaising with Facilities Colleagues in reviewing the water testing results supplied by the commissioning engineers.

- Recommending further actions (dosing), for a small number of outlets with TVCs above the acceptable limits.

In addition to a nurse consultant being seconded as a dedicated resource to the project team with involvement in design, commissioning and handover, the project team were supported by the IPCT. This support included regular review of the new builds hospital project at the infection control committee and senior IPC meetings. NHSGGC reported that both the infection control manager and associate director of nursing (infection control) liaised regularly with the project associate nurse director and ensured the numerous commissioning groups established were supported by a member of the IPCT. In addition all wards were reviewed by a member of the IPCT prior to occupation by patients.

Current management of situation/Control measures

In addition to holding regular incident management IMT meetings (IMT) NHSGGC established a multi disciplinary water technical group which is a sub group of the incident management team. This group is supported by HFS, HPS, with monthly representation from water solutions group and Makin & Makin.

A number of control measures have been instigated during this incident and in particular in wards 2A/B. These included parent and staff education sessions, daily visits to the ward from members of the infection prevention and control team (IPCT), increased domestic hours, environmental monitoring by means of audit, including Standard infection control precautions (SICPs) audits.

Limiting access to water

In the initial investigation the use of water within wards 2A/B was limited with portable wash hand basins being supplied for hand washing. Patients were requested not to use wash hand basins or showers and wipes were provide as an alternative. Drinking water was provided by means of bottled water. Access to water was re-established once point of use filters were in place in showers and wash hand basins/sinks. BMT patients continue to receive sterile water.

Point of Use filters.

Following the identification that the water contamination was widespread across both RHC and QEUH an additional control measure of point of use (POU) filters for high risk areas was implemented to ensure a safe water supply at the point of use. In addition if a high risk patient was being nursed in an area deemed to be of low risk, a point of use filter was fitted to water outlets in their room. POU filters require to be changed every 30 days and are a costly approach, however in the interim until the water contamination can be addressed, is considered the only feasible approach to ensure safe delivery of water. A number of studies found that installation of point of use filters reduced either infection rates in associated healthcare settings[5;6] or pathogen counts within tested water samples.[7]

Once the POU filters were in place the restrictions on access to water within wards 2A/B was removed and patients were able to access washhand basins and showers. It was noted that following the fitting of the POU filters there was a greater splash evident from the wash hand basins as the point of entry of the water from the outlet was closer the basin. This splash was noted more from clinical wash hand basins than ensuite wash hand basins and trough sinks.

Drain Sanitisation

Following the identification of the second phase of cases associated with this incident and the hypothesis that the cases may be related to drain contamination, the drains were inspected by the IPCT. Once the drains were identified as being visibly contaminated with what was thought to be biofilm, a programme of drain sanitisation was undertaken across high risk areas commencing with wards 2A/B.

Environmental decontamination

Prior to and following completion of the first drain decontamination process in wards 2A/B, a terminal clean of all areas using hydrogen peroxide vapour was carried out.

Water treatment

It is well recognised that drinking water distribution systems contain a diverse range of microorganisms.[8-10] The presence of microorganisms is affected by various factors including; the disinfection processes employed, the location and age of the system as well as pipe material.[11]

There were a number of options explored for longer term water treatment by NHSGGC. These options included:

Chlorine dioxide

A number of studies were identified which utilised chlorine dioxide systems within hospital settings, and use of these was found to reduce bacterial numbers.[10,12,13] Various advantages and limitations associated with use of chlorine dioxide are known, with the most relevant summarised below.[14,15]

Advantages**:** Known to be effective against a wide range of bacteria, viruses and some protozoa including Giardia.

Limitations: Production of disinfection by-products (DBP's). Although potential production of DBP's always needs to be considered, the efficacy of water disinfection should not be compromised in trying to eliminate these.[16]

UV light

A number of drinking-water treatment technologies are available which employ UV light radiation to inactivate microorganisms.[15] As with chlorine dioxide, various advantages and limitations associated with use UV are known, with the most relevant summarised below.[14-16]

Advantages: Bacteria, fungi and protozoa (considered to be more effective at killing Cryptosporidium than chlorine dioxide) are readily inactivated at low UV doses, with higher doses required for virus inactivation. In addition, UV disinfection does not result in the formation of DBP's like chlorine dioxide.

Limitations: UV disinfection does not leave any residual compound in treated water and therefore does not offer protection against possible microbial re-growth in distribution pipe-work.

Thermal disinfection

Very limited information was identified in the published literature in relation to advantages and limitations of thermal disinfection. One study found that heat shock treatment at 80˚C reduced Gram negative bacteria in a hospital water system but did not lead to complete eradication.[17] Copper silver ionisation was also considered however this was discounted due to pH levels.

Preferred solution

The NHSGGC preferred method of choice for water treatment was continual dosing chlorine dioxide. This was supported by HFS and HPS. Shock dosing of the system was considered and it was agreed that due to safety issues and the potential impact on both hospitals ability to function during the process, this was not the most appropriate approach. It was also recognised that in the absence of initial shock dosing it may take up to two years for the process to be effective from tank to tap level. The procurement process is well underway and installation expected to commence November 2018.

Temporary closure of wards 2A/B

A recommendation was made by the IMT to pursue the temporary decant of wards 2A/B to allow investigative and remedial work to be undertaken. A number of options were explored resulting in the transfer of patients from wards 2A/B to ward 6A of the QEUH. Adult patients within ward 6A QEUH were transferred to Gartnavel General. Three rooms within the adult BMT (4B) were identified and allocated to the paediatric BMT unit. The patients were transferred on 26th September 2018. It is anticipated that the decant facility will remain in place until mid/late December.

Remedial work/Investigations wards 2A/B

The planned investigations/remedial works planned during the decant period include:

- Drain Survey
- Ventilation review
- Replacement of clinical wash hand basins
- Replacement of taps (with no flow regulator)
- Review of any little used water outlets with a view to remove
- Replacement of sections of pipework where biofilm noted
- Review of toilet cisterns and adaptation to reduce potential toilet plume effect.

Hypothesis

There are a number of workable hypotheses being explored; it is currently considered the most likely cause of the widespread contamination is a combination of hypothesis B and C

A: Ingress contamination

A small low level number of micro-organisms may have been present in the water supply at the point of entry. Lack of temperature or chemical control may have enabled biofilm formation. Due to the increasing biofilm throughout the system this may have allowed any subsequent micro-organisms present at point of entry an opportunity to flourish and cause widespread

contamination of the system.

B: Regressional contamination

This may have occurred due to contamination occurring at the taps/outlets or flow straighteners and contamination has regressed backwards throughout the system causing widespread contamination. The widespread positive results and array of bacteria point to contaminated outlets at installation or contamination of high risk components in the tap from ingress as opposed to the patient contact route.

C: Contamination at installation/commissioning

Contamination may have occurred due to presence of contaminated pipework or outlets. Prior to handover the system required to be sanitised due to high TVC counts. It is unclear if a robust flushing regime was in place from installation to handover and from handover to occupancy to prevent contamination.

Secondary Hypothesis

It is recognised that in many situations control measures or actions taken in an attempt to minimise the risk of HAI there can be unintended consequences. In this scenario the secondary hypothesis is linked to the unintended consequence of the point of use filter use:

POU filters.

In an attempt to provide water of a safe microbiological quality NHSGGC applied point of use filters to all clinical and patient wash hand basins in high risk areas and areas where high risk patients were being treated. These filters meant the exit point of the water from the taps was closer to the washhand basin and as a result caused more splash which may also lead to disruption of any drain biofilm as well as potential environmental contamination. (Pictures 1, 2). At the time of fitting the filters, the issue of biofilm within the drains and the associated risk or the resultant splashing that was being caused had not been identified and therefore the subsequent increased risk of environmental contamination and potential exposure of the children was not recognised.

Picture 1

Picture 2

Additional potential considerations to minimise impact

Ensuite single side rooms/hand hygiene practice

Since 2008 it is recommended that all new build hospitals have 100% en suite single side rooms.[18] As a result this has substantially increased the number of wash hand basins and therefore the frequency with which a wash hand basin is used and the water volume in each basin reduced when compared to multi occupancy wards with a single wash hand basin. Since the introduction and widespread use of alcohol gel, the need for hand washing as a first approach has greatly decreased, as alcohol gel may be used on hands that are not visibly soiled. This requires further exploration and consideration and review of flushing regimes and number of wash hand basins required.

Disposal to drain

A number of drain samples were sent to Intertek for analysis. A report has highlighted that in addition to the general presence of biofilm, there was biofilm noted around the aluminium spigots. There was also some occlusion reported as a result of adhesive and pooling noted between the back of the sink and the pipework. All aluminium spigots in wash hand basins in wards 2A/B were replaced with PVC spigots. In addition a number of foreign objects were identified within the drains. It was also reported that there was evidence of a yellow fluid present suggestive of urine being disposed to the drain. The biofilm has a mustard yellow colour and an odour of ammonia was detected. There was a small amount of yellow liquid in the base of the bowl trap which when removed and looked at in isolation also had an ammonia smell. Parents, families and clinicians are advised that hand wash basins are for hand washing only and additional activities such as fluids being disposed of to drain via a handwash basin should not occur. Staff are aware that this is not acceptable practice however the positioning of a wash hand basin in every ensuite single side room may encourage patients or visitors to expel fluids such as contents of a drink bottle. Items such as coffee, sweet drinks encourage the growth of

bio film and microorganisms within a drain. The large open horizontal drain may also encourage the accidental disposal of foreign items.

Summary

There have been no new reported cases since the decant of patients to ward 6A on 26 h September 2018. The IMT will continue to meet regularly until the patients have been transferred back to wards 2A/B. The water subgroup will continue to meet until early/mid 2019 and will be supported by HFS/HPS. It has been evident to HPS that since the identification of this widespread incident and clinical impact on wards 2A/B, patient safety has been paramount with NHSGGC clinicians, facilities, IPCT and management team. A significant financial investment has been made to minimise ongoing risks including widespread use of point of use filters in addition to remedial work planned. A number of lessons can be taken from this incident for NHSGGC and NHSScotland as a whole in relation to water safety and commission, handover and maintenance of buildings. The national work and learning for NHSScotland will be driven via the HAI built environment steering group which is widely represented and chaired by the associate director of facilities (NHSGGC) and deputy chair is the lead ICD (NHSGGC).

Recommendations

A number of local and national recommendations have been made based on the investigation to date. This includes recommendations for NHSGGC which have been identified from a detailed HFS technical review. NHSGGC/HPS/HFS will produce an action plan based on the recommendations as follows:

1. NHSGGC

- To produce a detailed action plan addressing ALL points identified within the HFS technical review and should cover as a minimum:
  - Decontamination
  - The management of the water systems
  - All required rectification work
  - Management of recording systems
  - Routine and reactive maintenance schedules

2. All NHS Boards

- All NHS boards should ensure facilities teams are adequately resourced to ensure maintenance of all aspects of the water system are maintained in accordance with policies and guidance.
- All maintenance undertaken should be recorded and maintenance records should be reviewed regularly to ensure all aspects of the water system are maintained in accordance with policies and guidance

3. HPS/HFS

HPS (supported by HFS) to undertake an urgent national water review of all healthcare premises built since 2013 to provide assurance that a similar incident has not and is not likely to occur elsewhere.

HPS (supported by HFS) to establish a national expert group to:

- Review NHSScotland current approach to water safety including as a minimum:
  - Review NHSScotland current approach to water testing in healthcare settings.
  - Review NHSScotland current surveillance and reporting of potentially linked water related HAI cases.
  - Based on findings develop risk based guidance on water testing protocols, results interpretation roles and responsibilities and remedial steps to be considered.
- Give consideration to the development of a best practice built environment manual which will be evidence based and cover as a minimum current and emerging evidence

and the technical requirements from a clinical, patient safety and HAI perspective that will be adopted by all NHS boards. This will include as a minimum:

- Review existing national and international guidance relating to water safety.
- Develop robust requirements/guidance for all aspects of water safety.
- Develop robust handover requirements in relation to water systems.
- Review of the role of the IPCT into the built environment, and produce clear guidance on roles and responsibilities.
- Establish a risk based approach to water testing and any remedial action required, including roles and responsibilities that NHS boards will adopt.
- Review the requirement for 100% ensuite single side rooms the number of clinical wash hand basins per patient/bed.
- Review the use of flow regulators across NHS Scotland and identify and associated risks and recommend any remedial actions required.

- HPS/HFS will continue to provide support to NHSGGC relating to the current water incident and provide input into the weekly meetings until mid 2019 (and reviewed thereafter).
- Further develop the existing Scottish expertise in the built environment programme (mainly water and ventilation) at national level.

HFS (supported by HPS) to:

- Review all relevant water technical guidance to ensure all aspects are covered within the guidance including as a minimum:
  - Thermal disinfection in sections of water distribution systems
  - Handover checklists
  - Contract management procedures
  - Design guides to eliminate thermal pickup in cold water systems
  - Update advantages and disadvantages of chemical disinfection techniques
  - The organisms Boards should test for and action to take on defined levels
  - Drain cleaning regimes
  - Biofilm growth in drainage systems

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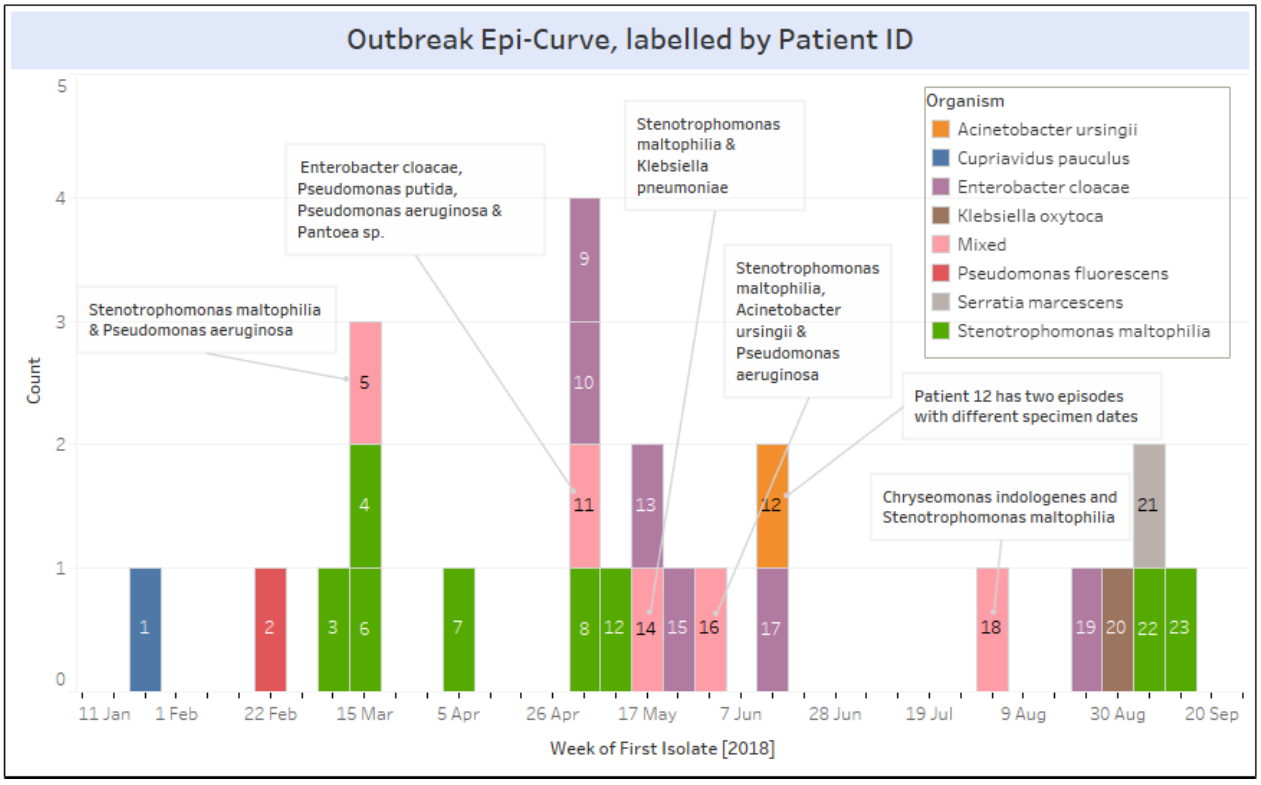
Appendix : 1 Timeline of cases

The epi-curve demonstrates that only one case of *Cupriavidus pauculus* was reported from 26th January 2018, with the other associated cases being *Stenotrophomonas maltophilia* and/or *Pseudomonas aeruginosa* positive between 21st February 2018 and 5th April 2018.



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Glossary

Alcohol gel	A gel, foam or liquid containing one or more types of alcohol that is rubbed into the hands to inactivate microorganisms and/or temporarily suppress their growth.
Aseptic Suite	An ultra clean environment within a department, (for example pharmacy) where sterile solutions are prepared such as chemotherapy under strict measures.
Bacteria	Microscopic organisms (germs).
Bib taps	A tap or stop cock which has a nozzle bent downwards.
Biofilm	Collective of one or more types of microorganisms, including bacteria, fungi and protists, that stick together and can become embedded on a surface.
Blood stream infection	The presence of bacteria in the bloodstream.
Chemotherapy	A cancer treatment where medication is used to kill cancer cells.
Chlorine dioxide	A chemical compound used for a variety of antimicrobial uses, including the disinfection of drinking water.
Clinical wash hand basins	A sink designated for hand washing in clinical areas
Cluster	A group of similar things located around the same location
Copper silver ionisation	A disinfection process where positively charged copper and silver ions are added into the water system. It is primarily used to control control Legionella, the bacteria responsible for Legionnaires' disease.
Decant	Temporarily transferring people to another location.
Decontamination	Removing, or killing pathogens on an item or surface to make it safe for handling, re-use or disposal, by cleaning, disinfection and/or sterilisation.
Drain	A fixture that provides an exit-point for waste water or water that is to be re-circulated.
Ensuite single side room	A room with space for one patient and containing a bed; locker/wardrobe, clinical wash-hand basin, en-suite shower, WC and wash-hand basin.
Flexible hoses	A flexible hollow tube designed to carry fluids from one location to another and are used to connect taps to the water supply
Flow regulators	Point of use regulators designed to provide constant and maximum flow rates at taps and showers etc. irrespective of changes in demand or water pressure

Flushing	The process of cleaning or “scouring” the interior of water distribution mains (pipes) by sending a rapid flow of water through the mains.
Gram negative bacilli	Gram-negative bacteria are bacteria that do not retain the crystal violet stain used in the gram-staining method of bacterial differentiation; examples include E.coli, and Pseudomonas aeruginosa.
Hydrogen Peroxide Vapour	Vaporized hydrogen peroxide is an airborne disinfectant and infection control measure that can be used for room decontamination after patient use.
Ingress	The act of entering.
Microbiological sampling	Sampling for harmful bacteria, parasites, fungi and viruses including those in water, environment and equipment.
Micro-organism	Any living thing (organism) that is too small to be seen by the naked eye. Bacteria, viruses and some parasites are microorganisms.
Organism:	Any living thing that can grow and reproduce, such as a plant, animal, fungus or bacterium.
Parenteral nutrition:	The giving of special liquid feeding products to a person using an intravenous catheter and bypassing the normal digestion process of the stomach and bowel.
Pathogen:	Any disease-producing infectious agent
Point of use filters:	A device that incorporates an integral filter with a maximal pore size of 0.2 µm applied at the outlet, which removes bacteria from the water flow therefore protecting the end user from exposure to harmful waterborne pathogens.
Portable wash hand basins	A sink that is not connected to the mains water supply but connects to a water tank which is filled locally.
Regressional seeding	Where micro-organisms from contaminated water outlets/biofilm regress ‘back’ through the water system and seed other areas (pipes/tanks/outlets). The microorganisms embed themselves and multiply contaminating other areas of the system.
Sanitisation	Use of antimicrobial agent on objects, surfaces or living tissue to reduce the number of disease-causing organisms to non-threatening levels.
Shock dosing	The use of large quantities of chemicals to the water supply to break down organic waste and get rid of bacteria and contamination.
Silver hydrogen peroxide	A solution of stabilised silver in hydrogen peroxide that is used for surface and water decontamination.

Sterile water	Water free of all microorganisms – bacteria, viruses, fungi.
Terminal clean	Cleaning/decontamination of the environment following transfer/discharge of a patient, or when they are no longer considered infectious, to ensure the environment is safe for the next patient or for the same patient on return.
Thermal disinfection	The use of water and heat for the disinfection process for example washer-disinfectors.
Toilet plume effect	The dispersal of microscopic particles as a result of flushing a toilet.
Total viable counts	A quantitative estimate of the concentration of microorganisms such as bacteria, yeast or mould spores in a sample.
Trough sinks	A long, narrow basin designed for communal handwashing with water delivered at hand-washing temperature via mixer taps in conjunction with a thermostatic mixing valve. Usually used for surgical scrubbing.
UV light	A disinfection method that uses short-wavelength ultraviolet (UV-C) light to kill or inactivate microorganisms.
Water outlets	Any hole or opening where water is released for example taps, showerheads.
Water sampling	The analysing of the water supply for harmful bacteria, parasites, and viruses.
Water system	A system of engineered hydrolic and hydraulic components to supply water.
Spigots	A short cylindrical pipe which connects the Clinical Wash Hand basin to the main pipework.
Occlusion	Obstruction or blockage

Management of New Buildings and Refurbishments 2019: Questionnaire Summary

Version: 0.4

Owner/Author: Infection Control Team

Situation:

Following the investigation of a contaminated water system in 2018 at NHS Greater Glasgow and Clyde (NHSGGC) Queen Elizabeth University Hospital (QEUH) and Royal Hospital for Children (RHC) the Scottish Government requested Health Protection Scotland (HPS) and Health Facilities Scotland (HFS) undertake a review of all NHS Boards in Scotland. The purpose of this assessment was to provide assurance that there were no other boards in a similar situation.

An initial scoping questionnaire was circulated to all NHS Scotland boards to identify all new builds and areas where there had been significant water system refurbishment since the 1st January 2013. NHS Boards that have responded as having raised total viable counts (TVCs) or a water system that has required treatment will be issued a follow up detailed questionnaire to assess the level of contamination, risk, remedial action taken and any clinical case association.

Aim:

The aim of this report is to summarise the responses from the 2018 NHS Scotland water survey to:

1. Identify areas where significant refurbishment and/or new builds have taken place since 2013 across NHS Scotland.
2. Obtain baseline understanding of where testing has identified potential contamination in water systems during/ after refurbishment or new builds

Methods:

In December 2018, all NHS Boards (fourteen territorial boards and four special boards) in Scotland were contacted by email to provide data on refurbishments and other construction works carried out in their boards since 1st January 2013. Data collection was carried out using a questionnaire (see appendix 1). Data was collated and analysed in Microsoft Excel 2007.

Results:

There was 100% response rate for questionnaire from NHS boards.

A total number of 187 building works, including 18 unfinished projects, were identified through the responses received to have been carried out across NHS Scotland since 2013. Of these 187 works, 53 were new builds and 96 were refurbishments. The level of work carried out was not reported for the remaining 38 projects.

NHS board refurbishments undertaken and new builds were as follows:

NHS Ayrshire and Arran

From 2013 to 2019, 20 significant refurbishments have taken place across 2 main hospitals; University Hospital Ayr and Crosshouse and one new build hosting an Ambulatory Care Hospital; Woodland View Community and Mental Health hospital were completed in 2016.

In terms of microbiological water testing undertaken in both hot and cold systems during commissioning, handover and thereafter in the new build and refurbished areas no micro-organism (including fungi) or TVCs greater than 10 were reported

It was mentioned that a process of Chlorine Dioxide (ClO_2) dosing system has been in place at University Hospital Crosshouse for over twenty years. As the Scottish Water Chloramination Project (Ayrshire Resilience Scheme) was extended to include the water supply network within NHS Ayrshire & Arran areas, the need for the dosing system will be reviewed.

From the information supplied no further follow up required

NHS Borders

Within this board, two refurbishments and four new builds were completed between 2013 and 2018.

It is reported that no microbiological water testing was undertaken in both hot and cold systems during commissioning, handover and thereafter in the new build and refurbished areas however sanitisation was reported to be carried out during the build process prior to hand over.

From the information supplied a follow up questionnaire will be issued

NHS Dumfries and Galloway

NHS Dumfries and Galloway reported one new facility constructed since 2013, Dumfries and Galloway Royal Infirmary.

A total of 1321 samples were taken between 2nd October 2017 and 17th December 2018. It is reported that water samples were tested for:

- TVC at 22;
- TVC at 37;
- Total coliforms;
- *Escherichia coli*;
- Total *Pseudomonas;*
- *Pseudomonas* in hot/cold;
- *Cupriavidus*; and
- *Sphingomonas*

Some of the water samples obtained from both cold and hot water systems had raised TVCs (i.e. TVC>10). Three samples were positive for coliforms (last positive sample dated 6th December 2017, no information after this date). Several samples grew *Pseudomonas* (last sample tested on the 11 h October 2018). Finally, five samples tested positive for *Cupravidus* and *Sphingomonas* (one on the 19th December 2018, two on the 3rd December 2018 and two on the 17th December 2018).

NHS Dumfries & Galloway reported that prior to handover water treatment/dosing/sanitisation was carried out.

From the information supplied a follow up questionnaire will be issued

NHS Forth Valley

NHS Forth Valley comprises of one acute hospital supported by a network of a further four community hospitals. A total of seven refurbishments were completed across two community hospitals. In Falkirk Community Hospital alterations were undertaken in ward 1 to Unit 5, and

wards 18 and 19 to form Woodlands Resource Centre. In Stirling Community Hospital alterations were completed across four clinical settings including maternity, upgrading of ward 5, and alterations to ward 30 to form Livelands Resource Centre and a two phased refurbishment of the Outpatients Department.

For new builds, Stirling Health and Care Village has incorporated two new settings; a new GP and Minor Injuries Unit and the Bellfield centre both completed in 2018. A further new build will incorporate Doune Health Centre which is in its early stage of construction.

Of the two new builds all results from microbiological water testing undertaken in both hot and cold systems during commissioning, handover and thereafter in those areas that were negative for micro-organisms (including fungi) or reported <10 TVCs.

From the information supplied no further follow up required

NHS Fife

Responses from NHS Fife confirmed two ward refurbishments carried out in the two main hospitals: Victoria Hospital completed in 2015 and Queen Margaret Hospital in 2017. Stratheden Community Hospital was a new build completed in 2018. Water testing was completed in line with local policy and no positive results were identified nor any water treatment required.

From the information supplied no further follow up required

NHS Grampian

A total of 8 new builds and 11 refurbishments have been carried out in NHS Grampian since 2013.

In all cases, water samples were taken and tested before hand over. When results were unsatisfactory, fittings were disinfected. In five cases: new build of a radiotherapy unit, the Aberdeen Community Health Village, the Woodside Health Centre, Inverurie and the Foresterhill Health Centre organism counts at 22°C and 32°C were positive, but satisfactory according to local assessment. Commissioning testing was carried out in the new build of radiotherapy unit and the Aberdeen Community Health Village. It is unknown if any remedial measures were implemented in the Woodside Health Centre, Inverurie and the Foresterhill Health Centre. In three new builds and three refurbishment works, arrangements were made

for flushing the system until occupation. Following NHS Grampians response to the scoping questionnaire, the IPCT have reported some concern relating to flushing and temperature control in a newly built dialysis unit in Stonehaven Hospital.

From the information supplied a follow up questionnaire will be issued

NHS Greater Glasgow and Clyde

A total of 21 new buildings have been constructed in NHS Greater Glasgow and Clyde (NHSGGC), including the construction of the Queen Elizabeth University Hospital (QEUH). In addition to this, 40 refurbishment works have been carried out. Seven works remain uncompleted. These include:

- The Adult & Royal Hospital for Children (RHC) chlorine dioxide (ClO_2) water treatment Project at the QEUH
- ITU expansion at the Royal Alexandra Hospital (RAH)
- Day Surgery Phase 1 at the Inverclyde Royal Hospital
- Replacement water mains complete with ClO_2 water treatment plant at the Gartnavel General Hospital (GGH)
- Queen Elizabeth Building (QEB) ward copper pipework replacement at the Glasgow Royal Infirmary (GRI)
- Woodside Health Centre

NHS GGC did not provide details on the microbiologic tests that are carried out to ascertain water quality.

Water treatment/sanitation/dosing was carried out in the 30 of the works, including some works that have not been completed yet. Sanitation of components was performed at installation in several works, including the constructions of wards 2A & 2B at the RHC. This was complemented by continual water treatment with ClO_2 at 0.5ppm CWS & 1 PPM DHW.

HPS are supporting NHSGGC with water contamination issues across QEUH and RHC. From the information supplied a follow up questionnaire is required for areas out with QEUH and RHC

NHS Highland

In NHS Highland, new builds include one new rural hospital (Midgedale) and three new health centres in Broadford (Skye), Tain and Drumnadrochit. At this time, a theatre refurbishment programme is in progress within Raigmore District General Hospital with plans for a further three projects for replacement hospitals in Skye, Aviemore and an elective care centre in Inverness.

The board confirmed the completed projects had microbiological testing as part of the commission process. In addition, routine water testing is currently carried out in Raigmore Hospital. Risks were identified following routine sampling in Tain Health Centre which led to uncovering of defects associated with the incorrectly installed pipework during building construction. Issues identified have been addressed through contractors with a process of rectification completed and ongoing water quality monitoring.

The Board have a commissioning manager to oversee water treatment/dosing/sanitation activities. It was reported by this board that handover of facilities does not occur unless water sampling are clear.

In NHS Highland carries out tank cleaning and disinfection, this is performed using hydrogen peroxide. In addition to this, annual water testing is performed.

From the information supplied no further follow up required

NHS Lanarkshire

In total 31 works have been carried out in NHS Lanarkshire since 2013, including three refurbishments. It is unknown if the rest of the works were refurbishments or new constructions.

NHS Lanarkshire tests water for TVCs at all stages of commissioning. It is reported that since 2013 they have had positive results (i.e. TVC>10). When results are not satisfactory, advice is sought from the Authorising Engineer and corrective measures are put in place. For example, raised TVCs were found during Monklands theatre refurbishment. Thus, remedial actions were undertaken before handover.

From the information supplied a follow up questionnaire will be issued

NHS Lothian

Since 2013 ten building works have been carried out in NHS Lothian, seven of which have been completed.

In NHS Lothian, new buildings are supervised and quality assured by the lead for water quality (Director of Facilities), Infection Control experts, Lead Microbiologist, Authorising Engineer, Authorised Person and the Decontamination Committee. Water samples are taken and tested to assure the quality is appropriate (e.g. TVCs).

Water quality tests were reported as not satisfactory (TVC>10) in two cases. In both instances remedy actions were implemented, including disinfection of the system, and implementation of ongoing testing and monitoring regimes.

From the information supplied a follow up questionnaire will be issued

Additionally NHS Lothian are currently pre handover of a new build childrens hospital. From the information supplied a follow up questionnaire relating to the new childrens hospital will be issued.

NHS Orkney

In NHS Orkney, one building has been built since 2013, the Balfour Rural General Hospital. This project is not yet complete and it is expected to be finalised by the end of April 2019.

No information was provided regarding testing and commissioning works. However, the project aforementioned is being reviewed by the Authorising Engineer and a representative from Health Facilities Scotland (HFS).

From the information supplied a follow up questionnaire will be issued

NHS Tayside

The construction of three new buildings and the refurbishment of six areas have been carried out in NHS Tayside since 2013. To date, the construction of the Ninewells Hospital and the refurbishment works at the Lochee Health Centre have not been finalised.

Testing for *Legionella* was carried out in all construction and refurbishment works. They reported one positive result, however no further detail was provided regarding remedy measures implemented.

From the information supplied a follow up questionnaire will be issued

NHS Western Isles

Between 1st January 2013 and 23rd January 2019 five building projects have completed, including the construction of two buildings, namely, Community Equipment Store Facility (Balavanic) and the Central Decontamination Unit at the Western Isles Hospital.

In NHS Western Isles water samples are taken and tested for *Legionella*. To date, all results have been negative. In addition to testing, heat sanitation was performed after the building of the new aforementioned facilities.

From the information supplied no follow up is required

NHS Shetland

No construction works have been undertaken in this board since 2013.

From the information supplied no follow up is required

Scottish Ambulance Services (SAS)

This questionnaire was not applicable to this board.

National Services Scotland (NSS)

A new building was constructed in 2017: the Jack Copeland Centre for the "processing, testing, supply, research and development of blood and human donor tissues and cells".[1]

This building has two tanks, both of which are reported as being tested for:

- Total aerobic colony count 37 °C;
- Total aerobic colony count 22 °C;
- Total coliforms;

- *Escherichia coli*; and
- *Pseudomonas aeruginosa*

Results were negative for both tanks and no remedy actions were required.

From the information supplied no follow up is required

Golden Jubilee National Waiting Times

No construction works have been undertaken in this board since 2013.

From the information supplied no follow up is required

State Hospitals

No construction works have been undertaken in this board since 2013.

From the information supplied no follow up is required

Discussion and future steps:

The main objective of the survey was to gather baseline information on water management at commissioning/handover stage of refurbishments and new builds across NHS Scotland since 2013 to date.

To assist responses a template was developed and issued to HPS Boards, although the response rate was 100%, several boards were unable to provide detailed information. For instance, information regarding what tests had been undertaken and that results were “not found” in several cases. Thus, it is difficult to ascertain that appropriate tests have been carried out in all cases or whether remedy measures were required.

Some of the refurbishments may have a greater impact on water systems or may present a more significant risk for patients than others. This may include refurbishments that are carried out in augmented care areas (e.g. haematology units, intensive care units).[2] Although most boards provided detailed information about the areas affected by the building works, others provided more generalised information.

Disinfection of the system and/or fittings was carried out in several boards. It is essential that flushing of the system is performed prior to disinfection.[3] This allows the removal of any debris from the system.[4, 5] Although flushing of the system was highlighted by one of the

boards, this was not asked for in the questionnaire and consideration should be given to include this in any future questionnaire.

It is accepted however that this was an initial scoping questionnaire to allow the identification of any potentially contaminated water systems in NHS boards across Scotland. A more detailed questionnaire is being developed to identify any associated clinical/patient safety risks from boards identified from their responses to the scoping questionnaire as having potential challenges.

Eight NHS Boards will be issued with a further detailed questionnaire. A summary report will be prepared following completion of this phase.

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Appendix 1: Questionnaire

Q1) Please provide details of all areas across your NHS Board that have had significant refurbishment that has required installation of new water systems since January 2013 until present.

Q2) Please provide details of all new builds across your NHS Board area since January 2013 until present (including those in progress not yet handed over to your board).

Q3) Were any results of microbiological water testing undertaken in both hot and cold systems during commissioning, handover and thereafter in those areas identified in questions 1 and 2 positive for micro-organisms (including fungi) or TVCs greater than 10? If yes, please provide details of location/s.

Q4) Has there been any water treatment/dosing/sanitisation carried out in any area identified in Q1 or Q2 across your NHS Board since January 2013 to present?

NSS Health Facilities Scotland

Water Management Issues Technical Review

NHS Greater Glasgow and Clyde – Queen Elizabeth University Hospital and Royal Hospital for Children

Health Facilities Scotland – March 2019

March 2019

A43940545

1. Executive Summary

NHS Greater Glasgow and Clyde (NHS GGC) requested the support of both Health Facilities Scotland (HFS) and Health Protection Scotland (HPS) in March 2018 as they were investigating contamination of the water system at the Queen Elizabeth University Hospital (QEUH) and the Royal Hospital for Children (RHC).

This summary is produced for internal NHS GGC purposes using the information made available as a management tool to assist improving internal processes.

The Contractor, sub-contractor or the Project Supervisor were not directly involved in the production of this report nor were they requested to verify its contents and they may have additional information not considered here.

NHS GGC had found organisms in the water system and had linked these to bloodstream infections associated with ward 2A. After extensive sampling of the water system and sink drains, it became apparent that the organisms were widespread and not limited to ward 2A.

The HFS brief was to review the available information relating to the design, construction and commissioning phases of the construction project relating only to the hot and cold water services installations. The brief also included a review of the available information concerning handover of the water system and ongoing maintenance of the system and its components. After the review of the information the brief called for a hypothesis to be established for the potential cause of the system contamination.

The following paragraphs are a summary of the findings of the review.

This report is based on interpretation of the data and information made available by NHS GGC, including that found within the electronic operating and maintenance manual (ZUTEC), during the course of the investigation. This report seeks only to consider the hot and cold water installation and the associated issues and does not consider in detail any issues with the operation of the Energy Centre other than to note its potential impact on the hot and cold water installation within QEUH and RHC.

Only Information presented by NHS GGC up to 25th July 2018 has been taken into account.

From review and interpretation of all literature provided, it appears that best practice has not been followed in a number of activities from the design, through installation to handover, and subsequent operation and maintenance of the installation. Each of these may have had an impact on the water system to a greater or lesser extent.

We have been advised that the NHS GGC Estates team were not part of the Client's project team and had no influence with regard to the design of the mechanical and electrical services or any input into the practicality of maintaining these services.

In view of the evidence provided and as reviewed, it is likely that the hot and cold water distribution pipe work installation was contaminated at one or more times during the installation process.

The Scottish Water main incoming supplies were tested in February 2012 and were reported by Scottish Water as being bacteriologically satisfactory.

There is good evidence that pipe work was not adequately protected from contamination during construction.

The Project Supervisor has noted in several reports that various pipes were left open-ended and unprotected during the installation period. There is no evidence to suggest that this pipe work was rejected, therefore the pipe work was probably subject to contamination and the introduction of moisture via condensation.

There is evidence that water was in the pipe work in some areas of the building in August 2014. Commissioning of the systems was not until November 2014.

NHS GGC relinquished the independent governance of the testing and commissioning of all systems (not just water) to the Contractor and the independent third party check on the commissioning was lost as a result.

The commissioning certification shows identification of *E.Coli* and high Total Viable Count (TVC) at the initial disinfection stage. There is no evidence to suggest that the fact that *E.Coli* was present in the system was brought to the attention of NHS GGC Infection Control or Project Supervisor by the contractor. It would appear that the post disinfection results show that the *E.Coli* was eliminated and TVC in some areas reduced at the second disinfection, but there is the potential that the level of chemical used was not adequate to remove all the organisms and any established biofilm. Some outlets failed the second disinfection test and no results are available to prove they subsequently passed. This suggests that the system may have been handed over in a failing condition.

There is also evidence that work was carried out by the contractor on the main incoming water tanks, calorifiers and pipe work post handover, which may have introduced contaminants into the hot and cold water systems. NHS GGC Estates were not aware of these works taking place; therefore there was no control of the methodology of the installation or re-commissioning, disinfection and re-testing of these parts of the water distribution system.

NHS GGC's specialist contractor, used to produce the legionella risk assessment, noted that there were visible signs of contamination immediately after handover and highlighted issues with the water sampling test results.

From review and interpretation of all available literature provided it appears that since handover the maintenance of the hot and cold water systems has not followed the manufacturers' recommendations or guidance.

There is no evidence that the maintenance procedures set out by the Contractor in the electronic maintenance manual for taps, showers and drains have been implemented.

There have been ongoing issues with the hot water supply to QEUH and RCH from the Energy Centre as well as issues regarding the control strategy, specifically hot water temperatures potentially not reaching those specified in the contract. These

issues require to be resolved and NHS GGC is working with the contractor to achieve this.

As noted above, NHS GGC employed an independent company (DMA) to carry out legionella risk assessments at handover and again in 2017. NHS GGC also employed an Authorising Engineer to Audit the management of the water systems at QEUH and RHC. These documents highlighted a number of actions required to be taken to resolve issues with the water management at QEUH and RHC.

NHS GGC has now (July 2018) resolved the majority of the outstanding items on the three reports noted in the paragraph above and as a result have reduced the risks associated with the management of the water systems at QUEH and RHC. The taps and showers in critical care areas of both QEUH and RHC have been protected by the introduction of point of use filters.

To provide assurance with respect to the water system, NHS GGC has consulted widely and proposes to install a permanent chlorine dioxide plant to dose the water systems and reduce the level of organisms in the water system.

2. Introduction

NHS Greater Glasgow and Clyde (NHS GGC) requested the support of both Health Facilities Scotland (HFS) and Health Protection Scotland (HPS) in March 2018 as they were investigating contamination of the water system at the Queen Elizabeth University Hospital (QEUH) and the Royal Hospital for Children (RHC).

NHS GGC had found organisms in the water system and had linked these to bloodstream infections associated with ward 2A. After extensive sampling of the water system and sink drains, it became apparent that the organisms were widespread and not limited to ward 2A.

Biofilm

There is a multitude of information in the published literature which directly links biofilm production/biofilm producing organisms to water source related outbreaks. Recent review articles focussed on the role of water in healthcare associated infections, with specific mention of biofilm formation as a key mechanism for sustained contamination of water systems. Biofilm formation has been described for *Cupriavidus* species (spp) and *Pseudomonas* spp, particularly in association with water systems. Biofilm formation with *Stenotrophomonas* on a variety of surfaces has also been demonstrated.

Water and water systems harbour a diversity of microorganisms and whilst the majority are considered harmless to healthy individuals, some, such as Pseudomonas aeruginosa, can cause serious opportunistic infections, particularly in individuals with a weakened immune system ((Lyczak JB, 2000) as citied in (G Moore, 2015)).

World Health Organisation guidelines state that the potential health consequences of microbial contamination are such that its control must always be of paramount importance (WHO, 2011).

Free floating Micro-organisms can attach to a surface and grow, they prefer to live in communities and usually the communities that contain a mix of micro-organisms, known as Biofilms. Biofilms can be described as a collective of one or more types of microorganisms they can grow on virtually any surface that is periodically or continuously wet (Flemming, 2010).

Biofilms commence formation when a free floating microorganism comes into contact with a suitable surface. The microorganism attaches itself to the surface by releasing extracellular polymeric substance (EPS), a sticky substance which allows free floating microorganisms to stick together in a matrix to form a biofilm layer. This matrix is a collection of DNA, proteins and polysaccharides that form a protective housing around bacteria, creating a safe space and preventing biocide treatment from reaching the bacteria. In fact, bacteria in a biofilm are 10 to 1,000 times more resistant to treatment than in their planktonic, free-floating form ((Monroe, 2007) as citied in (Vasilescu, 2017)).

Multiple environmental conditions such as oxygen availability, water temperature and the flow rate of water across the biofilm, will determine the extent to which a biofilm grows (Nocker, 2014).

Once a biofilm has advanced, it forms a complex structure in which different bacteria occupy different environments. This sophisticated approach means bacteria towards the outside of the community have a very different structure from those deep within the matrix. These physiological differences together with delayed penetration of chemical agents through the biofilm matrix result in an increased tolerance to antimicrobial agents, including disinfectants and other chemical biocides (Bridier et al. 2011, citied in (G Moore, 2015)). This has the potential to make biofilms stubborn to treatment, as treatment will need to target many different physiologies. For example a biocide may be effective against one bacterial strain whilst other strains may remain unaffected. Furthermore treatments do not always break down the protective matrix layer; this means bacteria within the matrix will remain protected and free to multiply ((Flemming, 2010) cited in (Nocker, 2014)).

Furthermore, the bacteria contained within the matrix use quorum sensing, meaning they are constantly undergoing genetic divergence. This gives biofilms phenomenal recovery and regrowth abilities after a population hit, often caused by treatment attempts (Vasilescu, 2017).

Building

The Queen Elizabeth University Hospital (QEUH) campus opened in 2015 is a 1,365-bed acute hospital located in Govan in the south-west of Glasgow.

The 14 floor, 1,109 bed QEUH (adult) building is one of the largest acute hospitals in the UK and home to major specialist services such as renal medicine, transplantation and vascular surgery, Critical Care, Theatre and Diagnostic Services.

The 256 bed Royal Hospital for Children (RHC) is adjoined to the adult hospital and replaces the former Royal Hospital for Sick Children located in Yorkhill.

The adult hospital is integrated with the children's hospital with separate functions and entrances.

Patient migration took place between April 2015 and Jun 2015.

Contract type

The contract type was a NEC3 Engineering and Construction Contract (ECC).Although this contract type is common and generally used for the appointment of a contractor for large scale engineering and construction work, including portions of design responsibility, it was relatively new to the NHS Scotland at the time this contract was signed.

The contract was awarded 18th December 2009, with a total value of the project at £610 million (including QEUH, RCH, Labs, car parks, Institute of Neuro Science etc) with an approximate value of the mechanical and electrical works of approximately £184 million.

The sectional completion certificate for the works associated with QEUH and RCH is dated 26th January 2015.

Roles

The following organisations were employed under the above noted contract to deliver the project for NHS GGC.

Team	Role	Name
Contractor	Main contractor	Brookfield Multiplex
	M&E subcontractor	Mercury Engineering
	Architect	Nightingale Associates (now IBI)
	M&E services engineer (Design Engineers)	ZBP Associates, subsequently taken over by TUV SUD (Wallace Whittle)
	Water Services Commissioning	H&V Commissioning Services Ltd
	Construction (Design and Management) Regulations 2007 (CDM)	Brookfield Multiplex Health & Safety Team

Table 2.1 Roles and responsibilities for design, installation and commissioning

It is noted that as the Contract was a design and build type, the NHS GGC Estates team were not part of the Client's project team and had no influence with regard to the design of the mechanical and electrical services or any input into the practicality of maintaining these services.

One member of the NHS GGC Estates Team and one member of NHS GGC Infection Control were involved during the commissioning period to review method statements.

The QEUH did not go through the NHS Scotland Design Assessment Process (NDAP). At the time of planning and design for this project, NDAP assistance was voluntary at the discretion of the Boards.

Information requested

To assist with the technical appraisal requests were made by HFS and HPS for information to NHS GGC and various third parties. The responses by NHS GGC to the information requests are shown in Appendix 3 as are responses from third parties.

The hypotheses, conclusions and recommendations in this report are based on the information received, discussions with various specialists and technical research.

3. Design and Construction

Guidance and specifications

Legal reference documents for water systems are as follows:

- Health and Safety at Work Act 1974
- Management of Health and Safety at Work regulations 1999
- Control of Substances Hazardous to Health (COSHH) 2002
- Approved Code of Practice (ACOP) L8
- Legionnaires' disease Technical Guidance HSG 274 (2014)
- Scottish Water Byelaws 2004

These documents set out the legal requirements and guidance which must be observed with respect to water systems during design, construction, commissioning and maintenance.

NHS GGC set out the design parameters and guidance to be followed in their Employer's Requirements (ER). In section 8.2.8 Water Systems and Filtration, the ER details the requirement for two new water supplies, storage and full compliance with certain guidance documents. An image of this section is detailed in Appendix 2[1]. Some of the documents referred to in this section are incorrectly referenced, superseded at the time of construction (but not at the time the ER were compiled) and therefore could be misleading.

It should be noted that the ER were written prior to the publication of SHTM 04-01 in August 2011. The inclusion of the references to this document in the ER notes that SHTM 04 was in consultation phase of production.

- The Health Technical Memorandum is noted as (S) HTM 04-01. It should be noted that all project in Scotland should follow guidance given in SHTMs.
- SHTM 2027 should not have been cited as it was superseded by SHTM 04-01 (published August 2011)
- SHTM 02 refers to medical gases (and therefore would not provide guidance on the safe operation of water systems).
- SHTM 2040 should not have been cited as it was superseded by SHTM 04-01 (published August 2011)
- The Health Guidance Note (HGN) "Safe Water Temperatures" noted was incorporated into SHTM 04-01.

The ER also details the test and certification requirements to be handed over for all services, but lists the water services documentation specifically as:-

- Flushing and Chlorination test certificates.
- Testing of all hot water TMV etc
- Mechanical pipe work pressure tests
- Water systems in accordance with CIBSE Code W

[1] Appendix 2 Item reference 1

- Domestic water bacteriological tests
- Legionella testing (including incoming mains)
- Chemical clean and inhibitor dosing

Contractor stated compliance with SHTM and specifically SHTM 04-01

The contractor has identified which guidance documents they intended to comply with in their submission response document, section 7.1 “NHS Mandatory Documentation”[2]. It is noted that the contractor’s proposal complies with SHTM 04-01 A and SHTM 04-01 B but there is no mention of any of the other parts which were published in 2011 (SHTM 04-01 parts C to F). The only deviation noted is the reduction in capacity of the storage tanks.

The contractor has also noted that they intend to comply with the NHS England HTM 04-01 A and HTM 04-01 B. It should be noted that these documents are not applicable in Scotland. The Contractor has also noted compliance with superseded water related SHTM (SHTM 2027).

The theme of compliance with superseded and English documentation is consistent through the contractor’s proposal document for other services. It is also noted that there are duplicate references to various items of guidance on the full table contained within section 7.1 “NHS Mandatory Documentation”.

It is not clear therefore what health care design guidance took precedence from the information provided.

The contractor has noted in their document “Design strategy for engineering systems reserve capacity” that an additional 25% capacity was allowed in the distribution pipe work, pump systems, mains and risers[3]. This same document notes that there is “nil reserve capacity” for the cold water storage system. It should be noted that over sizing water pipe distribution systems may lead to stagnation in parts of the water system which may contravene Health and Safety guidance as well as the guidance given in SHTM 04-01.

Larger diameter pipe work will have less velocity than smaller pipe work, which may lead to biofilm adhering to the pipe surfaces. Most designers build in a certain amount of capacity in their design (and this should be defined by assessment[4] to avoid stagnation), but the issue of biofilm formation may be exacerbated by adding 25% on to the main pipe work distribution.

Specification of water system

The contractor has specified that “The incoming water main service systems will comply with the relevant clauses of the NHS Model Engineering Specification Parts C01, C07, C82, D08, addendums to Part C, SHTM 2027, 2040, BS 6700, Scottish Water Byelaws 2004, and descriptions and requirements set out below” in their

[2] Appendix 2 Item 2 Extract from Contractors Proposals
[3] Appendix 2 Item 22
[4] CIBSE Design Guide G

specification document section 4.45-4.47. These are outdated references even at the time of the specification was written.

The specification for the hot and cold water supply systems is detailed in TUV SUD (Contactor's specialist mechanical and electrical (M&E) designer) specification reference ZBP-XX-XX-SP-500-103. This document makes it clear that the specialist sub-contractor has to develop the installation, setting to work and commissioning. The applicable guidance is noted as SHTM 04-01.

The document refers to thermostatic mixing valves (TMV) rather than thermostatic mixing taps (TMT). This (TMV) means a separate device for mixing the hot and cold water was envisaged rather than combing this unit with the tap (TMT) at the time the specification was written.

The cold water storage is sized for 24 hours with 10% spare capacity which is different from the nil noted above.

The hot water is designed for 60°C flow and 55°C return. It has been advised by NHS GGC that these temperatures are not what is being found in practice due to issues with the Energy Centre (this is discussed elsewhere in this document).

The specification states that "All main distribution and dropper connections will be provided with isolating valves, with local isolation valves installed to isolate and shut down individual ward/department areas". This is not what has been provided onsite as this level of isolation cannot be achieved.

The specification states that the Domestic Hot Water Service (DHWS) distribution system will be configured with a pumped return to maintain temperatures within the system in accordance with SHTM 04-01. The pumped return system will minimise "dead legs" and reduce water consumption by providing the correct temperature of water at the outlet with minimum delay. From the contractor's description and reports from the Project Supervisor, dead-legs have been introduced into the systems rather than minimised.

Water flow regulators are specified to reduce flow on both the hot and cold outlets. These have the potential to become colonised with bacteria and guidance issued after the commencement of this contract advised against using these devices. This guidance (CEL 08(2013)[5], SHTM 04-01 Part A and HPS guidance[6]) was produced in response to an incident in a Northern Ireland Hospital and published in 2013.

With respect to completion of the project, the specification calls for the following:-

COMPLETION

- The Sub-contractor shall protect the system from damage or interference during the works.

[5] Chief Executive's Letter
[6] Guidance for neonatal units (NNUs) (levels 1, 2 & 3), adult and paediatric intensive care units (ICUs) in Scotland to minimise the risk of Pseudomonas aeruginosa infection from water

- The Sub-contractor shall Test, flush and clean the system as per section Y12, Y50, SHTM/ HTM's and TR/20.
- The Sub-contractor shall submit O&M's (Operating and Maintenance Manuals) as required by The Contractor
- The Sub-contractor shall provide training as per section Y12, Y40 & Y50.
- The Sub-contractor shall provide spares as per section Y12, Y40 & Y50
- The pressure testing of the system is to be to BS 6700.

The ZBP/TUV SUD specification "Common Mechanical Clauses[7]", details Y12, Y40 and Y50 noted above amongst other requirements. Selected clause extracts from this specification are highlighted below as reference to points raised later in this report as follows:-

Y10 Pipelines

- Purpose made cap ends to prevent dirt and rodent infestation.
- Protect against frost, building works, or the operation of others.
- Keeping clean, tidy, and free from waste and superfluous material all of their areas.
- For water services, pipe runs should not be excessively long and dead legs should be kept to an absolute minimum to avoid stagnation.

Y12 MECHANICAL CLEANING AND CHEMICAL TREATMENT

- Water analysis: Analyse water samples before treatment.
- The use of stainless steel, PVC-U, PVC-C, PB or PE-X piping requires a leachate flushing regime to reduce the level of contaminants leaching from the piping material into the water. Details of this regime are given in SHTN 2. All parts in contact with the water must be non-dezincifiable. It is recommended that a specialist firms are engaged for the disinfecting and water sampling process.
  NOTE: chlorine should NOT be used for the disinfection of stainless steel piping or membrane filters manufactured from polypropylene.
- Disinfection and subsequent flushing should be carried out as a continuous and consecutive operation without any intermediate delays.
- Flushing: In accordance with BSRIA AG 1/2001.1.
- Installation checks: Thoroughly inspect pipework.
- Water treatment: Standard: To BS 6700.
- Samples for analysis: Provide after flushing.
- Water quality tests: Standard: To BS 6700.
- Samples: Submit samples for bacteriological analysis.
- Water temperature: Record the temperature of the water at each sampling point, at the time of taking the sample.
- Test results: Submit

Y50 Mechanical commissioning

[7] ZBP/TUV SUD Specification ZBP-XX-XX-SP-520-307

Completion

The Sub-contractor shall provide instruction to the clients engineers and maintenance staff in the safe operation of all systems and items of equipment for an adequate and reasonable period of time based on the manufacturs' recommendations and best practice. The Sub-contractor shall provide adequate and qualified staff in order to carry out their maintenance and repairs during the defects liability period.

Demonstrations

- Running of plant: Run, maintain and supervise the installations under normal working conditions.

  Duration: 4 weeks.

- Instruction: Instruct and demonstrate the purpose, function and operation of the installations.

Seasonal commissioning

Seasonal commissioning of plant and systems shall be undertaken over the first 24 month period in accordance with the requirements of the BREEAM Assessment. Measurement and recording of criteria for thermal comfort (temperature and humidity where applicable), ventilation rates and effectiveness, lighting levels and controls, etc shall be carried out at three monthly intervals. A representative from the Hospital shall also give subjective feedback for consideration in the monitoring process.

It is noted that water supplies are allowed for the courtyards. These could potentially be little used outlets and introduce dead-legs into the system. NHSGGC have advised that the outlets have been removed, but the pipe work has not been completely removed.

The stage 3 instruction to proceed log makes it clear that flexible hoses are prohibited. This is also highlighted in Invitation to Participate in Competitive Dialogue: Volume 2. It would appear that there may be 2 instances of flexible hoses having been used in areas retro-fitted by contractors employed by charitable organisations. It is not clear how a third party contractor managed to install these, attach them to the water system and commission them. In addition flexible hoses have been installed in several locations for rise and fall baths and sinks.

System description

NHS GGC negotiated two new water supplies from Scottish Water for the QEUH and RHC. One is known as Hardgate Road and the other is Govan Road. Each of these supplies can accommodate the full combined demand of the QEUH and RHC. These

enter the building at basement level and connect to two “raw” water storage tanks. A simplified schematic for the cold water distribution system is shown in Appendix 1[8].

Each supply connects to both raw water tanks via water meters which are connected to the Building Management Systems (BMS). The metering allows checks against the provider’s water mete rs. The supplies alternate every seven hours to minimise the risk of stagnation in the mains and assist in the Scottish Water distribution network.

Each raw water storage tank has a capacity of 100,000 litres, giving a total raw water storage of 200,000 litres.

The output of the raw water tanks links to filtration plant. This filtration plant removes dirt, debris and organisms to 0.2 micron. This level of filtration is used to remove organisms and fungi from the incoming water the average size of which is 0.2 micron or greater. *Legionella, Pseudomonas and Cupriavidus* are generally in excess of 0.3 micron.

From the filtration plant, the water is routed to one of two filtered water storage tanks. Each of these tanks has a capacity of 225,000 litres, giving a total filtered water storage of 450,000 litres.

The output of the filtered water tanks serves two booster pumps. Each booster pump serves different areas of the facility. The higher pressure systems (7.7 bar) serves mainly the tower of the QEUH (plant rooms 31, 32 and 33) and the lower pressure system (5.0 bar) serves mainly the RHC (plant rooms 21, 22 and 41) - although the floor distribution is not as simplistic as this. It should be noted that the designer (TUV SUD) describes two 7.7 bar systems in their specification and there is no audit trail to advise how the final solution was arrived at.

It should also be noted that the as-installed drawings on ZUTEC show a different pump distribution system to that which has been installed.

This Boosted Cold Water Supply (BCWS) into each plant room is metered and routed to either the vertical risers to the calorifiers. The water in the calorifiers is heated via plate heat exchangers with Medium Temperature Hot Water (MTHW) from the Energy Centre. It should be noted that the expansion vessels associated with the calorifiers are not of the flow through type as recommended in The Health and Safety Executive’s guidance document HSG 274 part 2[9]. These devices[10] introduce a potential problem of microbial colonisation as plant room temperatures generally exceed that of the incoming water and the internal lining of the diaphragm is made of a material which has been shown to increase the risk of organism growth.

The BCWS pipe work and the HWS pipe work are routed together horizontally in the ward corridors on each floor.

There is no return on the BCWS, but there is a return pipe work distribution network on the Hot Water Supply (HWS), which is normal. The BCWS does have temperature

[8] Appendix 1 Simplified water schematic for QEUH and RHC
[9] Appendix 2 item 30
[10] Appendix 2 item 31

controlled end-of-line dump valves. These have been installed to allow water to flow to the drain when the BMS detects a cold water temp of 23°C; this has been installed to prevent conditions which are favourable to the growth of *legionella*, however the trigger point is set at the start of the *legionella* growth curve. The bacteria multiply where nutrients are available and temperatures are between 25°C and 45°C. The bacteria are dormant below 20°C and will not survive above 60°C.

With respect to the return on the hot water pipe work, this has not been installed to the requirements of SHTM 04-01. The installed hot water pipe loop is created in the corridor or ceiling void and then a spur drops down behind the removable panel to the outlet. This method of installation creates a dead leg to the outlet. Both SHTM 04-01 and HSG 274 part 2 (2014) show the hot water circulation pipe work branching as close as practically possible to the outlet so that dead legs and stagnation are avoided. SHTM 04-01 part A notes:-

Paragraph 8.6

All pipework should be insulated, except for any exposed final connections to sanitary appliances, and should be arranged to eliminate or minimise dead-legs.

In addition there is a third system known as the Trades Water Supply. The Trades Water System supplies various outlets such as bib taps in plant rooms, irrigation connections points and the 12th floor helipad fire suppression system.

Pipe work

The manufacturer of the pipe work installed for the cold water system is noted in ZUTEC as Pegler Yorkshire. There is contact information for the manufacturer and wholesaler. There is a general Pegler Yorkshire XPRESS brochure which covers various materials (copper, low carbon steel and stainless steel).

This system is installed using crimp joint connections made using a bespoke tool.

There is no information on the compatibility of the pipe work or joint connection seals and chemical disinfectants. The manufacturer has no published data on this aspect of the pipe system installed (either on their website or via their technical department); there is no assurance regarding the suitability of the chemical used by the Contractor for disinfection of the water systems with the pipe, seals, pumps etc.

The water services pipe work was integrated into pre-fabricated modules and erected on site along with other services. Due to the density of services in certain locations, it may prove difficult to replace the water services pipe work at any future date without significant disruption to the QEUH and RCH services.

Pipe work installation

The following extracts are noted from the various Project Supervisor' (Capita Symonds) reports.

<u>Supervisors report number 12, dated March 2012</u>

Page 3 of 20 Executive Summary.

In general terms we are satisfied that the installations are being installed to the correct standard, and are of a good quality. However we are concerned that there are a number of open ends being left on the main pipework installations. There is also some damage to the ductwork sections as they arrive on site.

Page 8 of 20 item 4.3.7 Dual Carriageway to Renfrew Road

We noted that pipework has been left with open ends. This can lead to debris and other material contaminating or restricting the operation of the systems. Brookfield provided a short term fix all open ends sealed on site as of 30/03/12. The pipe in original photograph has final connection in place. Brookfield confirmed that in the long term Mercury supplier/sub-contractor are to ensure all pipe ends blanked are off prior to site delivery until final connection takes place. In this instance Supervisor s Communication General Matters / Other Instructions (CI 13.1) No 09 is now closed out.

Page 8 of 20 Item 4.3.8 Pipework

Installation of hot, cold, heating, & chilled water pipework in the A&C hospital is now progressing and in general is being installed to a good standard. It was noted however that there are open ends being left on the pipework[11]*, and the contractor should be reminded that these need to be sealed, to prevent the ingress of moisture and subsequent corrosion that may develop.*

Page 9 of 20 Item 4.3.10

The thermal insulation installation to the pre-fabricated sections of pipework is being completed off site, before delivery. It should be confirmed with Brookfield that these pre-insulated sections of pipework have been pressure tested, prior to the insulation being fitted.

Supervisors report number 14, May 2012

Page 9 of 12 item 4.3.6 pipework

Brookfield have confirmed that there will be no water in the sprinkler system at this stage the pressure test is pneumatic test and not hydraulic. Prior to commissioning a hydraulic test will be carried out prior to flushing and chemical clean and closed with inhibitor to stop rust. Supervisor s Communication General Matters / Other Instructions (CI 13.1) No 10 is closed out.

Installation of hot, cold, heating and chilled water and medical gas pipework in the A&C hospital is progressing at pace and in general is being installed to a good standard. The number of open ends seen has reduced to minimal levels. The contractor should be reminded that these need to be sealed, to prevent the ingress of moisture and subsequent corrosion that may develop.

[11] Appendix 2 Item 7

Page 10 of 12

The thermal insulation installation to the pre-fabricated sections of pipework is being completed off site, before delivery. Brookfield has confirmed that these preinsulated sections of pipework have been pressure tested, prior to the insulation being fitted.

Supervisors report number 19, October 2012

Item 4.3.5 pipework

Installation of hot, cold, heating, & chilled water pipework in the A&C hospital is progressing at pace and in general is being installed to a good standard. It was noted however that there are still some open ends being left on the pipework[12], although to a lesser degree than previously reported. The contractor should be reminded that these need to be sealed, to prevent the ingress of moisture and subsequent corrosion that may develop.

We have identified locations where the dead legs on hot water pipe runs are excessive and greater than the specified distance of 3m. We are working with the Contractor to review and identify all areas and to ensure this is not repeated in the future installations. It is noted that the dead legs noted in area CCW-31 were closed out in item 76 of the Project Supervisors report and is dated 30th November 2012. No other areas are noted.

We noted that Pipework was not capped on Level 2, Gridlines E1-F & 2.1-2.3, Level 2, Plantroom, Gridlines J-I1 & 1-1.1, Level 2, THE-208 Workstation 6x Persons and Level 1, Corridor, Gridlines G1-G & 4-5.1. Brookfield has confirmed that all ends capped off including facing module. MRI Quench pipe has been returned into the opening in the wall and this end is capped off. The other issues raised is work in progress, consequently Supervisor s Communication General Matters / Other Instructions (CI 13.1) No 59 is closed out

Supervisors report number 24, March 2013

4.3.5 pipework

Installation of hot, cold, heating, & chilled water pipework in the A&C hospital is progressing at pace and in general is being installed to a good standard. The contractor should be reminded that open ends on pipework should be sealed, to prevent the ingress of moisture and subsequent corrosion that may develop. More emphasis should be placed on this as work progresses at higher levels on site.

We are continuing to monitor all pipework installations to identify possible dead legs. The quality checking by Brookfield would appear to be identifying these before our inspections. Brookfield has confirmed that the maximum length prior to trimming back

[12] Appendix 2 Item 8

these pipes is cumulatively 2,890mm as shown in the photographs below Consequently pipework dead leg is no greater than 3 metres and Supervisor's Notification of Defect (CI 42.2) No 76 is closed out.

It should be noted that the version of SHTM 04-01 current during the design and installation stages of the contract advises in Paragraph 8.6 that for cold water systems *"All pipework should be insulated, except for any exposed final connections to sanitary appliances, and should be arranged to eliminate or minimise dead-legs."* For hot water systems paragraph 9.49 advises *"Generally, the downstream dead-leg should not exceed 2m, and the complete length of the spur without circulation should not exceed 3m".*

Supervisors report number 25, April 2013

Installation of hot, cold, heating, & chilled water pipework in the A&C hospital is progressing at pace and in general is being installed to a good standard.

We are continuing to monitor all pipework installations to identify possible dead legs. The quality checking by Brookfield would appear to be identifying these before our inspections.

It should be noted from HSG 274 Part 2[13] (2014) that "*ensuring water cannot stagnate anywhere in the system by regular movement of water in all sections of the systems and by keeping pipe lengths as short as possible, and/or removing redundant pipework and dead-legs;" to prevent or control the risk of legionella*".

It should be further noted from SHTM 04-01 Part A that[14]

"All pipework should be insulated, except for any exposed final connections sanitary appliances, and should be arranged to eliminate or minimise dead-legs."

It should be further noted from SHTM 04-01 Part E that[15]

"Note: Any pipes delivered unprotected or with open ends should be rejected." This equally applies to open ended unprotected pipe on-site, where the risk of contamination is the same as transportation/storage.

In addition the specification[16] makes it clear that pipework should be protected by caps to protect against dirt, rodents, frost and other inadvertent damage or consequences.

Supervisors report number 26, May 2013

4.3.5 Pipework

[13] HSE HSG 274 Part 2, paragraph 23
[14] SHTM 04-01 Part A, paragraph 8.6
[15] SHTM 04-01 Part E, paragraph 3.18, note
[16] ZBP/TUV SUD ZBP-XX-XX-SP-520-307

Installation of hot, cold, heating, & chilled water pipework in the A&C hospital is progressing and in general is being installed to a good standard. Some systems are undergoing chemical clean prior to testing. We have witnessed water tests for the chilled beam chilled water and heating pipework and results were acceptable.

It should be noted that during the course of the investigation the Contractor was asked[17]: - "once a system was chemically cleaned how was it left – i.e. purged with air or filled with water?

The contractor response was "*None of the domestic water services were chemically cleaned only closed systems such as Low Temperature Hot Water and Chilled Water and in these instances system were flushed, chemically cleaned, flushed again before corrosion inhibitor added*."

Supervisors report number 35 March 2014

4.3.5 Pipework

"Following a visit to site we raised our concerns that there are some locations where there is insufficient space for maintainable, replacement building services and plant as per the Employers Requirement Section 5.13 Facilities Management."

and

Level 3 / Zone H. Pipe Racks in area shown below have multiple levels of pipe work. We have asked Brookfield to confirm that future access will be available. Brookfield confirmed that access to the 3 areas identified will be accessible for FM in compliance with ER Section 5.13. The access arrangements for this item will be recorded as part of the Access Strategy Tracker which is currently being developed by Brookfield and

Mercury. (See Supervisor's Communication General Matters /Other Instructions (CI 13.1) No 126).

We asked Brookfield to confirm that future access will be available to pipework on Level 3 / Zone H and Level 2 Zone K. Brookfield confirmed that access to the areas identified will be by an adapted MEWP 540x 540. This has been recorded on their Access Strategy Tracker. Supervisor's Communication General Matters / Other Instructions (CI 13.1) No 126 is closed out.

[17] Email NHSGGC to HFS 3rd May 2018 "Queries regarding - Calibration certs, system cleaning, pipework storage"

And

Over the past few weeks there have been failures of crimped joints on Level 1 Area 1-533 and Level 0 Area 0-531. We have asked Brookfield to confirm if they propose to carry out a percentage quality inspection of the crimped joints to identify if it is operative error. Supervisor's Communication General Matters / Other Instructions (Cl 13.1) No 202.

It should be noted that the "MAJOR PLANT AND EQUIPMENT REPLACEMENT STRATEGY[18]" within ZUTEC does not include reference to any pipe work access strategy. This document primarily deals with major plant replacement and access strategy. It is therefore unclear how pipe work would be replaced without major disruption to the hospital.

Supervisors report 36 April 2014

4.3.5 Pipework

"Open unprotected ends are being monitored during our site inspections and there has been a marked improvement in all areas."

Supervisors report 39 July 2014

4.3.5 Pipework

Installation of hot, cold, heating & chilled water pipework in the A&C Hospital and

Children's Hospital is well in advance in all plantrooms and in general is being installed to a good standard which we are continuing to monitor. The DHWS and CW are being installed to a good standard with 2nd fix still to be completed. There is no water being discharged from the outlets at present.

Supervisors report 40 August 2014

4.3.5 Pipework

Installation of hot, cold, heating & chilled water pipework in the A&C Hospital is well in advance in all plantrooms and in general is being installed to a good standard which we are continuing to monitor. The DHWS and CW are being installed to a good

[18] ZDP MAJOR PLANT AND EQUIPMENT REPLACEMENT STRATEGY ZBP-XX-XX-DC-600-501 Rev 8 March 2014

standard with 2nd fix still to be completed. We are aware that water supplied topipework within the podium.

It should be noted that the pipe work has water present in advance of the water commissioning in November 2014. Supervisor's reports 41, 42 43 and 44 are identical with respect to the text noted above.

Supervisors report number 43 November 2014

3.2 Witness Testing and Commissioning

We witnessed a number of tests during November which were satisfactory and these were as follows:

....

(296) DHW systems in PR22 PU 103 / 104.

(323) LTHW and CW water treatment tests.

(324) Witnessing of sterilised outlets and tank inspection in Basement, and

Levels 0, 1 & 2.

4.3.5 Mechanical Services

Installation of hot, cold, heating & chilled water pipework in the A&C Hospital is well in advance in all plantrooms and in general is being installed to a good standard which we are continuing to monitor. The DHWS and CW are being installed to a good standard with 2nd fix still to be completed. We are aware that water is now being supplied to pipework within the podium.

This text indicates that water was being supplied to a partially complete system.

It should be noted that at no time in the descriptions of the supervisor's reports are specific standards, specifications or guidance cross referenced for compliance (other than to note the systems are compliant). The terms "in general terms" and "a good standard" are quoted in the Supervisor's reports, but this is subjective and is not quality related.

There is a consistent reporting of open-ended pipe throughout the supervisors reports examined and noted above. There is no evidence that the open-ended pipes were rejected or subject to any additional checks or cleaning measures. The open-ended pipes did not comply with the requirements of the specification[19], SHTM 04-01 or the various other guidance documents referenced.

[19] ZBP/TUV SUD Specification Common Mechanical Clauses ZBP-XX-XX-SP-520-307

Building Management System

As part of the design[20] a Building Management System (BMS) was designed, installed and commissioned. This system comprises of a network of sensors, controllers, meters, interfaces and a graphical interface to allow NHS GGC to monitor the plant condition, various water temperatures, energy readings and alarm conditions.

It is noted that the specification calls for a server to be provided, the storage of which was to be sized to accommodate (amongst other things) access of system archive information for a period of 53 weeks on a rolling basis. It is further noted that the storage should have been a Redundant Array of Independent Disks (RAID) configuration with automatic redundancy. A RAID is a data storage technology that combines multiple physical discs drive components into one or more logical components to improve data security and performance. A RAID server has not been supplied under the contract and NHS GGC is not aware of any specification change regarding this.

The contractor who was selected to carry out these works under the contract was Schneider Ltd and they have been retained by NHS GGC to carry out the maintenance of the system as well as any operational adjustments required.

Schneider Ltd utilise a “cloud” based data system for their solution

- At the early part of 2018 NHSGGC were advised by Schneider that the site database was “lost” as well as historical data relating to various trend logs pertaining to energy and temperature monitoring (for QEUH, RCH and the Energy Centre). At the time of writing (July 2018) the historical data has still not been recovered by Schneider; any data pre-dating this is not recoverable due to extended trend logging criteria not being enabled on the standard

BMS configuration

Schneider are currently modifying the extended logging criteria to resolve this issue moving forward but to confirm the historic data is **NOT** recoverable before 1st January 2018.

It is noted that there is no record available of the training (off site and on site) required by the specification to NHS GGC staff.

It is also noted that NHS GGC do not have a process in place for addressing any of the alarms which are generated by the BMS.

Flexible hoses

Flexible hoses are used to connect items of equipment which are required to change height (i.e. rise and fall sinks, specialist bathing equipment, etc) or equipment which vibrates (i.e. pumps, motors, etc).

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[20] TUV SUD Specification for Building Management Systems and Automatic Controls Rev F March 2014. Document ref: ZBP-XX-XX-SP-660-401

These hoses have been installed in potential contravention to Safety Action Notice SAN(SC)09/03[21] *"Flexible water supply hoses: risk of harmful micro organisms"*. The independent contractor and the Authorising Engineer have expressed concern in their reports regarding the type of hoses that have been installed.

HSG 274 Part 2 (2014) notes:

2.35 In buildings where there are those with an increased susceptibility to infection or with processes requiring specific water characteristics, materials of an enhanced quality may be required. Healthcare buildings and care homes should specifically take note of alerts and advice from the Department of Health and Health Facilities Scotland. For example, healthcare premises are advised against the use of ethylene propylene diene monomer (EPDM) lined flexible hoses (tails) as these have been shown to be a risk of microbial colonisation. Such flexible connections should therefore only be used in healthcare premises where an installation has to move during operation or is subject to vibration.

The designers, TUV SUD, have stated in their "Specification Hot and Cold Water Systems[22]" and section "Flexible Supply Hoses for Final Connections" on page 10 that no flexible hoses (or tails) connections shall be used. This is also highlighted in Volume 2 of NHS GGC's Invitation to Participate in Competitive Dialogue document.

It is noted in the "2010 Instruction to Proceed Log-FINAL"[23] agreement was made to prohibit the use of flexible hose connections by all parties.

It would appear that the Contractor installed flexible hoses in rise and fall sinks and baths or the connection to certain items of equipment. The contractor has advised that all the hoses installed are Water Regulations Advisory Scheme Approved (WRAS) approved, however that does not mean that they are acceptable in the context of the healthcare environment and specifically SAN (SC) 09/03. If the hoses contain EPDM (ethylene propylene diene monomer) there is the possibility that pseudomonas and legionella bacteria may exist. The SAN notes that these hoses should be risk assessed and should be changed to a suitable alternative to EPDM as well as being WRAS approved.

Where installed these hoses should be part of the planned maintenance and replacement procedures.

Outlets

The Mechanical and Electrical Services designer did not specify the type of tap to be installed. Their specification[24] refers to the Architect's schedules. The room datasheets compiled by the Architect detail the requirements for each room. An example of this is shown in Appendix 2. The Architect has noted the guidance

[21] Safety Action Notice SAN(SC)09/03 "Flexible water supply hoses: risk of harmful micro organisms"
[22] TUV SUD Specification Hot and Cold Water Systems Rev C April 2014. Document ref: ZBP-XX-XX-SP-500-103
[23] Extract from NHS GGC 2010 Instruction to Proceed Log - FINAL
[24] TUV SUD Specification ZBP-XX-XX-SP-500-103

document the sanitary ware should comply with, but not the actual manufacturer. This is also reflected in the layout drawings.

There are no records to confirm the TMT and TMV associated with the outlets were initially commissioned satisfactorily or that the adjustments required for in-service tests at 6/8 weeks and 12/15 weeks have been carried out.

Dust during construction

The Control of Substances Hazardous to Health Regulations 2002 (COSHH) gives advice on precautions which may be required or prevent exposure to dust (amongst other things).

Dust will be a 'substance hazardous to health' for the purposes of COSHH if it is a substance:

- Which is listed in Table 3.2 of part 3 of Annex VI of the CLP Regulation[25]; and
- For which an indication of danger specified for the substance is very toxic, toxic, harmful, corrosive or irritant; or
- If it is a substance to which a workplace exposure limit (WEL) applies.

If not falling within any of the above categories, paragraph (d) of the definition of 'substance hazardous to health' in regulation 2 of COSHH states that any dust when present in the workplace at a concentration in air equal to or greater than 10 mg/m^3 of inhalable dust or 4 mg/m^3 of respirable (as a time-weighted average over an 8-hour period) is considered to be a substance hazardous to health.

If the dust falls within the definition of 'substance hazardous to health' then the requirements of COSHH will apply, including the need to assess the risk to workers and to ensure exposure is prevented or adequately controlled.

The dust measurements taken by the Contractor did not consider the dust expressed as a weight per volume, but rather the percentage coverage of a "DustDisc" sample and the results expressed as Absolute Area Coverage (AAC) and Effective Area Coverage (EAC). These can be combined to indicate possible annoyance caused by dust deposition. There are no formal limits for dust annoyance published.

There was only one monitoring point on the QEUH/RHC building[26]. This is known as point 6 and is where the higher levels were recorded.

The risk assessments made available for this report all note the risk as very low.

[25] The Classification, Labelling and Packaging of Chemicals Regulations 2015
[26] Appendix 2 Image 16

Previously suggested EAC% assessment criteria are as follows:

EAC% per day	Outcome
0.2	Noticeable
0.5	Possible complaints
0.7	Objectionable
2.0	Probable complaints
A5.0	Serious complaints

Table 3.1 EAC percentage assessment criteria

It is noted that some results are tending towards EAC % of 0.7 (objectionable) on particular days.

It was advised during the compilation of this report that there was anecdotal evidence of complaints regarding the levels of dust prior to and post handover of the facility, but no written evidence was available.

It should be noted that NHS GGC are cleaning the chilled beam system within the campus between once and twice a year due to dust accumulation. The manufacturer recommendation for cleaning the chilled beams is noted in ZUTEC as five years. Additionaly it has been reported, particularly in Wards 2A and 2B that there appears to be intermittent condensate dripping from the chilled beams to the floor.

In addition, although there is no empirical evidence regarding particulate, certain buildings were demolished during the construction period of the QEUH and RCH. The demolition of older buildings can release fungal spores (including *aspergillus*) and it should be noted that the water samples from 2018 record high levels of fungi across all areas sampled including the main water tanks. There is no evidence that any tests were carried out for *aspergillus* or fungi as a result of any demolitions in the vicinity of QEUH and RCH.

4. Commissioning of Water Systems

Scottish Water

The incoming water supply for the QEUH and RCH together with the existing supply to the site was tested by Scottish Water on 20th February 2012 and was reported as bacteriologically satisfactory. Heterotrophic colony counts at 22°C and 37°C were reported as <1 CFU/ml for both locations.

Scottish Water also provided water quality data for their distribution network point (Milngavie) from 2014 to 2015 and show results taken from a selection of mains points and customers outlets and are all within Scottish Water's operating limits.

It should be noted that Scottish water tests are for potable water quality criteria and do not monitor for Legionella, Pseudomonas or Gram negative organisms.

Standards

The main industry standards applicable to the commissioning of the water services and as noted in the specification[27] are:

- SHTM 04-01
- CIBSE Guide W (2010)
- BS EN 806 Specifications for installations inside buildings conveying water for human consumption
- BS 6700 Design, installation, testing and maintenance of services supplying water for domestic use within buildings and their curtilages.
- BS 8558 Guide to the design, installation, testing and maintenance of services supplying water for domestic use within buildings and their curtilages - Complementary guidance to BS EN 806.

Disinfectant used and effectiveness

As part of the commissioning process, the contractor used a water treatment disinfection product known as Sanosil[28] to disinfect the hot and cold water pipes. Sanosil is a patented formula made from a unique blend of hydrogen peroxide and silver. It is widely used for surface disinfection and water treatment and the product used by the Contractor was "Sanosil Super 25.

The manufacturer notes that the product has "low corrosivity – protects pipe work" and is approved under Regulation 31 of the Water Supply (Water Quality) Regulations 2000. It should be also noted that Sanosil Super 25 also is approved under regulation 27(4)(a) of the water Supply (Water Quality)(Scotland) Regulations 2001.

[27] ZBP/TUV SUD ZBP-XX-XX-SP-520-307
[28] www.sanosil.co.uk

Within this product the active substance is hydrogen peroxide. The manufacturer recommends[29] the following for cleaning and disinfecting of pipes:

- 500mg/l (equivalent to 500ppm) for smooth pipe surfaces (PVC or metal), with a contact time of between 6 and 12 hours.
- 1000 ml/m^3 (equivalent to 0.1% or 1000ppm) for pipeline and tank disinfection (shock disinfection). The manufacturer also suggests 10% concentration to combat mould (mycelium), bacteria, yeasts and fungi and a 6% concentration where there is a high degree of contamination.[30] The contact times for these concentrations are between 12 and 24 hours.

The manufacturer of Sanosil is not aware of any issues with compatibility of "at use concentrations" of Sanosil with Brass or Neoprene[31].

In the Health and Safety Executive's (HSE) guidance document HSG 274 part 2[32] (2014) it is noted that "Silver stabilised hydrogen peroxide has a history of use in the control of legionella in water systems. A silver hydrogen peroxide solution is injected directly into the water system and if applied and maintained according to the manufacturers' instructions, can be an effective means of control. However, this should not be used in water systems supplying dialysis units." (It should be noted that the dialysis unit was not operational at the time of commissioning).

The concentration of Sanosil used (150 ppm) seems have been agreed by the Contractor and the manufacturer of the Mains Filtration plant as this is noted in the risk assessment method statement Sterilisation of Water Services/DHW/TMV Temp Checks[33]. There is no record of dialogue between the Contractor any other equipment manufacturer. It is also noted that the main 0.2 micron protection filters were not in place at the time the Sanosil was used, which may have caused micro-organisms to enter the system.

There appears to be a discrepancy with the recommended concentrations of the solutions from the manufacturer and their main supplier in Scotland (Water Treatment Scotland) which may have led to the 150ppm dosage. The manufacturers recommended dosage is as noted above (500ppm to 1000ppm); however the agent's recommendation is 150ppm[34].

Impact of chemicals on pipe work

Published independent and academic studies researched during the course of this report did not highlight any major detrimental impact from hydrogen peroxide on 316 stainless steel, gaskets or sanitary ware components at the concentrations or pH

[29] https://www.sanosil.com/en/produkte/sanosil-super-25-2/ Disinfection of drinking water
[30] https://www.sanosil.com/en/produkte/sanosil-super-25-2/ Manual
[31] Email correspondence from Water Treatment Products to HFS 9th May 2018
[32] HSG 274 Legionnaires' disease Part 2: The control of legionella bacteria in hot and cold water systems.
[33] Document 0037-MS-MER-GB10008-186 REV02
[34] http://www.watertreatmentproducts.co.uk/pdf/Sanosil_MS_Sterilisation.pdf

noted. The only exception to this are the comments made by Horne Engineering and Armitage Shanks/Ideal standard regarding their taps noted later in this report.

If the contact time is prolonged and the pH of hydrogen peroxide is increased to pH10 there is evidence of pitting of the surface of the steel and rubber gaskets.

The manufacturers of the taps have noted the impact of various chemicals on their products and this is discussed elsewhere in this report.

Results

The information noted below is located in ZUTEC under “Operation and Maintenance Information – Mechanical-Water Services” and ” Operation and Maintenance Information – Water Services-Above Ground Drainage - Test and Commissioning”

The above ground drainage stacks have been tested, however the testing standard is not quoted and the test gauge model and calibration certificate are marked as “N/A”. It is noted elsewhere that a “water gauge was used – no calibration certificate”.

The following are records from ZUTEC detailing some of the commissioning results from specific areas or plant rooms.

Basement Water Services

It is noted that only one calibration certificate is presented in ZUTEC, which is surprising given the physical size of the installation. It is also noted that the date on the calibration certificate is 20th April 2012, but the actual static tests were carried out in November 2013. One of the tests (BS03 TCWS) was carried out in May 2014 with a gauge different from the one supplied with a calibration certificate. It is therefore noted that more than one area was tested on more than one occasion using equipment with no calibration certificate.

The drawings associated with BS03 show bib taps on the roof and courtyards. These taps and associated pipe work have the potential to be classed as little used outlets and significant dead legs. NHS GGC have advised that these have been removed, but some of the associated pipe work is still in place.

There is a method statement for the “Sterilisation of Water Services/DHW/TMV Temp checks”. This notes the following parameters:-

BS 8558 (Flushing and disinfection of domestic water services)

SHTM 04-01 (Water safety for healthcare premises)

Agreed Sterilising medium: Hydrogen Peroxide (Sanosil Super 25) @: 150ppm

Acceptable parameters

- Total Coliforms 0 (zero) per 100ml
- E.coli 0 (zero) per 100ml
- TVC @37 Degrees Celsius Minimum achievable
- TVC @22 Degrees Celsius Minimum achievable

It should be noted that SHTM 04-01 part A makes reference to CIBSE commissioning guide W, which is not mentioned above.

In addition SHTM 04-01 part C details the actions to take when various concentrations of TVC are found. This is not referenced in the Contractor's documentation.

There is no record of the pre commissioning checks as noted in SHTM 04-01 Part A.

There is no record available of the analysis of the water prior to treatment as required by the specification[35].

From the information provided, it would appear that there is no record of the results for the tests noted in the either the method statement or the SHTM.

The temperatures at the outlets when the tests were taken are not recorded.

The contact time for the disinfectant chemical is noted as one hour. This is not as per the manufacturers recommendations of six to twelve hours.

The concentration of disinfectant chemical used by the contractor is equivalent to 0.015% or 150ml/m^3 and does not reflect the recommendations made by the manufacturer.

The following non-zero results (Table 4.1) are recorded for TVC on the certificates of analysis associated with the serialisation certificates for Plant room 32 (please note: TVC results of 10 and above recorded in all plant room systems. SHTM 04-01 Part C requires action to be considered for TVC counts of 10 and above).

There is evidence from the contractor that percentages of the Horne taps failed the initial disinfection tests, were disinfected and retested (a month-and-a-half) later[36] and failed the second test. There is no evidence within ZUTEC of any additional testing to resolve these failures. There is also evidence that as a result of re-disinfection, some retested outlets passed the second test (after first failure).[37]

[35] ZBP/TUV SUD ZBP-XX-XX-SP-520-307
[36] Appendix 2 Item 10
[37] Appendix 2 Item 11

Area/Sample ref	Date	TVC (2 days @ 37°C) cfu/ml	TVC (3days @ 22°C) cfu/ml
32k L9 WS9-021 MIX	22-12-14	~2000	~1400
32F L5 GENWD-065 MIX	22-12-14	Escherichia coli 5 cfu/100ml	
32f l6 genwd-029 MIX	22-12-14	~2800	~1200
		Escherichia coli 5 cfu/100ml	
32F L6 GENWD-065 MIX	22-12-14	~500	216
		Escherichia coli 5 cfu/100ml	
32F L8 GENWD-001 MIX	22-12-14	~2100	~2200
		Escherichia coli 5 cfu/100ml	
32f l9 genwd-001 mix	22-12-14	~2000	~940
		Escherichia coli 5 cfu/100ml	
32f l11 genwd-065 MIX	22-12-14	~2800	~3100
32f l7 genwd-001 mix	22-12-14	~320	~1600

Table 4.1 Extract from sterilisation results in ZUTEC

The results within ZUTEC are extremely difficult to interpret with respect to whether a retest of the outlet has been carried out and successfully passed (it would appear the majority have passed). The Contractor has changed the references of the outlets and there is no correlation of any reference changes on ZUTEC. For example 31H GENWD-028 MIX changed to zhl11t5genwo-028mws.

NHS GGC has had to carry out some considerable work to analyse this data to try and ensure that this cross referencing is valid. Notwithstanding this, the data in ZUTEC is at best difficult to reference and is incomplete as NHS GGC has had to ask the contractor for some of the results not contained within ZUTEC. Some of these “new” certificates have the same test date as the test results which show E-coli and high TVC located within ZUTEC.

It should be noted that the European Drinking Water Directive (98/83/EC), The Water Quality (Scotland) Regulations 2010 and Scottish Water By-Laws, do not permit any *E.Coli* readings at the consumers outlets. There is no evidence the E-coli was type tested.

There is no evidence to suggest that the *E.Coli* found in the water system was escalated to NHS GGC Project Team, NHS GGC Infection Control, Health Protection Scotland or any other agency. If any amount of E. coli bacteria is found in a water sample, it is an indication that human sewage or animal faeces has contaminated the water supply[38].

Although Scottish Health Technical Memorandum (SHTM) 04-01 Part B paragraph 9.1 states that routine quality control microbiological testing for TVCs is no longer considered to be necessary (other than where there are taste or odour problems), many NHS Estates personnel invariably have them undertaken on a regular basis after acceptance of installations as a 'rule of thumb' indicator by which an abnormal change assists in identifying potential problems at an early stage. SHTM 04-01 Part C provides a TVC testing protocol. There is no evidence to suggest that the actions highlighted in this document were followed.

Water management between commissioning and handover.

There is some documented evidence presented with respect to the water management of the system between the various parts of the system being commissioned by the contractor and NHS GGC taking over the system. The contractor advised in a response to NHSGGC[39] that "*Water Management is the term we use for the process of managing the water system after disinfection leading up to handover to ensure the water is not left stagnant in the system for long periods of time. Typically this would involve flushing water through tap outlets regularly.*" NHS GGC has obtained[40] a sampling methodology from the Contractor together with a sample recording sheet. Neither of these is contained within ZUTEC.

HSG 274 Part 2 (2014) notes

2.45 If water turnover is anticipated to be low initially, it may be advisable not to commission certain parts of the system, such as cold water storage tanks, until the building is ready for occupation. This will ensure flushing during low use periods will draw directly on the mains supply rather than intermediate storage. The manufacturer of any component to be bypassed should be consulted for any requirements, such as whether it needs to be filled or can remain empty until it is brought into use.

2.47 If there is a prolonged period between pressure testing using water and full occupation of the development, a procedure should be adopted to maintain water quality in the system. Weekly flushing should be implemented to reduce stagnation and the potential for microbial growth, keep temperatures below 20 °C and to ensure residual chemical treatment levels eg. the low level of chlorine in the incoming water supply, is maintained throughout the system.

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[38] MyGov.Scot
[39] NHS GGC email 14 05 18
[40] NHS GGC email 19 07 18

2.48 In large systems, where a long period of time from filling to occupation cannot be avoided, continuous dosing with an appropriate concentration of biocide as soon as the system is wetted, combined with regular flushing at all outlets can control the accumulation of biofilm more effectively than flushing and temperature control alone. While other disinfection methods could be used, maintaining 1–3 mg/l of chlorine dioxide is generally effective, however dosing at such high levels may reduce the life of the system pipe work and components. This initial high level disinfection should not be confused with ongoing dosing at lower levels in operational systems where the water is intended for human consumption. National conditions of use require that the combined concentration of chlorine dioxide, chlorite and chlorate in the water entering supply do not exceed 0.5 mg/l as chlorine dioxide.

5. Handover

Professional accountability[41]

Team	Role	Name	Handover responsibilities
Contractor	Main contractor	Brookfield Multiplex	To provide a zero defects, fully commissioned building to relevant standards To provide certification of tests and inspections (To provide plumbers for continuation of flushing regime - 6 weeks)
	M&E subcontractor	Mercury Engineering	N/a - contract was with Brookfield
	Architect	Nightingale Associates (now IBI)	N/a - contract was with Brookfield
	M&E services engineer	TUV SUD (Wallace Whittle)	N/a - contract was with Brookfield
	Water Services Commissioning	H&V Commissioning	N/a - contract was with Brookfield
	CDM	Brookfield Multiplex Health & Safety Team	Brookfield internal arrangement
	ZUTEC collation	Zutec Brookfield All sub-contractors Capita	To assist contractor/sub contractors to upload all certification and PPM information (Allowance of 60 days post handover to complete certification upload)
NHS GGC	Project Supervisor	Capita	(extract[42]) • Carry out test and inspections • Assist NHS Named Project

[41] Provided by NHS GGC
[42] Pages from NSGH Supervisor Brief Final

Team	Role	Name	Handover responsibilities
			Manager • Be central liaison between Contractor and NHS re defects/incorrect works/quality issues/outstanding items • To agree timescales for completion of outstanding works
	Mechanical & Electrical advisor	Capita (review of RDD drawings TUV SUD (Wallace Whittle) – pre construction, specialist input during design development (prior to ZBP going into liquidation)	As above None as contract was with Brookfield
	Architectural advisor	HLM (pre-construction only)	No input - commission was pre-construction as design developed through User Group meetings between NHS and Contractor
	Construction (Design and Management) Regulations 2007 (CDM)	URS (now Aecom)	To check the (CDM) H&S File is complete (noting allowance of 60 days post handover for doc upload)
	Independent commissioning		NHS GGC gave instruction to omit this service[43]. The detail of the omission of the Independent Commissioning Engineer is given here[44]

[43] Removal of Commissioning Engineer instruction #2073
[44] Pages from NSGACL - ITPD Volume 2_iss1_rev1

Team	Role	Name	Handover responsibilities
		NHS GGC Estates	• Obtain Legionella Risk Assessment • Water quality manager programme • Fire tests • To provide Access Cards to NHS contractors • To agree RAMS[45] for NHS Contractors • Hydropool maintenance, monitoring & equipment • NHS water testing and commissioning
		NHS GGC Infection control	Pre-handover - to witness the flushing and sterilisation of water system and to undertake 4 weeks of testing. Advise if any issues
		NHS GGC Public Health	No input re water
		NHS GGC Decontamination Engineering Team	Scope Decontamination Commissioning Induct contractors Install washers and dryers Water quality manager programme

Table 5.1 Roles and responsibilities at handover

The role of the Independent Commissioning Engineer (ICE) differs from that of a commissioning manager in that the ICE would normally incorporate a review of the design, and suitability of systems to be practically commissioned. In addition it is normal that the ICE would ensure compliance with the requirements of the ER, specifications, guidance and codes of practice as well as witnessing commissioning activities and certifying documentation. From the above table it is noted that NHS GGC relinquished governance of the testing and commissioning of all systems (not

[45] Risk Assessments and Method Statements (RAMS)

just water) to the Contractor and the independent third party check on the commissioning was lost as a result.

NHS GGC infection Control

There is no documented evidence of NHS GGC Infection Control being involved in the handover process of the project. However The NHS GGC Infection Control lead at the time has provided a statement[46] to confirm that he was involved in reviewing the water testing methodology and the results for QEUH and RHC during commissioning and handover. It should be noted that this at variance from the table of responsibilities noted above.

ZUTEC

The project data management system, ZUTEC[47], should be a repository for all design and construction information for the Queen Elizabeth University Hospital (QEUH) and any other projects which are recorded there. Access is by registration and is password protected per user.

There appears to be different access levels and it is recommended that all NHS GGC Estates staff that have access to ZUTEC have the appropriate level of visibility to folders, especially the data relating to maintenance instructions.

There is no reference to any recognised industry standard for the production or content of the project data management system as an operating and maintenance manual i.e.

BS EN 82079-1:2012. Preparation of instructions for use. Structuring, content and presentation. General principles and detailed requirements

CIBSE Guide M. Maintenance Engineering and Management

BSRIA BG 1/2007. Handover, O&M Manuals, and Project Feedback. A toolkit for designers and contractors.

On interrogation of ZUTEC and in particular the sections under Adult and Children Hospital; General Project Information A&C; the information relating to the following are all empty (see Appendix 2[48]):

- Building description
- Public and Local Authority Consents
- QA/QC
- Schedule of Guarantees and Warranties
- Residual Hazards
- Statutory Requirements
- Employers Requirements

[46] Statement from Professor Craig Williams 15th June 2018
[47] https://www.zutec.com/site/
[48] Appendix 2 Item 12

- Principals of Design
- Compliance Documentation
- Third Party Approvals

The Health and Safety File, required under the Construction (Design and Management) Regulations 2007 (CDM 2007), which was current at the time of the project, is located within ZUTEC in a separate electronic folder titled “Health and Safety File A&C”. This should contain information relating to the project which is likely to be needed during any subsequent construction work to ensure the health and safety of any person. The Health and Safety File should not generally contain design information, although it is noted that there are planning documents and design statements included within this section of the ZUTEC information. The CDM files contained within ZUTEC have only been considered with regard to the water incident.

Within the section for residual risk under Building Services Engineer there is no risk noted for water (residual risks noted for working at height, high voltage cabling, the major plant replacement strategy and the dangers of electric shock).

The section “Access and Maintenance Strategies” only deals with access to the roof and its maintenance. It does not address the maintenance access required for isolating water service behind panels, ceiling voids or plant rooms.

Within the “Health and Safety File” section under Project Development and description there is a document titled “Design Strategy Final”. This notes that:

Quantities of clinical handwash basins complies with HFN30 (one per single bedroom, two per four-bed bay, one per critical care bedroom, one per consult exam).

Procedure rooms as a rule have, as a minimum, a clinical handwash basin, or- where appropriate a scrub trough

Clinical wash basins are equipped with thermostatically controlled, single lever action taps; spray taps are not to be used.

Within the “Health and Safety File” section under Design Description there is a document titled “WW Design Description A&C” (WW refers to TUV SUD Wallace Whittle who were the M&E designers for the project). This notes that:

Domestic Cold Water System Wholesome cold water is derived from two separate incoming water main supplies entering the basement tank room. Each supply is capable of isolation by valves within the building. A water meter is incorporated on each supply within the tank room with direct reading and a BMS interface.

From the bulk storage tanks, the wholesome boosted cold-water service is routed via the main distribution routes to roof plant level and vertical risers to feed the various departments.

In the plant rooms, the wholesome boosted cold water service feeds un-vented HWS plant, and a number of direct connections to demand points within the building, including system pressurisation units, and dedicated water service systems storage tanks, via type AB air gaps for prevention of cross contamination.

Air gaps are required by the Scottish Water Byelaws[49] in water tanks to prevent backflow. There are five fluid categories, with fluid category 5 being the most onerous (includes water containing pathogens, human waste, etc). The type AB air gap is one where a physical air gap is maintained between the lowest water inlet point and the highest level of the water in the tank at overflow.

It should be noted that there is no mention of taps or any sanitary ware in the aforementioned documentation.

Also within the "Health and Safety File" section under Residual Risks there is a document titled "WW Residual Risks A&C". There are no risk assessments contained within this document, merely statements and there is no noted residual risk of the water systems.

Within the "Client Training and Familiarisation" section under Mechanical Services Training there are two documents associated with "Water Services". One is a PowerPoint presentation and the second is a register of attendance for the water services training. Within the PowerPoint presentation it is noted that there are temperature controlled dump valves installed throughout the installation. The detailed specification of the water tanks is not part of this presentation, therefore clarity is required on the type of tank lid support. There is a basic schematic within the PowerPoint presentation showing the non-domestic water system and associated cold water feed, strainers, valves and expansion vessels.

It is noted that there are several entries contained within ZUTEC which appear not to have reached final approval stage and are still reviewed with comments status[50].

Training at handover

The only evidence of formal training on the water system by the Contractor to NHS GGC is recorded in ZUTEC as follows:

Domestic and Trade water systems 24th November 2014. Attended by eleven NHS GGC employees.

MTHW and LTHW Detailed training – systems & Equipment 16th December 2014. Attended by twelve NHS GGC employees.

Each training session comprised of a presentation on each system, detailing incoming services, risers, distribution pipe work and equipment. From the documentation contained within ZUTEC there does not appear to have been a practical element to the training on any of the water systems or associated equipment. There is no mention of system sterilisation/disinfection or water management and the risk of legionella or other pathogens.

The specification[51] calls for the sub-contractor to "provide instruction to the clients engineers and maintenance staff in the safe operation of all systems and items of

[49] Scottish Water byelaws
[50] Appendix 2 Item 44

equipment for an adequate and reasonable period of time based on the manufactures' recommendations and best practice". There is no evidence that this happened.

In the Building Management System (BMS) Specification[52], there is a significant amount of on-site and offsite training specified. There is no record of this being provided and NHS GGC has confirmed that system familiarisation only was provided on site. NHS GGC confirmed they arranged additional training for the KNK (Konnex) data bus system as part of their maintenance contract with the supplier.

Horne Engineering has advised in their email of 4th May 2018[53] that "*With regards to training we have made multiple offers of training for both Estates/FM and clinical staff users (see attached example). Maintenance Training was also offered as a specified item on our quotation for the project. Our Applications Engineer who is our principal provider of maintenance training is currently off work but he has advised me that a training event was organised which he attended but unfortunately no Estates personnel appeared and the session was abandoned*".

Initial Risk Assessment

DMA produced an initial Legionella Risk Assessment on 29th April 2015.

DMA noted several points which required to be actioned and some of these are noted as follows (extracts from Executive Summary):

DMA were advised the NHS sampling programme has highlighted a number out of specification Legionella and Potable results and a responsive programme of daily flushing and local disinfections was underway in affected areas. Neither the actual microbiological results returned after sampling nor the method statement for disinfections was not submitted for comment or review by DMA.
At time of assessment there was no formal management structure, written scheme or communication protocols and there were significant communication issues between parties involved
It should be noted that there is no separate dedicated supply to the Renal (or other medical) systems, with all being fed from the Bulk Water system. This means that system disinfections will require to be very carefully scheduled or carried out locally as the disinfection procedure/chemical may interfere with the renal/medical systems and impact on patient welfare.
There are various issues with the calorifiers including temperatures being low due to a heating failure on 21st April, individual calorifiers running at lower temperatures than the linked vessels and returns not achieving the design temperatures of 55°C.
The cold water temperatures recorded by DMA vary considerably with

[51] ZBP/TUV SUD ZBP-XX-XX-SP-520-307
[52] ZBP/TUV SUD ZBP-XX-XX-SP-660-401_F
[53] Horne Engineering Ltd Email 4th May 2018

the majority being more than 5°C higher than those recorded at the water tanks and with peak temperatures of 30°C being noted. Additional control measure such as flushing, disinfections and background dosing flushing should be implemented until such times as the area/department fully occupied, storage and distribution temperatures and microbiological results are consistently satisfactory.
There are various other risk systems fitted throughout the hospital building including Hydrotherapy Pool, Arjo Baths, Dental equipment, Emergency showers, Irrigation systems, Sprinkler/Wet fire fighting systems, Renal dialysis (x 2), Endoscopy Wash, Water softeners, Medical Gases/Medical Equipment (e.g. Nebulisers, incubators, etc.), Dry/Wet (Adiabatic) Cooling (e.g. MRI chillers), Closed heating systems, Closed chilled water systems, Steam Humidification, Air Conditioning

Table 5.2 Extract from DMA Executive Summary: Report April 2015

It is noted that even at this early stage DMA considered that the site should be considered for background dosing[54].

The DMA report highlights in detail various risks associated with the water system at handover, with a significant number to be dealt with either immediately, as soon as reasonably practicable or within three months. At the time of this review, no evidence was presented that the items listed had been addressed, although NHS GGC has as of July 2018 resolved the majority of the outstanding items on the three reports noted above and as a result have reduced the risks associated with the management of the water systems at QUEH and RHC. The main items to be addressed in the DMA report are noted below.

When DMA were on site on the 21st of April there was a significant drop in the temperatures of the calorifiers, which we understand was caused by a failure on the heating system. Temperatures recorded on these calorifiers on this day were 40-45°C. This represented a significant break in the control system and there were no records of any remedial or corrective actions and no records of additional control measures.
There are numerous connection points onto other “nondomestic” outlets such as renal dialysis, endoscopy wash, pressurisation units, steam humidifier units and MRI chiller cooling which are connected to the Bulk Water system. It is advised that Estates (or Brookfield/Mercury) confirm these systems have suitable backflow protection installed or if necessary suitable backflow protection fitted.
DMA have been advised by Estates there are ongoing commissioning problems on the cold water dump valve system and the system is not operating as intended. DMA have noted during site surveys there were areas with cold water temperatures in excess of 20°C and dump valves are fitted, but the valves not discharging. Corrective action should be taken and once fully operational the control set points and parameters for discharging should be referenced in site written scheme.

[54] DMA L8 Risk Assessment (pre occupancy) 29th April 2015 p18 and Appendix 2 Item 3

DMA have been advised by Mercury Engineering that the domestic hot water systems do not operate on a conventional flow and return system, with principle, sub-ordinate and tertiary loops, instead utilising a reverse return circuit. This means that there are longer “deadlegs” to the outlets than SHTM 04-01 advises. However, it was noted that hot temperatures generally rose very quickly when DMA were recording temperatures throughout the building and the flow and return circuits appear to be circulating hot water to all areas, with only a few exceptions noted.
Flexible hoses have been noted in Kitchen/Pantry areas where there are flexible connections to dishwashers (not all fitted at present), in Facilities rooms (connections to double level sinks), in Dirty Utility rooms (connections to sluice machines) with the only patient areas DMA have noted as having flexible hoses being the connection to Arjo baths (both connections to the hot/cold system and internally within the actual bath). Wherever possible DMA would recommend all flexi hoses are removed and connections hard piped. Where flexible hoses cannot be removed then replacing with alternative WRAS approved hoses with linings other than EPDM should be considered. In healthcare premises additional guidance on the replacement and use of flexible hoses is provided in the “safety action notice SAN(SC)09/03[55]”. Flexible hoses have also been noted on the boosted bulk water system on pressure reducing valves. If possible these should be hard piped (stainless steel) or WRAS approved hoses with linings other than EPDM should be considered. Should these not be available for these types of units/connections then a regular inspection and replacement schedule should be implemented for these. DMA were advised by Mercury Engineering and Estates that all materials fitted during the construction are WRAs approved and therefore do not support bacterial growth. In particular Horne TMV taps were designed specifically with Legionella and Pseudomonas control in mind. The use of EPDM flexible hoses in some areas may contradict this statement and their use should be reviewed to ensure compliance.
The steam humidifiers do not appear to have been commissioned as yet (and DMA were informed by Estates these may not actually be commissioned in the immediate future) creating deadlegs on the cold system within the relevant plantrooms. It is advised that these have suitable backflow protection installed on the lines where the tee-off from the main line or are included in the site flushing regime until such times as the units are commissioned and fully operational.
General management structure in place though not specific to legionella. Formal Legionella management roles and responsibilities have yet to be documented. Documentation should also include communication routes between NHS Estates, NHS Projects and Building Contractor(s). DMA have been informed by Estates personnel there have been breakdowns in communication between Estates, Projects and Building Contractor(s) where defects highlighted by NHS Estates to other parties are being acted upon without Estates without Estates being informed to allow proper consideration of bacterial

[55] Safety Action Notice SAN(SC)09/03 “Flexible water supply hoses: risk of harmful micro organisms”

control to be made, or to review/sign off that actions have been carried out in a compliant manner minimising any potential bacterial control impacts. Examples include: • A direct and open connection installed by the Building Contractor(s) between the Hardgate Road mains supply and the PR 41/22/21 distribution pipe bypassing the filtration plant running for an unknown length of time which NHS Estates were previously unaware of. • A calorifier which appeared to have been offline for over three months being reinstated by the Building Contractor(s) with no evidence of flushing/pasteurisation/disinfection. In addition to problematic cold water temperature control (highlighted in section 7) and other mechanical concerns, a lack of defined communication between involved parties may be a contributing factor to the out of specification bacterial and legionella results recently recorded by NHS Estates.
Photographs of various installation points described in the report are highlighted in the DMA Report. Three have been extracted and are shown in Appendix [56]2.

Table 5.3 Extracts from DMA Report April 2015 highlighting risk

DMA produced a second legionella risk assessment in 2017 and this is discussed in section 6 of this document.

[56] Appendix 2 Item 4

6. Post Handover

Maintenance software

NHS GGC utilise an Estates and Facilities Management Software called Fmfirst(R)[57]. Certain maintenance tasks are written into the software database and are then allocated to staff based on the Planned Preventative Maintenance (PPM) Schedule (or planner). The NHS GGC operatives have a hand held device on which the daily tasks[58] allocated to them are loaded. The operatives can sign the work as completed on the mobile device, but any associated forms are completed manually.

It was observed that the forms are returned to the NHS GGC engineer responsible for managing the PPM, however these are left in a filing stack for the Engineer to go through and there is no formal mechanism or process in place to highlight any defects or discrepancies found by the operatives. There is the potential for items to be missed.

The PPM schedule made available, only consider critical care areas of both the RHC and QEUH, with the exception of shower heads which cover the whole hospital (except the ARJO baths, which are currently not maintained by NHS GGC Estates).

It is noted that NHS GGC are piloting a newer PPM system in other sites.

Seasonal commissioning

Seasonal commissioning involves re-commissioning heating systems in winter and mechanical ventilation and cooling systems in summer. Seasonal commissioning may also be applied to other systems, such as motorised actuators for windows and active solar-shading devices any other building services system affected by seasonal changes.

The specification calls for seasonal commissioning at QEUH and RCH to be carried out over a 24 month period. NHSGG&C has confirmed they have no records of any seasonal commissioning haven taken place.

Maintenance

The contractor has provided, within ZUTEC, comprehensive details of plant and equipment planned preventative maintenance (PPM) routines, general maintenance instructions and fault finding instructions. These PPM instructions include maintenance instructions on all pipe work and equipment associated with the hot and cold water services. It is not clear how, or if, these have been transferred to NHS GGC PPM package (FMFirst).

[57] https://fmfirst.co.uk/
[58] Typical PPM job card

The maintenance of the water systems in critical areas has been sub-contracted recently to DMA Canyon (DMA). DMA produce a record sheet (sample records from 2017 and 2018 provided) of their inspections and this includes:

- Temperatures (hot, cold, mix)
- Fails safe test
- Filter cleaning & disinfection
- Isolation valve operation
- Any issues found.

On the DMA reports inspected (snapshot in Appendix), there are issues found and reported during the maintenance[59], but no indication if they have been resolved or signed off by NHSGGC.

In house water maintenance records for certain (high risk) wards from 2016 and 2017 were provided[60]. The records for non critical care areas were not available.

The records of the shower chlorination from FMfirst are for critical areas and are from 2016 and 2017. They show the results of the chlorination of the shower heads and record the mixed water temperature and the cold water temperature. It is noted that a significant number of the cold water results show temperatures in excess of 20°C[61]. We have been advised that a program of replacing the shower hoses and shower heads in the critical care areas is about to commence, however the disinfection program for the showers will remain in the rest of the hospital.

Water Management Hierarchy

SHTM 04-01 Part B[62] identifies the Board's structure for the safe management of water systems. In addition this document gives comprehensive advice and guidance to healthcare management, design engineers, estate managers and operations managers on the legal requirements, design applications, maintenance and operation of hot and cold water supply, storage and distribution systems in all types of healthcare premises. It is equally applicable to both new and existing sites.

Section 2 covers management responsibility, section 5 covers operational management and section 6 details the hierarchy and designated staff functions.

Since handover, no formal appoint was available for any of the positions noted in Section 6 of SHTM 04-01 Part B. This has also been identified by the Authorising Engineer (Water) and independent contractor in their reports/audits which are detailed elsewhere. It is noted that the updated Written Scheme has the positions identified and as of 5th June 2018 an Authorised Person has been appointed and operatives have been trained.

[59] Appendix 2 Image 18
[60] Appendix 2 Image 19
[61] Appendix 2 Image 20
[62] SHTM 04-01 Part B Water safety for healthcare premises Part B: Operational management.

Authorising Engineer (Water)

NHS GGC has appointed Legionella Control as the company who provide the Authorising Engineer (Water) (AE (W)) duties for the whole of NHSGGC Estate. Mr Dennis Kelly is the Authorising Engineer who represents Legionella Control.

The AE (W) produced the only audit[63] of the installation in May 2017. This document is with respect to Legionella Management and Compliance Audit – Domestic Water Systems.

The audit highlights fifty six points of recommendations (there are two duplicates). In addition there is a supporting document[64] developed by NHS GGC with details of relevant dates costs associated with the various recommendations. At the time of the review there was no evidence of any of the points raised haveing been closed by NHS GGC.

Points raised by the AE (w) in the 2017 audit include (not exhaustive):-

- Ensure the new risk assessment covers all the ancillary water systems on site such as renal dialysis.
- The competency of all named, involved personnel should be reviewed at the time of the new risk assessment.
- Create an up to date set of schematics for the QEUH. Maintain these in electronic format and ensure that they can be accessed by the responsible person and any others who may need access.
- There are very few hot water temperatures measured in the records. Most of the temperatures recorded are from mixed outlets. In future temperatures need to be taken of the hot water system and not from mixed temperature outlets.
- It was noted that there is a water storage tank in a 12th floor plant room. There are no monitoring or risk reduction processes and procedures in place for this tank. The tank should be risk assessed and appropriate procedures put in place if required.
- No evidence that the risk assessment remedial actions have been completed. Once a new risk assessment has been completed a plan for addressing the remedial actions should be implemented.

NHS GGC has noted that “Initial AE audit was postponed by the AE due to site commissioning, migration and site establishment. Subsequent audit was carried out on 4th May 2017”. This is unusual as it is normal for the Board to instruct the Authorising Engineer (regardless of discipline) to carry out audits of the facility they require; the AE would not normally reject these instructions.

DMA

DMA were instructed by NHS GGC to carry out a second risk assessment[65] in September 2017.

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[63] Legionella Control AE Audit – Queen Elizabeth University Hospital – May 2017
[64] NHS GGC Action Plan - Timescales
[65] DMA L8 Risk Assessment September to October 2017.

The points raised in the Executive summary of this report are similar to those highlighted in their report of April 2015.

DMA continued to highlight that (not exhaustive)

- There were issues with the calorifier temperatures
- The expansion vessels were not of a flow through design as highlighted in SHTM 04-01 and HSG 274
- Very dirty water is being purged from calorifier drains.
- Double check valves locations could not be verified due to insulation coverage.
- NHS Estates have fitted 'Emergency Dialysis' points on cold water system since the initial installation. NHS should confirm location of all Emergency Dialysis Points and ensure System Drawings and Asset Lists are updated to reflect this.
- Cold water temperature gain was again noted.
- The thermal facility to maintain and service the Horne taps has not been completed or commissioned.
- Maintenance of TMV taps in non clinical areas not being serviced.
- DMA Gap Analysis identified gaps in the PPM program.

In the Gap Analysis, DMA note the following:-

The information gathered highlights significant gaps in the Legionella (and potentially other bacterial) control on site both in terms of management processes and the implementation of the recommended planned preventative maintenance tasks.

- The Estates Manager placed in the role of 'AP Water' has not undergone any training in Legionella control (or other bacteria) and has limited knowledge of the water systems on site and the requirements of L8, HSG 274 and SHTM 04-01.
- We would advise corrective actions are taken as a matter of immediate urgency to ensure an accurate and compliant Written Scheme is compiled and the appropriate PPM schedule implemented.
- We would describe the Legionella Management on site as being High Risk until remedial actions highlighted within the legionella risk assessment and within this Gap Analysis are implemented.

As part of the Gap Analysis DMA provided a"Summary of L8 Management Tasks Required for L8 and SHTM 04-01 Compliance". Several of the comments note that various items are not documented therefore there is no evidence to support and there is no Authorised Person training in place (at the time of the DMA reports being written).

It is noted that (as of July 2018) NHSGGC have put in significant effort to address and resolve the vast majority of the issues raised in AE (W) Audit and in the two DMA reports. NHS GGC anticipates that all matters will be addressed fully by October 2018 and have already instructed the AE (W) to conduct a new audit.

Written Scheme QEUH

A Written Scheme has been produced for QEUH dated December 2016 and is based on a DMA template. Assurance is sought that the items noted as part of the action lists is being carried out and recorded for all areas of the QEUH and RCH.
It is recognised that this written scheme is specifically oriented towards legionella, but in light of recent incidents it should consider wider organism infection.

Water tanks

The turnover of the raw water tanks has been calculated as approximately 442m^3 on average daily. This will mean that (providing the tanks are working balanced) the raw water tanks will turnover twice per day and the filter storage tanks approximately once per day. From the information provided the Hardgate Road tank is not turning over as much as the Govan Road tank. It is suggested that the tanks are checked for balancing as the water meter results show one tank turnover less the other and therefore a risk of stagnation exists.
As noted in the DMA reports various items of debris were found in the water tanks[66]. NHS GGC had all tanks cleaned in July 2018 and addition material was recovered from the tanks.

Water treatment

There has been no documented evidence provided of any system wide or area wide water treatment post handover. It is noted however that there is anecdotal evidence of targeted water treatment on certain parts of the RCH as a result of water quality issues.

Water samples

Evidence has been provided[67] of water sampling of water outlets at various times from April to December 2015 with sampling of the main raw water tanks in October 2016. The sampling was carried out by NHS GGC and processed by ALcontrol Laboratories (a United Kingdom Accreditation Service (UKAS) accredited testing facility).

There are positive results for *legionella* species (*spp*) in certain areas in April 2015. For example the spreadsheet shows 41 samples taken between the 18th and 22nd August 2015 with 15 of the samples shown as being “out of specification”. A screen shot of this spreadsheet is shown in Appendix 2 Item 6[68]**.** These show positive *legionella spp* results ranging from 20 cfu/l to 1360 cfu/l.

The results from November/December 2015 detailed as “potable” show 5 outlets out of specification from a sample of 151 and returning positive *legionella* results between 23cfu/l and 101cfu/l.

The results from November/December 2015 detailed as “Healthcare” show 124 outlets out of specification from a sample of 2392 and returning positive *legionella* results between 20 cfu/l and 4800 cfu/l. It is noted that some outlets which have positive *legionella spp* results have not been included in the overall percentage (or highlighted). These results also note TVC counts in some areas (highest 620 cfu/ml 2days at 37^{o}C and 320 cfu/ml 3 days at 22^{o}C).

From the spreadsheet provided, a typical set of results for particular tap outlets is as follows:

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[66] Appendix 2 Item 41
[67] Alcontrol 18 08 2015 samples spreadsheet
[68] Appendix 2 Item 6

Area	Area	Result cfu/l
GENW - 034 A H1	09-04-15	None detected
	10-04-15	None detected
	29-05-15	None detected
	29-05-15	40
	12-06-15	None detected
	11-09-15	1480
WSG-005 CORE A H1	18-08-15	80
	21-08-15	20
	07-05-15	120
	07-05-15	100
	08-06-15	100
	28-06-15	160
	13-07-15	80
	31-07-15	20
	31-07-15	None detected
	31-07-15	140
	31-07-15	320
	28-08-15	240
	28-08-15	640
GENW - 065 A H1		
5th floor	09-04-15	1460
9th floor	10-04-15	Not detected
5th floor	29-05-15	20
5th floor	12-06-15	20
WSG-005A H1		
11th floor	21-08-15	Not detected

Area	Area	Result cfu/l
11th floor	07-05-15	100
10th floor	07-05-15	100
11th floor	19-05-15	3280
10th floor	19-05-15	140

Table 5.4 Extracts from Alcontrol 18 08 2015 samples spreadsheet

The ward 1D of the RHC Paediatric Intensive Care Unit (PICU) test result[69] was taken on 29th September 2015 and tested on 4th October 2015. The results show the presence of *Cupriavidus pauculus* in the pre and post flush samples. The results also note positive results for *Pseudomonas spp* and *Steno Maltophilia*.

Test results for Ward 4A[70] were also provided from July and August 2017. These show initial *legionella spp* positive results post disinfection of the system. Thermal disinfection and replacement taps were undertaken to overcome the issue. All final test results for the outlets show that they passed.

The raw water tank tests in June 2016 do not show any positive *legionella spp* results.

There has been no evidence presented to advise what control measures or actions were put in place (as per SHTM 04-01 Part C) as a result of the various positive results in 2015.

Samples were taken from the water tanks in April 2018 before NHS GGC implemented a cleaning program for the water tanks as noted in the DMA reports. The results of these tests are shown on the following table.

Date	Sample location	Outlet Type	Description	Cupriavadus (CFU\100ml)	Species (isolates)	Fungi
16\4\2018	Basement Tank room	CWST	Bulk Filtrate tank 2A	0	N\A	0
16\4\2018	Basement Tank room	CWST Drain Cock	Bulk Filtrate tank 2A	0	N\A	>100 fungi saprophytic Aspergillus
16\4\2018	Basement Tank room	CWST	Bulk Filtrate tank 2b	0	N\A	0

[69] PICU Pseudomonas test results 04.10.2016 spreadsheet
[70] Latest Ward 4 A Samples Re-Tests spreadsheet

Date	Sample location	Outlet Type	Description	Cupriavadus (CFU\100ml)	Species (isolates)	Fungi
16\4\2018	Basement Tank room	CWST	Bulk Filtrate tank 1a	1	Cupriavadus pauculus	0
16\4\2018	Basement Tank room	CWST	Bulk Filtrate tank 1b	0	N\A	3 fungi Saprophytic
16\4\2018	Basement Tank room	CWST	Raw 1A	0	N\A	3 fungi Saprophytic
16\4\2018	Basement Tank room	CWST Drain Cock	Raw CWST 1A	0	N\A	>100 fungi saprophytic Aspergillus
16\4\2018	Basement Tank room	Govan Rd In-coming Mains	Raw CWST 1B	>100	environmental GNB	>100 fungi saprophytic Aspergillus
16\4\2018	Basement Tank room	CWST	Raw CWST 1B	0	N\A	5 fungi Aspergillus versicolor Saprophytic
16\4\2018	Basement Tank room	CWST Drain Cock	Raw CWST 1B	0	N\A	>100 fungi Saprophytic
16\4\2018	Basement Tank room	Hard Gate road In-coming Mains	Raw CWST 2A	0	Delftia acidovorans environmental GNB	>100 fungi Saprophytic

Date	Sample location	Outlet Type	Description	Cupriavadus (CFU\100ml)	Species (isolates)	Fungi
16\4\2018	Basement Tank room	CWST	Raw CWST 2A	6*10²	Cupriavadus pauculus, Pseudomonas xanthomonas Mexicana	4 fungi Saprophytic
16\4\2018	Basement Tank room	CWST Drain	Raw CWST 2A	0	S paucimobilis, M oxydans	>100 fungi Saprophytic
16\4\2018	Basement Tank room	CWST	Raw CWST 2B	0	no Cupriavadus	2 fungi Saprophytic
16\4\2018	Basement Tank room	CWST Drain	Raw CWST 2B	0	Delftia acidovorans	>100 fungi Saprophytic

Table 5.5 Water samples from water tanks April 2018

NHS GGC's Infection Control's interpretation[71] of the results detailed above concludes:

There are several hypothesis for these findings;

1. *Low level contamination of the incoming water supply - unlikely given we have a 0.2micron filter*
2. *Contamination at the time of construction/installation e.g. pipework*
3. *Back seeding from contaminated outlets because the outlets themselves were contaminated at installation*
4. *Back seeding from contaminated outlets from organisms found in patients via hands of healthcare workers or patients themselves*

Given the range of bacteria and fungi found 2 and/or 3 seem most likely.

[71] NHS GGC Email 25-07-18

Water coolers

Water coolers are provided under the contract at various locations throughout QEUH and RCH. The mechanical and electrical specification[72] notes:

- Water coolers, drinks and vending machines shall be supplied and installed by others.
- The Sub-contractor shall supply services to the coolers and vending machines at locations shown on drawings and agreed with the Contractor.

These units are supplied by third parties via NHS GGC Procurement and either connected on to the mains cold water system or stand alone units with water bottles. It is noted that these units are not under the control of NHS GGC Estates and therefore not part of any scheduled PPM but these units are maintained as part of the procurement contract. It is not clear which NHS GGC department has maintenance responsibilities for these water coolers.

As a result of a poor standard of microbiological quality of the water sampled for these coolers, NHS GGC Lead Infection Control Doctor produced an SBAR[73] the recommendations of which were as follows:-

- NHSGGC should apply the draft document SUP 05. Whilst only in draft form this is based on expert opinion and the advice is in keeping with policies in England.
- Water coolers already in the high risk areas listed above can remain but may be removed if deemed an infection control risk i.e. implicated in an outbreak.
- No new mains coolers should be installed in high risk areas.
- IPCT and estates should be alerted to purchases of new water coolers.
- Mains coolers should be subject to regular quarterly maintenance and weekly cleaning.
- Users should ensure that water is not consumed directly from the cooler and that drip trays are kept clean and dry on a daily basis. Water should not be allowed to pool as this will create stagnant conditions.
- Stand alone water bottle coolers should be removed .The only agreed exception should be maternity Ultrasound Scan (USS) clinics or urology clinics where patients may be required to drink water pre procedure and no mains fed cooler is in the vicinity. These coolers should be identified and a cleaning regime should be agreed with the IPCT.

The document referred to in the recommendations SUP05[74] is a “Standard Unified Procedure” which is seen as best practice (rather than guidance) and is available in draft for NHS Boards to discuss and amend as necessary to reflect their own situations.

It is noted that NHS GGC Estates proactively disconnected all the water coolers when evidence of contamination was found.

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[72] TUV SUD Specification Hot and Cold Water Systems Rev C April 2014. Document ref: ZBP-XX-XX-SP-500-103

[73] NHS GGC SBAR Water coolers 2nd March 2017

[74] SUP05 Drinking Water Procedures

It should be noted that the Department of Health (DoH) revised their guidance (Health Technical Memorandum (HTM) 04-01) in 2016 which included the following regarding water coolers et al

HTM 04-01 Part A

Vending, chilled water and ice-making machines

Note: These should not be installed in augmented care areas.

9.24.1 The design, installation, location and risk assessment of all equipment should be approved by the WSG (see also HBN 00-09 – 'Infection control in the built environment'). The risk assessment should consider:

- carbon filtration in these devices, which are a high nutrient source for bacteria;
- cleanability and maintenance of the machine.

9.25 The water supply to this equipment should be taken from a wholesome supply via a double-check valve to prevent backflow, and be upstream of a regularly used outlet with the minimum of intervening pipe-run, that is, less than 3 m. The supply should not be softened. Additionally, it should be established that the usage is sufficient to avoid deterioration in water quality, for example that the inlet water temperature does not exceed 20°C. The equipment should be positioned so that the warm air exhaust does not impinge directly on taps or hoses supplying cold water and to provide access for maintenance.

9.26 Design considerations include, for example:

- no drinking fountain or vending machine should be installed at the end of the line (potential dead-leg);
- the pipework should be as short as possible from take-off point (mains water tee);
- the cold water supply pipework should be copper and fitted with a local isolation valve and drain valve;
- the flexible pipe connector should be kept as short as possible (see paragraphs 3.39–3.41).

Note: Flexible EPDM should not be used (see Estates and Facilities Alert DH (2010) 03 – 'Flexible water supply hoses').

9.26 Reference should also be made to the Food Safety (Temperature Control) Regulations 1995 and Food Safety (General Food Hygiene) Regulations 1995.

HTM 04-01 Part B

Vending, chilled-water and ice-making machines

8.3 See paragraphs 9.24–9.27 in HTM 04- 01 Part A for guidance on installation of this equipment.

8.4 Where equipment is hand-filled, there should be clear instructions on the water used; it should be hygienically collected and decanted into the equipment from a clean vessel.

8.5 Chilled-water drinking fountains normally include a reservoir to assist in the cooling cycle; if machines are turned off, water quality can deteriorate. Provision of bottle dispensers should be approved only by the WSG. Where carbon filters and/or UV are fitted, these should be maintained as per the manufacturer's instructions. Additional cleaning to ensure adequate hygiene of nozzles etc should be put in place as recommended by the WSG.

Note: Proprietary water containers for water dispensing machines should be returned to the supplier.

8.6 Ice machines should not be placed in augmented care units. Where ice is needed for treatment purposes, it should be made using water obtained through a microbiological POU filter or boiled water in sterile ice trays or ice bags.

8.7 Ice should not be allowed to stagnate in an ice-making machine's storage bin, but should be changed frequently. Appropriate cleaning and hygienic procedures, agreed by the WSG, including the cleaning and disinfection of scoops etc should be put in place. For guidance on infection-control precautions with regard to ice-making machines, see HBN 00-09 – 'Infection control in the built environment'.

8.8 Maintenance for ice-making machines should be carried out in accordance with the manufacturer's recommendations. Care should be taken to ensure that the water supply to the ice-making machine is not subjected to heat gain.

HTM 04-01 Part C Advice for augmented care units

3.0 Protecting augmented care patients

3.1g. All other uses of water used in augmented care units should be considered and appropriate action/ changes to operational procedures taken. Uses of water to be considered include:

i. drinking water fountains;

ii. bottled water dispensers;

iii. wet shaving of patients who have a central venous catheter inserted into the jugular vein;

iv. washing patients with in-dwelling devices.

Notes:

1. *Tap water should not be used in neonatal units for the process of defrosting frozen breast milk.*
2. *Water features should not be installed in augmented care units.*
3. *Chilled water and ice-making machines should not be installed in augmented care units. Where ice is needed for treatment purposes, it should be made using water obtained through a microbiological POU filter or boiled water in sterile ice trays or ice bags.*

It should be noted that the Scottish Engineering Technology Advisory Group (SETAG) has agreed that the Water Guidance in Scotland (SHTM 04-01) should be

updated to mirror HTM 04-01 (with Scottish amendments as necessary detailed in Appendices).

Dishwashers

In a separate but related incident it was noted that certain patient groups were colonised by fungi. These fungi did not cause clinical infection. The Infection Control Doctor (ICD) had the dishwashers (amongst other areas and equipment) swabbed and tested. These were found to be positive and matched the fungi colonised on the patients.

Issues were noted with cleaning practices and the plumbing of the units, which were addressed. The dishwashers are currently not being used and will not be put back into service until acceptable results are achieved. The ICD has requested point of use (POU) filters on the incoming water lines to the dishwasher before re-swabbing and testing.

Water temperatures

At the early part of 2018 NHSGGC were advised by Schneider that the site database was “lost” as well as historical data relating to various trend logs pertaining to energy and temperature monitoring (for QEUH, RCH and the Energy Centre). At the time of writing (July 2018) the historical data has not been recovered by Schneider; any data pre-dating this is not recoverable due to extended trend logging criteria not being enabled on the standard BMS configuration.

Schneider are currently modifying the extended logging criteria to resolve this issue moving forward but to confirm the historic data is **NOT** recoverable before 1st January 2018.

As a result it is not possible to confirm that water temperature records for the period when NGSCCC took possession of the QEUH and RCH until January 2018.

The BMS Contractor provided snapshot logs of the hot and cold water temperatures for both the QEUH and RCH recorded between the 10th April 2018 and 15th April 2018. There is unfortunately no reference point with respect to the incoming water temperatures at the mains or tanks, however, the following are noted:

- Level 0 DMV1 to 6 and 10; constant value indicating possible faulty sensors and all above 20°C.
- Level 0 DMV7, 8, 9 and 12; constantly over 20°C

This pattern is mirrored to a greater or lesser degree in the logs for the other levels. The temperature in the cold water system rises during night hours when consumption is lower. This would suggest thermal pickup for heat sources (lighting equipment, heating pipes and low/zero ventilation) in the ceiling voids.

With respect to the hot water trend logs made available for the period noted above no sensor location information is given so it is impossible to comment on specific temperatures. There are some sensor showing constant temperatures (no

fluctuation) and these may be faulty. It is noted that the temperature fluctuates on all floors between 65°C and 52°C. It should be noted that SHM04-01 Part A notes:-

9.43 *The minimum flow temperature of water leaving the calorifier/water heater should be 60°C at all times, and 55°C at the supply to the furthermost draw-off point in the circulating system. The minimum water temperature of all return legs to the calorifier/water heater should be 50°C.*

Note 14: A minimum of 55°C may be required for the operation of suitable mixing devices required to provide 'safe' hot water at the upper limit of the recommended range.

The cold water temperature is also noted on the NHS GGC Estates Department and DMA maintenance records for the thermostatic mixing taps (TMT). It can be seen[75] that these temperatures are approaching 20°C. The significance of this temperature is it is recognised as the temperature which legionella (and other organisms) begin to multiply.

Dump valves

The Contractor has included what is commonly known as "dump valves" on the cold water system on each floor. These comprise of a solenoid valve controlled with a temperature sensor and the Building Management System (BMS). The purpose is to instigate flow in the cold water circuit if the cold water temperature exceeds 20°C as above this point legionella bacteria begin to grow. The water is literally dumped to drain.

The set point for the solenoids at QEUH and RHC is advised as opening at 23°C and closing at 20°C.

It is noted that there is no maintenance schedule for these items and there is no metering to establish the volume of water being put to drain or indeed if there are any equipment (solenoid) failures. If the sensor accuracy if +/-2°C then this may mean that the open action could be initiated as high as 25°C.

There is anecdotal evidence that these solenoids can "weep" into the drains and can be the site of bacterial growth.

HFS has been advised of several new healthcare buildings which are experiencing cold water temperatures being elevated. The main contributory factors to thermal gain in the cold water systems are:

- Proximity of other services (typically the hot water pipe work)
- Proximity of lighting control gear (particularly LED control gear).
- Lack of ventilation in ceiling voids.
- Higher than anticipated incoming water temperatures from Scottish Water.
- Over sizing of storage tanks and pipe work systems.
- Lack of flow through water pipe work (particularly at weekend and night).

[75] Appendix 2 Item 20 and item 24

- Many wash hand basins used very infrequently.

Training (specific to water systems)

Training records have been provided for eight operatives who completed a one day training course on “legionella awareness HTM 04-01” by PPL training on various dates in March 2018. It is noted that this course is not with respect to SHTM 04-01 which has some different requirements to the HTM. It is not clear how many of the operatives are employed directly at QEUH and RCH.

Horne Engineering have advised[76] that “With regards to training we have made multiple offers of training for both Estates/FM and clinical staff users. Maintenance Training was also offered as a specified item on our quotation for the project. Our Applications Engineer who is our principal provider of maintenance training is currently off work but he has advised me that a training event was organised which he attended but unfortunately no Estates personnel appeared and the session was abandoned.”

Point of Use Filters

Point of use (POU) filters were not specified as part of the project. SHTM 04-01 Part A (paragraph 5.19) provides guidance on the use of POU filters.

A POU filter is a disposable device which fits on to an existing tap or shower, which has internal membrane which acts as a barrier to material and organisms above 2μm (generally). The lifespan of the POU filter varies from manufacturer to manufacturer but is typically 31 days. The connection to the tap may be via a connector, rather than a direct fit onto the tap.

The chosen POU filter installed in the critical care areas (taps and showers) of both QEUH and RCH when NHS GGC discovered there was an issue with the water system is manufactured by PALL Medical (PALL), who presented technical and microbiological papers to support the efficacy of their filters.

The cost to NHS GGC of installing these filters is significant, as is the ongoing costs of the monthly replacement program. Some filters are being replaced every seven days as an added protection measure requested by clinicians.

The filters will not eradicate the issue but will (providing they are not dislodged) remove bacteria and fungi by acting as a barrier.

Due to the configuration of the taps[77] and sinks, with the adaptor fitted and the POU filter in place, it was reported that some clinical staff, patients and parents experienced difficulty in hand washing as the outlet of the POU filter was in close proximity to the bottom of the sink.

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[76] Email Horne Eng to HFS 4th May 2018
[77] Appendix 2 Image 32

During practical tests, it was noted that “normal” washing also caused splashing back from the sink on to the filter.

There was confusing and conflicting information provided regarding the cleaning of the filters by the manufacturer. Initially a cleaning specification was provided by PALL Medical[78] to HFS as a result of a direct question, but the NHS GGC was given the advice not to clean the filters. The latter was adopted to prevent the filters being dislodged which potentially could result in contamination.

Water tests continued once the POU were installed and all but two came back negative. The POU filters were sent back to the manufacturer for detailed analysis to determine the cause of the failure. The manufacturer’s letter[79] dated 1st May 2018 confirmed that there was no fault found in either filter, therefore any contamination would have been retrograde (i.e. contamination after the POU was fitted).

[78] PALL Medical Surface disinfection letter May 2017
[79] PALL Medical letter reference 1673-CY18-POR & 1907-CY18-POR Final Closeout Letter

7. Sanitary ware

Taps

There are two main manufacturers of thermostatic mixing taps (TMT) in both the QEUH and RCH with one main manufacturer of showers in both buildings. The first TMT and most prevalent is the manufactured by Horne Engineering and is from their "Optitherm" range. The second is Ideal Standard/Armitage Shanks TMT from their "Markwik 21" range.

The showers are mainly manufactured by Horne Engineering and from their "TSV-1" range. Other showers are integral as part of the specialist baths from Arjo Huntleigh.

In and around July 2012 the contractor proposed the Horne Optitherm tap to NHS GGC Project Team. NHSGGC produced a paper "Installation of Taps" dated 27th July 2012 as a review of the proposed taps with respect to functionality, maintenance and infection control issues. The paper also considered a benchmarking exercise with NHS Fife and NHS Lanarkshire. The summary of the paper is as follows:

TAP	INSTALLATION	POINTS TO CONSIDER
Horne Optitherm	Clinical wash hand basins Scrub sinks Pantry wash hand basin	Thermal disinfection is recommended by the manufacturer. Chemical disinfection not recommended - will degrade internal components within the tap.
Markwick Sensor Tap	Public areas ? Staff toilets & staff change	Nil noted
Armitage Shanks disabled basin tap	Patients en-suites Assisted bathrooms	'Screaming' taps following chemical disinfection. Likely to be related to manufacturing, storage or installation issues.
Need to consider the type of tap for equipment wash up sink, discard sink in clean utility, & treatment sinks in dermatology.		

Table 5.6 Tap type summary for QEUH and RCH July 2012

As part of the benchmarking it is noted from correspondence provided by NHS GGC, that the Horne tap was installed at Monklands Hospital and Vale of Leven Theatre Suite. "*Vale of Leven provided information direct from the company who have recommended thermal disinfection of the taps instead of chemical disinfection which is currently used for other taps. Monklands have reported that this has not been an issue in practice.*" Also "*Monklands did however advise that we accept the training sessions offered by the company to train staff on the use of the taps as the design is different from what we currently use*."

In August 2012, there was discussion regarding the NHS representative Currie and Brown, Brookfield and Horne Engineering regarding chemical sanitisation of the Optitherm tap. From the email correspondence referenced It is noted that the manufacturer stated in response to technical questions on the correct method of disinfection posed by NHS GGC that:

Horne have confirmed[80]*, and evidenced, that point of use filters can be fitted to the Optitherm tap and it is recommended that these are for maximum 14 day use.*

They have further confirmed that the tap can be chemically disinfected subject to the correct processes and concentration of product. Their tap has shown no greater degradation than other parts of systems where incorrect treatment has been undertaken.

In relation to the combined flow conditioner and regulator, which is not an aereator, they do not recommend its omission on a risk assessed basis

Also[81]

"There are no materials or components in any of our products which makes them peculiarly susceptible to chemical damage".

He goes on to state that in isolated cases where damage has occurred " I think that what has really happened is that chemicals which have traditionally been used in the food production process sector have been offered as pipework sanitizing chemicals but insufficient consideration has been given to the fact that the materials of which a domestic water system is typically composed are substantially different from those found in process applications."

He goes on to say:

"However I would not wish to cause any undue alarm on this point and would suggest that it is a risk easily managed and controlled once understood. Domestic pipework systems in healthcare applications are widely, if not universally, occasionally exposed to chemical

[80] Email Currie and Brown to NHS GGC 3rd August 2012
[81] Email Currie and Brown to NHS GGC 6th August 2012

disinfectants and the correct use of the appropriate chemical should pose no risk whatsoever. "

The above is different to what NHS GGC noted in the July 2012 tap type summary table and in any other correspondence which Horne Engineering has provided either verbally or in writing.

Horne Engineering has advised in correspondence to HFS that each of their products (including those provided to QEUH and RCH) is shipped with their document reference 10378, which states "*HORNE PRODUCTS MUST ONLY BE EXPOSED TO POTABLE WATER SUPPLIES. ANY EXPOSURE TO HARMFUL CHECMICALS MAY CAUSE DAMAGE AND WILL INVALIDATE THE WARRANTY*". There is no detail on what, in this context, is a "harmful chemical".

Horne Engineering has also advised that they had commissioned a report in the course of investigating product failures. They believed these failures to be a consequence of exposure to oxidising chemicals used in the course of sanitising and commissioning domestic water services. With regard to the impact that chemicals may have on lifespan of product and components it is very difficult to say since the type of chemical used, the concentration of the chemical, temperature and duration of exposure are all important factors. As a result of this report, a summary of which was made available to the contractor, Horne Engineering advise that:

"Any cleaning or sanitisation regimes that have been proven not to damage valves in the past will not damage them now. It is just that we are aware of a plethora of new chemicals that we KNOW are likely to damage our valves, and also damage other items in the domestic hot water system. We believe that anything that contains hydrogen peroxide is likely to come into that category. Thus we suspect that hydrogen peroxide, silver peroxide, peracetic acid and all derivatives of this type of product can certainly pose a risk to Horne valves. However, we have consciously decided not to recommend any one chemical treatment over another. We have experience where even chlorination can cause very similar damage if excessive concentrations are used. We do recommend thermal disinfection for our products, where appropriate, and our website has details on this."

The design of the Horne Optitherm tap is unique in the market place. There is a flow straightener included at the outlet which they advise is an integral flow regulator and a flow conditioner. The flow straightener is a device used to produce an even flow of water from the tap and reduce splashing. This is a plastic device which retains water at the mouth of the tap due to surface tension created by the lattice network of the straightener. An exploded image of this device can be seen in Appendix 2. Horne Engineering advice that this prevents contaminants from being introduced into the body of the tap.

SHTM 04-01 Part A (2014) note 15 advises *".....the type of tap should be carefully selected to minimise the formation of aerosols. The water flow profile must be compatible with the shape of the wash hand basin. Rosettes, flow straighteners and aerators have been found to be heavily colonised with biofilm but their removal can create turbulent flow at increased pressure resulting in splashing of surrounding surfaces and flooring. Current advice is that they should be removed but this should be subject to risk assessment."*

In April 2014 NHSGGC requested advice from HPS on removal of the flow straighteners. As a result HPS produced an SBAR[82] (Situation-Background-Assessment-Recommendation) which highlighted three options, namely:

1. *Instruct the contractor to install the procured taps in all clinical areas across the SGH. This would subsequently require NHS GG&C to commence a water sampling regimen to monitor for Pseudomonas in high risk units.*
2. *Instruct the contractor to install the: Procured taps in all clinical areas across the hospital excluding high risk units; andProcured taps without flow straighteners in high risk units.*
3. *Instruct the contractor to install: The procured taps in all clinical areas across the hospital excluding high risk units; and New compliant taps (without flow straighteners) in high risk units.*

The recommendation of the SBAR was as follows:

The HPS Guidance for NNUs, adult and paediatric ICUs in Scotland is designed to minimise the risk of infection with Pseudomonas aeruginosa – the risk however can never be eliminated.

Based on the above assessment and the extant national guidance on water safety and potential infection risks to patients, particularly in high risk units HPS recommend NHS GG&C to progress with option 2 or 3.

As a result of the revised Guidance noted above, NHS GGC requested a meeting to discuss the implications as the Contractor had already purchased or ordered the majority of the outlets for the project. This meeting took place on 5th June 2014 with representatives from NHSGGC, Public Health England, Golden Jubilee National Hospital, NHS Ayrshire and Arran, HPS, HFS and Horne Engineering. It was agreed that the development and the specification of the taps at the time complied with the guidance published at the time of specification and procurement. It was agreed any residual perceived or potential risks would be identified and form part of the routine maintenance.

During the early stages of the investigation (2nd March 2018 and 14th March 2018) taps and showers were sampled by NHS GGC microbiologists and an internal report[83] produced to aid the investigation. The showers and taps were dismantled under laboratory conditions to sample specific components within the outlets. These tests returned positive results for *Cupriavadis pauculus*, *Sphingimonas Paucimobilis*, *Ochrobactrum anthropi* and Bevundimonas *sp* amongst others (detail of location and species are presented in the report).

The above noted report confirms the results from the tap samples taken by NHS GGC and processed by their laboratory at Glasgow Royal Infirmary. The samples were at first only taken from RCH wards 2A and 2B, but it was decided that, in order to determine the extent of the contamination, samples were taken from all levels of

[82] HPS SPAR “Pseudomonas – Taps” April 2014
[83] REPORT on Environmental Sampling on 2A and 4B

QEUH and RHC, including the water tanks and risers. These results indicated that the majority of the water system was contaminated with various organisms and fungi.

It is noted that the laboratory struggled to cope with the volume of additional testing being requested of it and maintain business-as-usual. NHS GGC advised there was no other accredited lab available to assist with the testing.

Maintenance issues

In the ZUTEC "Manufacturers' Literature" section, the following Horne documents are located:-

- Optitherm INSTALLATION, COMMISSIONING, OPERATING AND MAINTENANCE INSTRUCTIONS
- TSV1-A108A DUAL CONTROL SHOWER PANEL
- TSV1-A108A2L DUAL CONTROL SHOWER PANEL

In the Optitherm document, the following observations are made:-

The tap operating conditions are noted as hot: 52^{o}C to 65^{o}C and cold: 5^{o}C to 20^{o}C with a minimum differential between mixed and supply temperatures of 11^{o}C (between 1 and 5 bar). Horne will not guarantee operation out with these conditions.

There is evidence that some cold water temperatures are in excess of the *20^{o}C noted above.*

There are two methods of flushing the pipe work described prior to installation of the tap. There is no evidence within the commissioning documentation contained within ZUTEC that these have been followed.

There is no evidence contained within ZUTEC that the various checks noted (flushing, hot temp, cold temp, mixed, mixed temp and cold water failure test) were carried out at commissioning. The contractor has provided a series of drawings within ZUTEC which appear to indicate various taps and outlets being checked-off as operational; but this does not replicate the manufacturers commissioning requirements. There are also blue crosses annotated on these drawings, the meaning of which is unclear (i.e. has the tap/shower failed the test?) A sample image[84] is shown in Appendix 2.

Thermal disinfection is noted as the method of disinfection for the Horne tap. It was noted that the during routine maintenance functions, the brass isolating screws of the Horne tap are being damaged when NHS GGC operative are using the manufacturer's approved tools as they are constructed of soft brass. These isolating screws are also difficult to access given their location. A series of photographs of the maintenance of the tap is shown in Appendix 2[85].

[84] Appendix 2 Item 21
[85] Appendix 2 Item 13

The flow straightener was taken apart and the components can be seen in Appendix 2[86].

The other taps installed in the project (mainly non clinical) are manufactured by Armitage Shanks/Ideal Standard.

These taps are from their Contour range. A comprehensive maintenance document is available on ZUTEC for this product. It has the same temperature operating parameters as the Horne Optitherm tap.

These taps have a flow similar flow straigtener but this tap does not retain water as the Horne Engineering tap does.

There is a comprehensive installation and commissioning process. There is no evidence that these were carried out from the ZUTEC information.

From the documentation it is recommended that these taps should be audited :

- 6 to 8 weeks and 12 to 15 weeks after commissioning
- If all OK then 6 monthly servicing cycle

There is no evidence that the above recommendations have been carried out for areas out with critical care areas.

The Contour 21 tap has two flow control devices installed (one on the TMT and one on the incoming supply to the outlet). This may increase the risk of promoting biofilm formation due to the resultant restrictions in water flow.

There is no internal means of isolating the Contour 21 tap. The isolation valve, strainers, check valve and flow regulator are located in the service void behind the IPS panel, therefore outlet isolation for servicing requires the IPS (Integrated Plumbing System) panel to be removed which can be difficult in an operational hospital. The manufacturer requires that the strainer is cleaned every six months.

It has been reported that IPS panels have caused injury to operatives as they have fallen as a result of the type of fixing employed on the panels.

It is noted that this tap meets the requirements of HBN 64 and HTM 04 as noted by the manufacturer.

HSG 274 Part 2 (2014) notes

2.34 It is important that there should be ease of access to all parts of the system, components and associated equipment for management and maintenance purposes, eg tanks, calorifiers, thermostatic mixing valves (TMVs), blending valves, circulation pumps etc. Isolation valves should be included in all locations to facilitate maintenance and the implementation of control measures. The pipework and any components should be easy to inspect so that the thermal insulation and temperature monitoring can be checked.

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[86] Appendix 2 Item 14

SHTM 04-01 Part A notes as follows:-

7.46 Strainers should be fitted within the water pipework system to protect thermostatic valves etc against ingress of particulate matter. The installation of these fittings should allow adequate access for maintenance/replacement, and they should be provided with means of upstream and downstream isolation. (see also paragraph 5.4, however) Strainers can be a source of Legionella bacteria and should be included in routine cleaning, maintenance and disinfection procedures (see Section 7, Part B).

7.47 Service isolation valves should be fitted to all pipework preceding sanitary tapware and WCs etc for servicing, repair or replacement. Drain-valve provision may also be appropriate for certain installations, for example, service pipework to en-suite facilities etc.

Recommendations (Page 12)

It is preferable that thermostatic mixing devices are fitted directly to the mixed temperature outlet, or be integral with it, and be the method of temperature and flow control.

Notes 14:

in all new installations thermostatic mixing devices shall be fitted directly to the mixed temperature outlet or be integral with it, and be the method of temperature and flow control, i.e. the mixing device should not be separate and supply water via second tap or manual mixer since there will be many cases where draw-off of cold water will not occur;

Given the lack of suitable isolation at the tap itself, this solution is operationally difficult to maintain in an operational hospital. In addition the inclusion of additional in line isolation, flow control and strainers which, due to the installation are difficult to maintain, may prove an additional risk for biofilm growth.

Warranty issues

As a result of the use of chemicals to disinfect the Horne Engineering Ltd taps rather than the manufacturers recommended thermal disinfection methods, the warranty on these taps is void. There is contradiction in the advice given previously by the contractor in August 2012 and that provided in ZUTEC and subsequently given by Horne Engineering as noted above.

Armitage Shanks/Ideal Standard do not share the same general concerns regarding chemical disinfection of their taps, providing the dosage is to the World Health Organisations (WHO) and manufacturer's recommendations. Armitage Shanks/Ideal Standard note that hydrogen peroxide (main active component of SANOSIL) is detrimental to the system and do not recommend its use[87]. Horne Engineering has also noted the detrimental impact of hydrogen peroxide.

[87] Appendix 2 Item 17

Wash hand basins

The Mechanical and Electrical Services designer did not specify the type of sink to be installed. Their specification[88] refers to the Architect's schedules. The room datasheets compiled by the Architect detail the requirements for each room. An example of this is shown in Appendix 2. The Architect has noted the guidance document the sanitary ware should comply with, but not the actual manufacturer. This is also reflected in the layout drawings.

The range of clinical and non clinical wash hand basins chosen by the contractor are manufactured by Armitage Shanks from their Contour 21[89] healthcare range. There is no facility to connect the tap on the sink as the taps are panel mounted. The drain connection is at the rear of the sink bowl and there is no overflow, all as per guidance.

The connection to the drainage pipe work from the sink is via an aluminium spigot with a silicone gasket or washer.

A clinical incident was identified around the 4th of June 2018 in wards 2A and 2B. On investigation it was noted that the sink drains had a build up of biofilm and the aluminium spigot was corroding. Images of one sample from a sink can be seen in Appendix 2[90].

It is noted that around the time of procurement and installation of the sinks in 2013/2014, the manufacturer changed the aluminium spigot to a PVC spigot. It is not known the extent of the aluminium spigots across QEUH or RHC.

Further investigation is required on this matter and NHS GGC has submitted an incident report to HFS Incident Reporting and Investigating Centre (IRIC). In addition HFS, HPS and NHS GGC are arranging discussions with Public Health England (PHE) who are currently investigating (unrelated) drainage issue in healthcare environments.

NHS GGC have analysed the material in the sink from a microbiological perspective and have identified the following organisms across a number of sinks.

[88] TUV SUD Specification ZBP-XX-XX-SP-500-103
[89] Appendix 2 Item 26
[90] Appendix 2 Item 25

Drain swabs wards 2A AND 2B RCH	
Area	**Organisms**
Consulting room 4 trough sink drain	*Enterobacter cloacae and Pseudomonas fluorescens*
Consulting room 2 sink drain	*Pseudomonas aeurginosa*
Clean prep room sink	*Pseudomonas aeurginosa and Cupriavidus pauculus*
Room 5 sink plug hole	*Enterobacter hormacechei, Sphingomonas paucimobilis and Pseudomonas fluorescens*
Rm A bathroom sink	*Acinetobacter haemolyticus and Fungi*
Rm A sink plug	*Acinetobacter haemolyticus and Fungi*
Large clean prep room sink	Klebsiella oxytoca, Cupriavidus pauculus, Enterobacter cloacae, Pseudomonas aeurginosa

Table 7.1 Summary of drain swabs for wards 2A and 2B

In addition to the above, NHS GGC has had a sample of the sink spigots as well as the flow straighteners from several taps analysed by an independent laboratory (Intertek). As a result an interim report[91] has been produced and this details some of their findings. The main points to note from this very comprehensive report are:

- From 17 of the flow straighteners tested 11 were found to have biofilm[92].
- CFU were recorded in excess of 1000 in the biofilm samples.
- CFU were estimated to be in excess of 200million per flow straightener.
- *Pseudomonas sp* and CFU were recorded in a flow straightener which was unused.
- The microbiological analysis of the spigot was similar to that observed by NHS GGC.
- Plastic film, hair and other organic matter was found to be in the drain spigot and on the spigot seal.
- The material found[93] in the water tanks indicted the presence of biofilm.

It is noted that the Contractor's as installed information relating to the drainage detail loaded into ZUTEC is actually not what has been installed. An extract from drawing

[91] Intertek Interim Report ITSS-0718-0001W
[92] Appendix 2 Item 43
[93] Appendix 2 Item 41

ZBP-XX-XX-DT-581-0061[94] shows the “as-installed information” in ZUTEC. Some of the differences observed in the installed versus the drawings are :-

- Thermostatic Mixing Valve (TMV) shown rather than the Thermostatic Mixing Tap (TMT) installed.
- Isolating/commission valves not installed.
- Traditional “U” bend shown rather than the bottle trap installed.
- The rodding access point has not been installed.
- Main access panels not practically accessible (noted in DMA reports)
- The bottom access panel is only around 200mm high which leads to the plumber having to lie on the floor in order to reach up to access the bottle trap.

NHS GGC have advised *“The DWS (Domestic Water Services) ‘as fitted’ layout drawings are generally consistent with the actual installation, however minor discrepancies have been found during various investigators pertaining to general services”.*

[94] Appendix 2 Item 29

8. Energy centre

To provide an efficient source of heating and power for QEUH, RCH and other parts of the QEUH campus a new separate Energy Centre was built to house the Combined Heat and Power Unit (CHP) and boilers.

Hot water is distributed to the building plant rooms from the energy centres via a Medium Temperature Hot Water (MTHW) heating system derived from seven MTHW dual fuel boilers and 3 gas fired CHP units. The CHP system is designed to be the lead system and provide a high portion of the campus heating requirement.

In the QEUH and RCH plant rooms there are plate heat exchangers which convert the MTHW to Domestic Hot water (DHW) and Low Temperature Hot Water (LTHW) to serve the hot water and heating circuits respectively, for the wards and ancillary spaces.

The CHP plant was not commissioned within the original project time line and was subject to contractual penalties. A summary of the current situation is as follows:

Question	NHS GGC response
Intended project completion	January 2015.
Actual project completion	January 2016. All 3 CHP units were brought on line, there was no sign off on the compliance of the CHP with the contract as Multiplex still required to prove the control strategy and energy performance, to date (July 2018) this has not been provided.
First indication not working as intended	January 2016.
Date changes made to control software	These changes have been ongoing since January 2016 under the control and instruction of Multiplex, current configuration was implemented Aug 2017 by Multiplex (not proven or signed off as working).
Have all software changes been documented	No these software changes have not been documented despite requests for this documentation and sign off by the system control philosophy changes by the design engineers. Following pressure (from NHS GGC Estates) a user guide was issued (by the Contractor) for use by the operational Estates Team.

Question	NHS GGC response
Training provided	System familiarisation training was provided on site. The offsite BMS training specified under the contract was not provided.

Table 8.1 Energy centre summary

NHS GGC have advised they have not been able to operate the plant as intended due to numerous failures of the system, which are highlighted in the following documents:-

- QEUH Energy Centre Forensic Analysis Report[95]
- QEUH Building Presentation[96]
- Comments on BMS Graphs[97]

The Contractor has indicated[98] that they and their advisors can see no consistent issues with temperatures although there may be some control issues which were instigated in 2017 and it has been these changes which have caused the potential issues with the hot water temperatures at QEUH and RCH.

Temperature issues

NHS GGC has advised that the main issue is that the MTHW flow and return temperatures are not as specified. This in turn means that on occasion that the DHW temperatures on the wards will fall[99] below the specification and parameters set out in SHTM 04-01. The DHW graph shown in appendix 2 (item 27) shows a set point of approximately 65°C however this drops off to a mean of about 60°C over a period of 43 days with minimums of approximately 53°C.

The plots for the CHP[100] show flow temperatures generally of 105°C and return of generally 70°C, however there are temperatures outside of this band which will have a negative impact (albeit for a short time) on the LPHW and DHW in QEUH and RCH.

It should be noted that there are no test or commissioning results for the water services in the Energy Centre contained in ZUTEC.

[95] Innovated Design Solutions QEUH Energy Centre Forensic Analysis Report 10th May 2018
[96] Innovated Design Solutions QEUH Building Presentation 22nd May 2018
[97] Innovated Design Solutions Comments on BMS Graphs 11th June 2018
[98] Email Multiplex to NHS GGC 16th June 2018
[99] Appendix 2 Item 27
[100] Appendix 3 Item 28

BMS issues relating to the Energy Centre

From the preliminary information available at this time, it would appear that there are several issues relating to the Building Management Software. As noted previously the BMS maintenance contractor's database was lost and to date has not been fully recovered.

The alterations made to the plant in the energy centre have not been documented; therefore it is unclear if the current control strategy has changed from the design intent.

From the various graphs and reports provided it is evident that there are some sensors which are malfunctioning.

NHS GGC does not have a process in place for BMS alarm prioritisation, reaction or resolution.

9. Potential solutions

NHS GGC has been in discussion with various specialists to consider an appropriate response to the current situation with the water system at QEUH and RCH.

Various chemical treatment solutions were researched and considered, including a new technology called CLORIOUS 2 which is a variant of chlorine dioxide, but as yet is untried in large scale healthcare environments. The chosen solution is based on Chlorine Dioxide (ClO_2)

A full analysis of various chemical treatments is given in SHTM 04-01 Part D[101].

The solution is detailed in the following NHS GGC's documents:

- Potable Water System: Proposed Sanitisation Strategy Paper (5/06/2018)[102]
- Proposed SOE for ClO2 Disinfection and Dosing (D5 180613)[103]
- Water Quality Incident Action Plan 2018 (DW 180612)[104]
- Appendix 1 Distribution Zone Map[105]
- Appendix 1A-1D Shock Dosing Schedule of Areas Affected[106]

The basis of this proposal is the installation of new Chlorine Dioxide (ClO_2) plant external to the RCH in a new purpose built housing. Pipe work will be routed from this new housing in existing ducts to various existing pipe work risers to the various plant rooms.

The ClO_2 plant requires to be procured as it is not an "off the shelf" item and therefore this will delay the implementation of the solution. This delay will however be used to carry out any enabling works, such as planning consent for the housing, surveying connection points, cleaning and disinfection of plant. There will be a total of nine dosing systems (one for the bulk storage tanks and eight others distributed through both hospitals).

The ClO_2 will be introduced to the RCH in the first instance and then to QEUH. The dosage limits will be within the World Health Organisation Guidance, EU Drinking Water Directive and Scottish Water Bylaws. The initial dosage of ClO_2 will be approximately 0.1ppm at the taps and other outlets.

Once the ClO_2 is established in the water system a shock dosing of the system using ClO_2 to assist in the removal of biofilm. The concentration of the shock dosing and contact time will depend on specialist advice as the contact time of a high concentration may have a detrimental impact on the pipe work and fittings.

After the shock treatment the residual level of ClO_2 will be reduced to 0.2ppm at the outlet to provide protection to the system.

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[101] SHTM 04-01 Part D: Disinfection of Domestic Water Systems
[102] QEUH sanitisation strategy paper 05-06-2018
[103] Proposed SOE for ClO2 Disinfection and Dosing (D5 180613)
[104] Water Quality Incident Action Plan 2018 (DW 180612)
[105] Appendix 1 Distribution Zone Map
[106] Appendix 1A-1D Shock Dosing Schedule of Areas Affected

During these works wards will have periods of time (up to 24hrs) when there is no water available through the system and a ward-by-ward contingency is required and is being developed by NHS GGC.

It may take up to two years before the ClO_2 has had a significant impact on the level of organisms within the system.

NHS GGC will put in place a testing regime to ensure the dosage of the ClO_2 is maintained to between 0.2ppm and 0.1ppm and the microbiological results are acceptable.

The current cost of the protective measures to date expended by NHS GGC is circa £500k.

The preliminary estimate cost from NHS GGC associated with the installation of the ClO_2 plant is in the region of £1.3 million including VAT (and includes pipe work modifications, POU filters, microbiological testing, review of all control and legislative documentation, etc). This excludes any whole scale replacement of taps across QEUH and RCH but includes tap replacement in critical care wards.

NHS GGC estimate the recurring cost associated with the solution circa £720k (including VAT) per annum.

Until the microbiological levels are returned to normal there will be a need to utilise point of use filters in certain high risk clinical areas such as RCH wards 2A and 2B and QEUH wards 4A and 4B. Other areas may also require POU filters, but this will be determined and advised by NHS GGC microbiologists and clinical staff.

Consideration is being given to removing the Horne Engineering taps in critical care areas as it is not possible to remove the flow regulator and the Manufacturer is not prepared to modify the design to accommodate the removal of this device as they do not share the same view on its function or role in the microbiological event surrounding this incident. This is discussed in the paper presented to the Water Group Meeting on 8th June 2018[107].

[107] QEUH High risk area TMT Review paper 05-06-2018

10. Conclusions and hypothesis

It is impossible to determine the exact cause of the various organisms and fungi which have been found to be present in the water system as both QEUH and RCH. From the information provided to both HPS and HFS the following is a plausible scenario.

- The incoming water supply from Scottish Water was not infected with any organism.
- The incoming mains pipe was identified as being contaminated with soil and debris.
- There is evidence that the water tanks were not clean at the time of handover.
- The hot and cold water system pipe work at both QEUH and RCH were contaminated during the installation process. This contamination could have come from dust and debris on the site as there is documented evidence of open ended pipes. Moisture may have entered the open-ended pipes and started to provide a basis for biofilm proliferation.
- There is evidence that flushing took place without the main water system filters in place. These filters are designed to prevent organisms above 2μm entering the water supply.
- From the manufacturers information the strength of the disinfectant agent used was potentially insufficient to be effective against the organisms and biofilm established before the commissioning process occurred.
- The manufacturers of the taps have advised that hydrogen peroxide will have detrimental effects on their products, should not be used and will void their warranty.
- The water system commissioning results show initial high levels of TVC and certain other organisms. These results are not isolated to particular areas of the water system and included E-coli. New test results have been produced to indicate that subsequent test cleared these outlets of E-coli, but it is likely that the biofilm survived the chemical dosing applied.
- There are no records of the commissioning of the dump valves, therefore the potential has existed for these to become dead legs if the valves are not functioning or the set point for actuation is set too high.
- The pipe work had water in since July 2014 and there is no evidence that this was circulated or flushed.
- The commissioning of the system was completed in stages from November 2014 to January 2015, with some individual outlets being re-tested in February 2015.
- During the commissioning period there is no evidence that the outlets (all taps, showers, external taps, connections to equipment or water coolers were flushed). This may mean that the biofilm had an opportunity to grow and establish.
- As part of the commissioning some outlets failed the tests. Some of these passed subsequent tests, but others did not. There is no evidence in ZUTEC of certain outlets passing the disinfection process (indeed some are marked as failing).

- There is evidence that undocumented work was being carried out on the water system post handover (as noted in the DMA reports) which may have introduced contamination into the system. There is no record of this work or if the section or system was disinfected.
- As the system was colonised, the type of flow straightener on the Horne tap became a site for certain organisms to grow, particularly gram negative organisms such as *pseudomonas and cupriavadus*. As a result of the investigations by NHS GGC, the contamination of the tap body and components was shown to be wide spread. This biofilm may have caused retrograde contamination back into the water system.
- Prior to any POU filters being installed it is probable that the drainage system (via the sinks) became contaminated and biofilm began to colonise the drains.
- There is no evidence of NHS GGC Infection Control Team being involved in the handover process of the hospitals to review the water test results.
- There is some evidence to suggest that the Contractor was flushing the taps in the hospitals in April 2015. Some records have been provided for flushing by NHS GGC in March and April 2015. Subsequent to 2015, there are records for critical care areas, but not for other wards or general areas.
- It is clear from the DMA report dated April 2015, that the water system did have a significant number of deficiencies at the time of the initial legionella risk assessment. These included (but not limited to):-
  - Issues with the MTHW from the energy centre
  - Cold water temperature were recorded as high
  - Dump valve not operating as per design
  - EPDM flexible hoses installed with are contrary to SAN(SC)09/03
  - Areas could not be accessed for flushing
  - Areas still under construction
  - Water tanks had various degrees of detritus at handover
  - Very few, if any, of the actions noted in the DMA report of April 2015 were actioned.
  - Very few, if any, of the actions noted in the DMA report of September/ October 2017 were actioned.
- These points are again picked up in DMA's report of 2017 and the Authorising Engineers report of 2017.
- It is therefore suggested that there was a lack of routine maintenance on the water system with the exception of critical care areas. This included a failure to replace flow straightners as per the manufacturer's recommendations.
- As noted in DMA's reports there were issues reported at the time with the MTHW supply to QEUH and RCH from the Energy Centre. This may have contributed to the LTHW temperatures to the outlets dropping below the minimum 50^{o}C required and into the legionella growth zone (which would have also aided other organism growth). There is evidence from the BMS logs that the LTHW temperature is low. This situation has not been resolved at the time of writing (July 2018). Issues with

the function of the CHP are being addressed directly by NHS GGC to the Contractor.

- Indicators that a system-wide contamination issue may be present manifested in the positive organism results in 2015. Due to the focus on critical care areas the scale of the problem was missed.
- It took a significant amount of time to establish the extent of the contamination because NHS GGC laboratory became swamped with requests for test results and the sheer volume of results and data was problematic to manage.
- As a result of the biofilm and organisms in the water, the drains have become infected prior to the POU filters being installed. This has been exacerbated by organic material, plastics and other material being flushed down the sinks. There is a possibility that cross contamination has occurred from “misting” from the drain on-to hands being washed.

11. Recommendations

Recommendations NHS GGC

1. Provide assurance that the management of the water systems is as described in guidance, including letters of appointment; appropriate numbers of authorised persons and competent person and appropriate training.
2. Resolve outstanding issues with Energy Centre.
3. Consider revising the Employer's Requirements for future projects to include current guidance, competency checks for all contractors, project management, project supervision (specialised clerk of works) and project handover requirements. The inclusion and collaboration of the Estates Department for all Capital projects should be considered.
4. Resolve all the points noted in the two Legionella Risk Assessments and Authorising Engineers reports.
5. Consider having a formal process in place to prioritise, manage, record and react to any BMS alarms from anywhere in the campus network.
6. Carry out routine maintenance and reactive maintenance on the hot and cold water systems and components as per the Planned Preventative Maintenance (PPM) schedules in ZUTEC and specific manufacturers' recommendations and ensure that all infrequently used outlets are managed and flushing is recorded. This should include all water dump valves and checking turnover of the water tanks.
7. Have the seasonal commissioning as required by the specification carried out by the Contractor.
8. Ensure all pipe work to removed external bib taps has been removed and all EPDM flexible hoses have been removed or managed by risk assessment.
9. Ensure that the BMS server provided under the contract meets the requirements of the contract specification in relation to data storage integrity.
10. Have all electronic records checked and any missing or incorrect documentation rectified and provided to ensure a robust and comprehensive set of records.

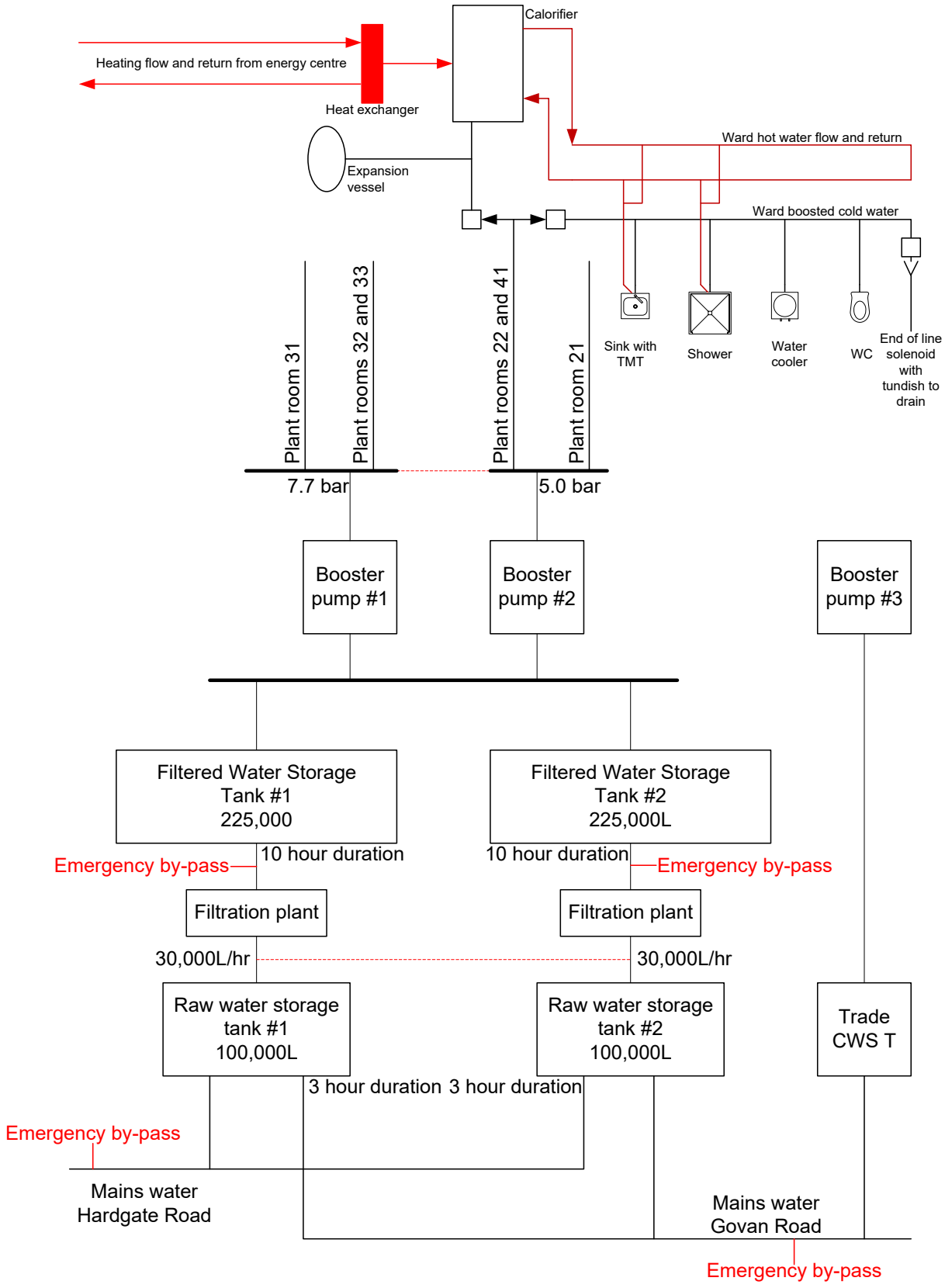
Recommendations for new/updated guidance

1. Review of construction management guidance to establish how it can provide assurance that similar issues will not occur in future projects.
2. Consideration to be given to production of updated "standard" Employer's Requirements (also known as Authority Contract Requirements (ACR) or Board Contract Requirements (BCR) as a National resource for all Boards.
3. Consideration for updated water and other guidance to include:-

    - Thermal disinfection in sections of water distribution systems
    - Handover checklists
    - Contract management procedures
    - Design guides to eliminate thermal pickup in cold water systems

- Update advantages and disadvantages of chemical disinfection techniques
- The organisms Boards should test for and action to take on defined levels
- Drain cleaning regimes
- Biofilm growth in drainage systems

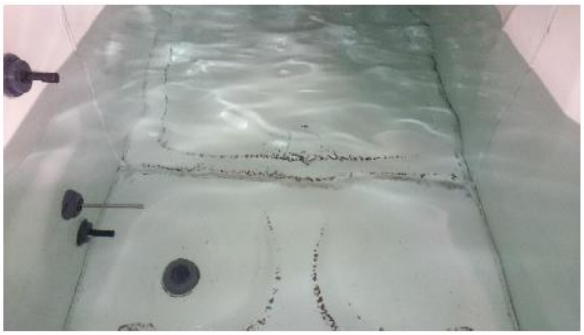
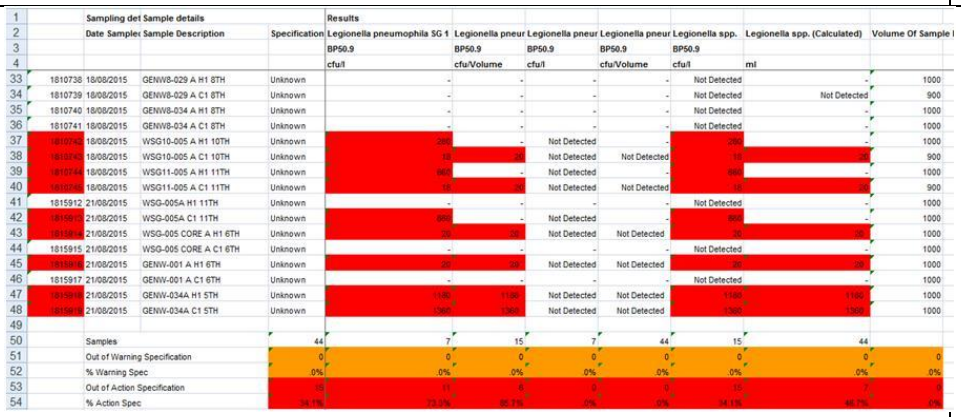
Appendix 1 Simplified water schematic



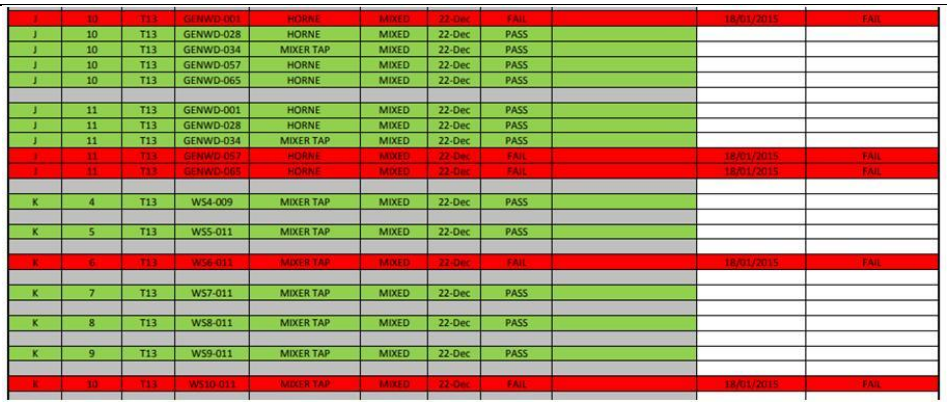
Simplified water schematic for QEUH and RHC

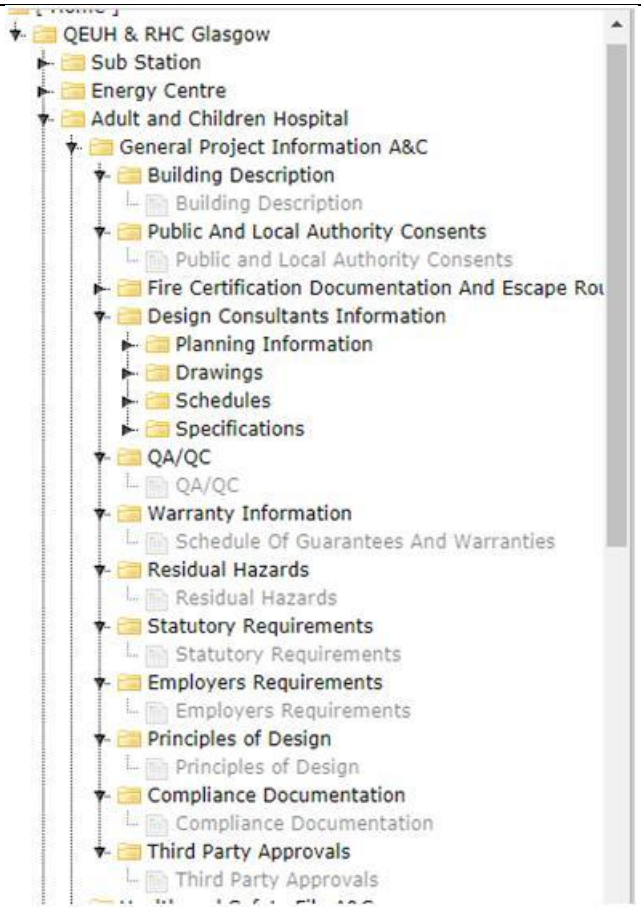
Appendix 2 Images and screen shots

<table>
<tr><th>Item</th><th>Image</th><th>Comments</th></tr>
<tr><td>1</td><td>
8.2.8. Water Systems and Filtration
8.2.8.1. Cold Water Supply
8.2.8.2. The water supply system for The Works shall include two new supplies and also incorporate on-site segregated bulk water storage (24-hours). Treatment of potable cold water supplies is not acceptable and the provision of a wholesome supply from Scottish Water's mains with the minimum of storage and handling is required.
8.2.8.3. The Contractor shall design and install the domestic cold and hot water supply installations to fully comply with the requirements of;
a) (S)HTM04-01;
b) SHTM 2027;
c) SHTM 02;
d) SHTM 2040 "The control of legionella in healthcare premises - a code of practice"; and
e) Health Guidance Note "Safe Hot Water and Surface Temperatures."
166
</td><td>Extract from NHS GGC Employers requirements (ER) showing guidance required to be complied with respect to the domestic hot and cold water systems</td></tr>
<tr><td>2</td><td>
<table>
<tr><th>Document</th><th>Title</th><th>Proposals Comply? (Yes/No)</th><th>Compliance Narrative (How compliance is being Achieved)</th></tr>
<tr><td>SHTM 04-01 Part A</td><td>Control of Legionella...drinking systems Part A</td><td>yes</td><td>Hot and cold water services are described in Design Strategy for Hot and Cold Water Services Volume 3 Section 3.7 and specification sections Volume 4 Sections 4.27, 4.28 & 4.51. However, the following adjustments are proposed:- Fig 2 shows A small CWS break cistern serving each cold water system, prior to the main filtration plant will be provided. However, a secondary break cistern before each bulk storage cistern will not be provided. At least two equally sized bulk storage cisterns with a total of 100% of the design capacity in each location have been provided. The recommended quantities of water storage given in Table A1 are considered excessive for modern hospitals. Therefore, reduced levels have been used. Refer to Design Strategy for Hot and Cold Water Services Volume 3 Section 3.7 for further details. Clauses 9.13/9.23 recommend providing peak continuous hot water output for 20 minutes. Following the recommendations of the SHTM, results in excessive storage capacity, which can increase energy consumption and increase the risk of Legionella, the HTM approach is also outdated and relates back to when there was high usage of baths at set periods of the day. Modern hospitals predominantly use showers, which use less water and have a much higher diversity factor. This approach will not be followed, but diversity will be considered using the principles of BS 6700.</td></tr>
<tr><td>SHTM 04-01 Part B</td><td>Control of Legionella...drinking systems Part B</td><td>yes</td><td>Hot and cold water services are described in Design Strategy for Hot and Cold Water Services Volume 3 Section 3.7 and specification sections Volume 4 Sections 4.27, 4.28 & 4.51.</td></tr>
</table>
</td><td>Extract from contractors response section 7 NHS Mandatory Documentation "Table 2 (extract from ITPD Vol 2/1 Section 5.1.2) – ITSFB Clarification Appendix 1"</td></tr>
<tr><td>3</td><td>
<table>
<tr><td>Should background dosing be considered for this site?</td><td>Yes. However as renal dialysis, and other medical systems, are fed directly from the Raw/Bulk Water supply any background dosing system would have to be fully risk assessed and approved prior to installation.</td></tr>
</table>
</td><td>Extract from DMA initial legionella risk assessment April 2015</td></tr>
</table>

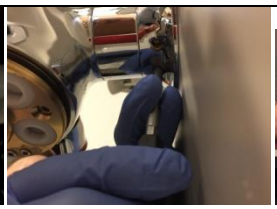
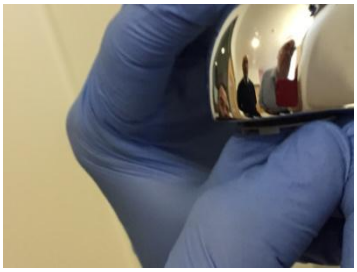
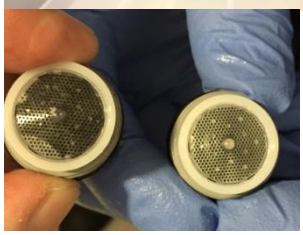
Item	Image	Comments
4	  Raw 1B CWST Raw 2A CWST  Trade LHS CWST	Images from DMA initial legionella risk assessment April 2015 showing debris in water tanks
5	7.9.6(h) Make a note in H&C specs about prohibited use of flexible hose connections Prohibition to remain and be enforced + noted in specifications by BCL Agreed	Extract from "The 2010 Instruction to Proceed Log - FINAL
6		Extract screen shot from water sampling test result summary August 2015.

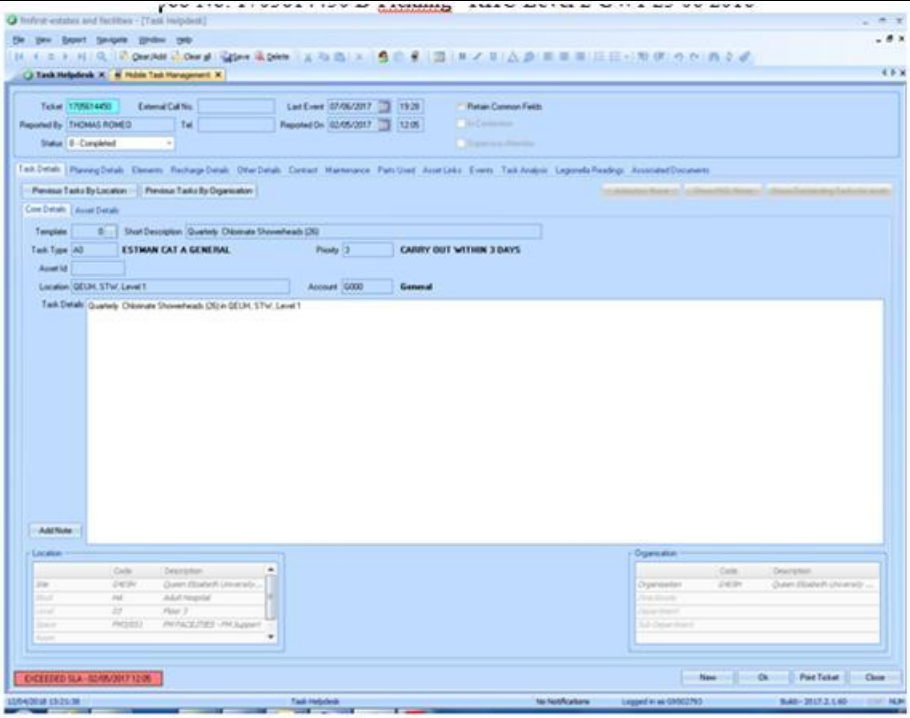
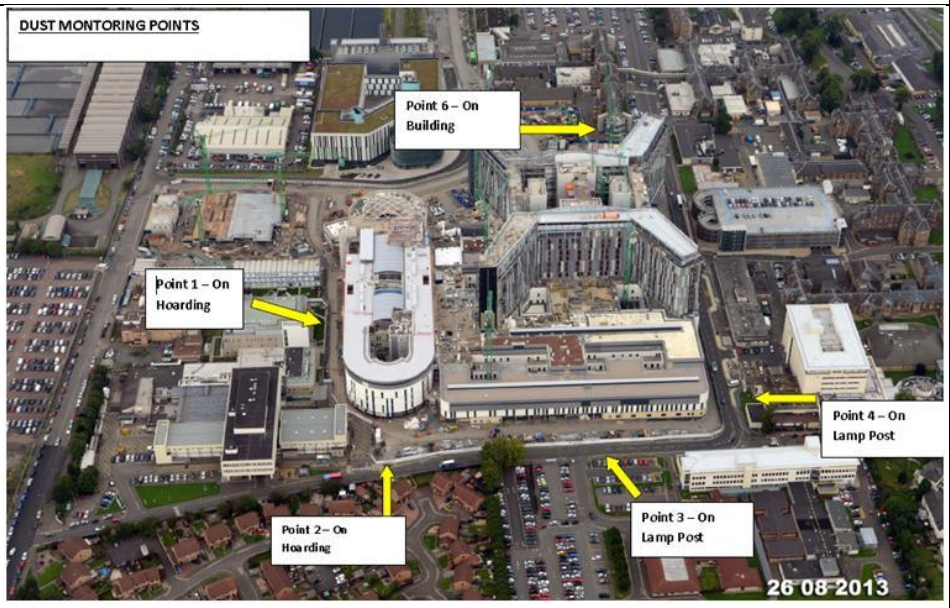
Item	Image	Comments
7		Photograph 6 from Capita Symonds Supervisors Report number 12 dated March 2012, showing open-ended pipe.
8		Photograph from Capita Symonds Supervisors Report number 19 October 2012, showing open-ended pipe.

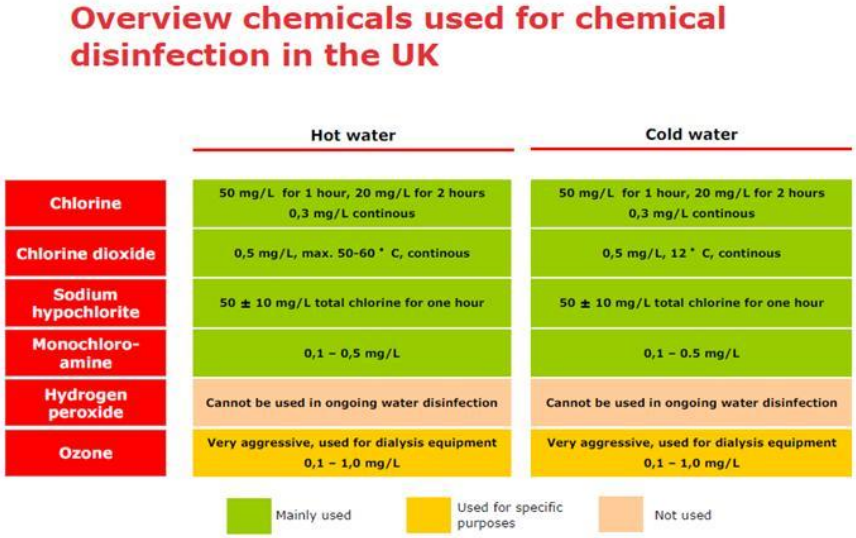
Item	Image	Comments
9	W0.9 Commissioning Records It is essential that the results of all checks and measurements are recorded in writing at the time they are made. Breaks in the continuity of commissioning operations are likely and proper records will show the state of progress at any stage. It is most important that commissioning records are provided as part of the 'hand-over' information. It is therefore recommended that a standardised format be compiled from this Code for a particular project (see sections W5.5, W6.6, W7.10 and W8.4). W6.4.1 General Care should be taken during construction to keep the internal surfaces of pipework as clean as possible. Blockages in equipment may prove difficult to locate and expensive to rectify. It is therefore most important that the system is thoroughly cleaned of all detritus. In order to minimise the risk of corrosion and biofilm development, flushing and cleaning should commence as soon as possible after the initial system fill, ideally within 48 hours.	Extract from CIBSE Commissioning Guide W
10	 J 10 T13 GENWD-001 HORNE MIXED 22-Dec FAIL 18/01/2015 FAIL J 10 T13 GENWD-028 HORNE MIXED 22-Dec PASS J 10 T13 GENWD-034 MIXER TAP MIXED 22-Dec PASS J 10 T13 GENWD-057 HORNE MIXED 22-Dec PASS J 10 T13 GENWD-065 HORNE MIXED 22-Dec PASS J 11 T13 GENWD-001 HORNE MIXED 22-Dec PASS J 11 T13 GENWD-028 HORNE MIXED 22-Dec PASS J 11 T13 GENWD-034 MIXER TAP MIXED 22-Dec PASS J 11 T13 GENWD-057 HORNE MIXED 22-Dec FAIL 18/01/2015 FAIL J 11 T13 GENWD-065 HORNE MIXED 22-Dec FAIL 18/01/2015 FAIL K 4 T13 WS4-009 MIXER TAP MIXED 22-Dec PASS K 5 T13 WS5-011 MIXER TAP MIXED 22-Dec PASS K 6 T13 WS6-011 MIXER TAP MIXED 22-Dec FAIL 18/01/2015 FAIL K 7 T13 WS7-011 MIXER TAP MIXED 22-Dec PASS K 8 T13 WS8-011 MIXER TAP MIXED 22-Dec PASS K 9 T13 WS9-011 MIXER TAP MIXED 22-Dec PASS K 10 T13 WS10-011 MIXER TAP MIXED 22-Dec FAIL 18/01/2015 FAIL	Plant room 32 This shows taps which have failed the sanitisations in December and January.

Item	Image	Comments
11		Image showing initial failures of Horne taps, with retest passing a month-and-a-half later.
12		Image of ZUTEC file structure showing empty folders.

G	0	M1	AAW 375	HORNE TAP	MIXED	03-Dec	FAIL		18/01/2015	PASS
D	1	M5	CCW 131	HORNE TAP	MIXED	03-Dec	FAIL		18/01/2015	PASS
D	1	M5	CCW 141	MIXER TAP	MIXED	03-Dec	PASS			
D	1	M5	CCW 200	HORNE TAP	MIXED	03-Dec	PASS			
D	1	M5	CCW 200	HORNE TAP	MIXED	03-Dec	PASS	LEGIONELLA SAMPLE TAKEN		
D	1	M5	CCW 202	MIXER TAP	MIXED	03-Dec	PASS			
D	1	M5	CCW 214	MIXER TAP	MIXED	03-Dec	PASS	1ST WHB		
D	1	M6	CCU 004	SINK	HOT	03-Dec	PASS			
D	1	M6	CCU 004	SINK	COLD	03-Dec	PASS			
D	1	M6	CCU 036	HORNE TAP	MIXED	03-Dec	FAIL		18/01/2015	PASS
G	1	M1	CCW 017	SINK	HOT	03-Dec	PASS			
G	1	M1	CCW 017	SINK	COLD	03-Dec	PASS			
G	1	M1	CCW 029	MIXER TAP	MIXED	03-Dec	PASS			
G	1	M1	CCW 048	HORNE TAP	MIXED	03-Dec	FAIL		18/01/2015	PASS
G	1	M1	CCW 087	HORNE TAP	MIXED	03-Dec	FAIL		18/01/2015	PASS
G	1	M1	CCW 089	HORNE TAP	MIXED	03-Dec	FAIL		18/01/2015	PASS
G	1	M1	CCW 092	HORNE TAP	MIXED	03-Dec	FAIL		18/01/2015	PASS
G	1	M1	CCW 109	HORNE TAP	MIXED	03-Dec	PASS			
G	1	M1	CCW 109	HORNE TAP	MIXED	03-Dec	PASS	LEGIONELLA SAMPLE TAKEN		
G	1	M1	CCW 126	HORNE TAP	MIXED	03-Dec	FAIL		18/01/2015	PASS
G	1	M1	CCW 130	HORNE TAP	MIXED	03-Dec	FAIL		18/01/2015	PASS

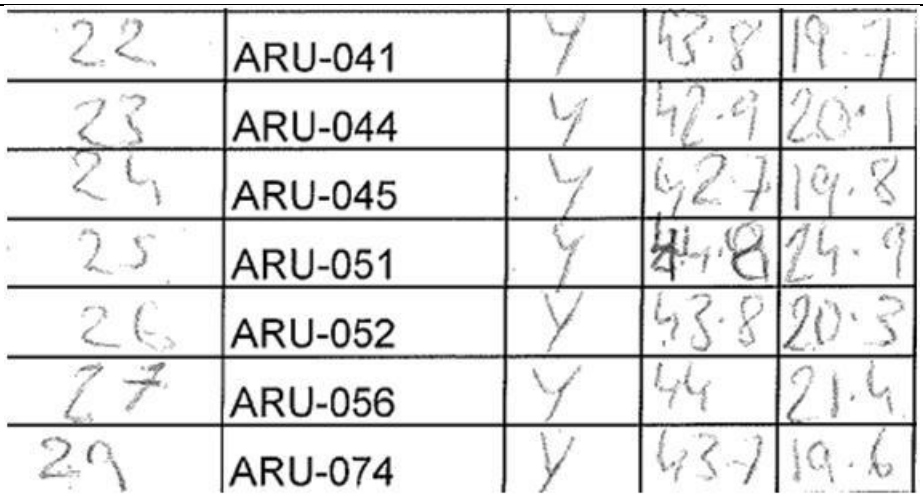
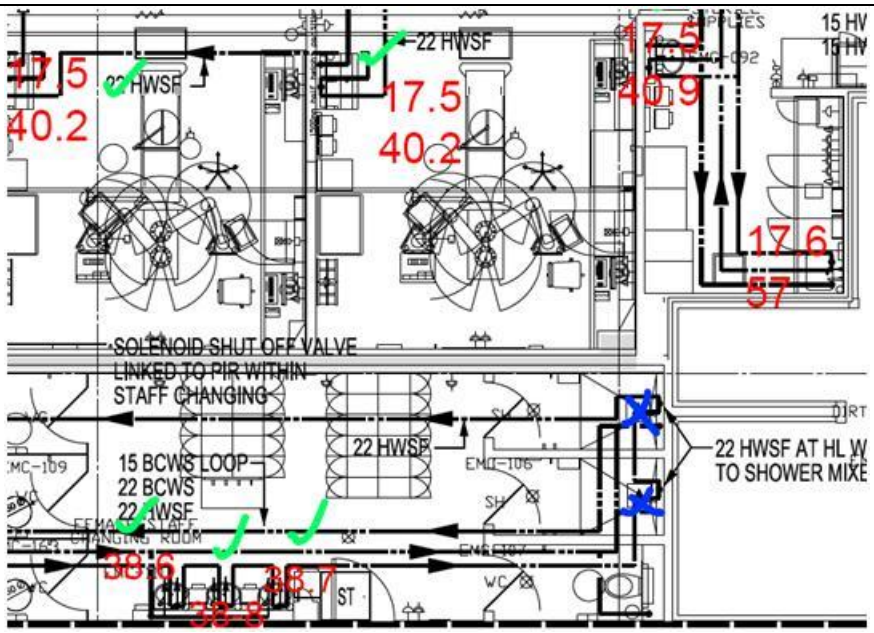
Item	Image	Comments
13	      	Routine maintenance of Horne Tap. Image (top left) show damage to brass isolating screws. Image (bottom right) shows old and new flow straightener.
14		Exploded view of Horne flow straightener

Item	Image	Comments
15		Image of a typical FMfirst(R) job card
16		Image showing the dust monitoring points.

Item	Image	Comments
17		From Armitage Shanks / Ideal Standards regarding the concentration of chemicals which can be used with their taps without detrimental impact.
18		DMA Canyon report
19		NHS GGC report

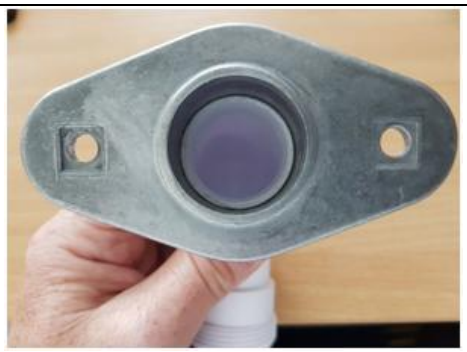
Location/Room No.	TMV ID No.	TMV Make & Model	TMV Type & Size	Temp °C Pre Cold	Temp °C Pre Hot	Temp °C Mix	Fail Safe Test	Filters Clean & Disinfect	Check Valves Working	Isolation Valves	Pressure Test (Bar) Hot	Pressure Test (Bar) Cold	Access & Comments
BED 2 A 1 CCW-047		HORNE OPTITHERM	TMV TAP	12.8	59.4	41.2	PASS	YES	N/A	YES			
BED 3 FOYER A 1 CCW-042		HORNE OPTITHERM	TMV TAP	12.5	58.4	41.4	PASS	HOT ONLY	N/A	YES			COLD FILTER IS CHEWED AND UNABLE TO REMOVE
BED 3 A 1 CCW-242		HORNE OPTITHERM	TMV TAP	14.4	58.1	40.8	PASS	YES	N/A	YES			
BED 3 TOILET A 1 CCW-044		ARMITAGE SHANKS MONO TAP	TMV TAP	14.5	56.2	39.1	N/A	N/A	N/A	N/A			NO ACCESS TO ISOLATION VALVES AS THEY ARE BEHIND IPS PANELS
BED 1 A 1 CCW-048		HORNE OPTITHERM	TMV TAP	14.2	58.7	41.2	FAIL	YES	N/A	YES			SLAM TEST FAILED TO ISOLATE WATER HOT FILTER IS CHEWED AND UNABLE TO REMOVE
SHOWER ROOM A 1 CCW-029		ARMITAGE SHANKS MONO TAP	TMV TAP	16.8	57.4	39.4	N/A	N/A	N/A	N/A			NO ACCESS TO ISOLATION VALVES AS THEY ARE BEHIND IPS PANELS

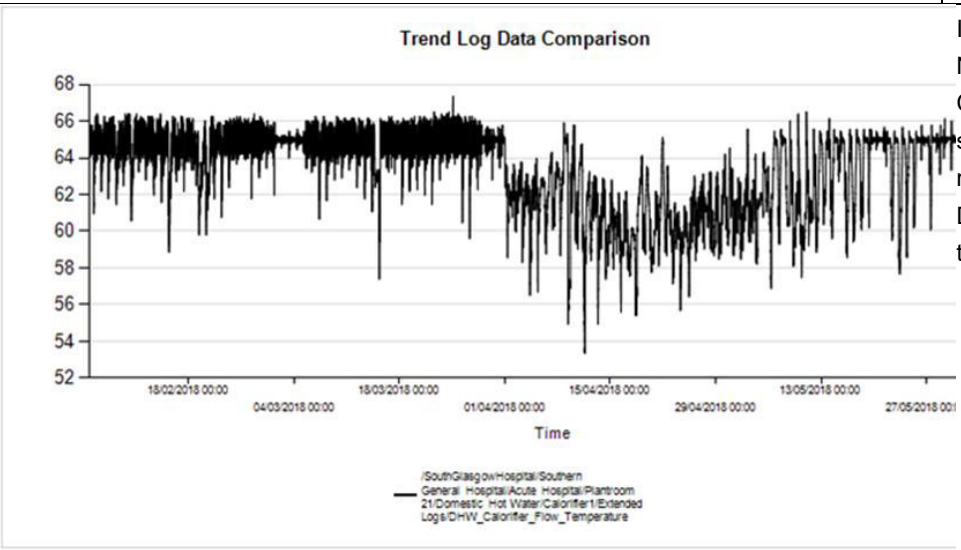
Area / ward	Room	Outlet Horne	Outlet Shanks	Function test Pass / Fail	Temperature Hot	Temperature Cold	Thermal Disinfection Yes	Thermal Disinfection No	Date
HDU 1	CCW-025	X							
HDU 1	CCW-026		X						
HDU 1	CCW-027	X							
HDU 1	CCW-031	X		PASS	42.1	13.1	✓		19/11/16
HDU 1	CCW-032	X		PASS	42.3	13.4	✓		19/11/16
HDU 1	CCW-033	X		PASS	42.0	12.9	✓		19/11/16
HDU 1	CCW-034	X		PASS	42.1	13.0	✓		19/11/16

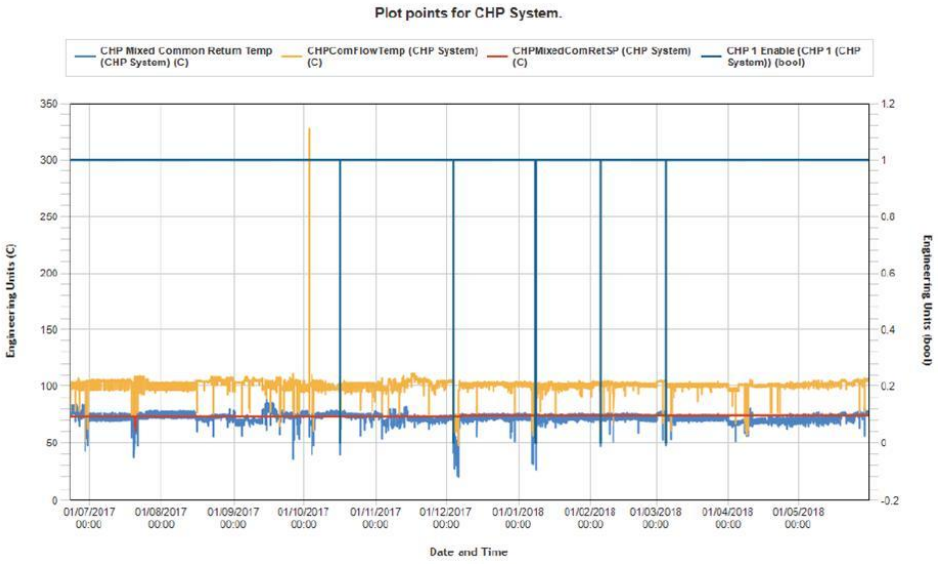
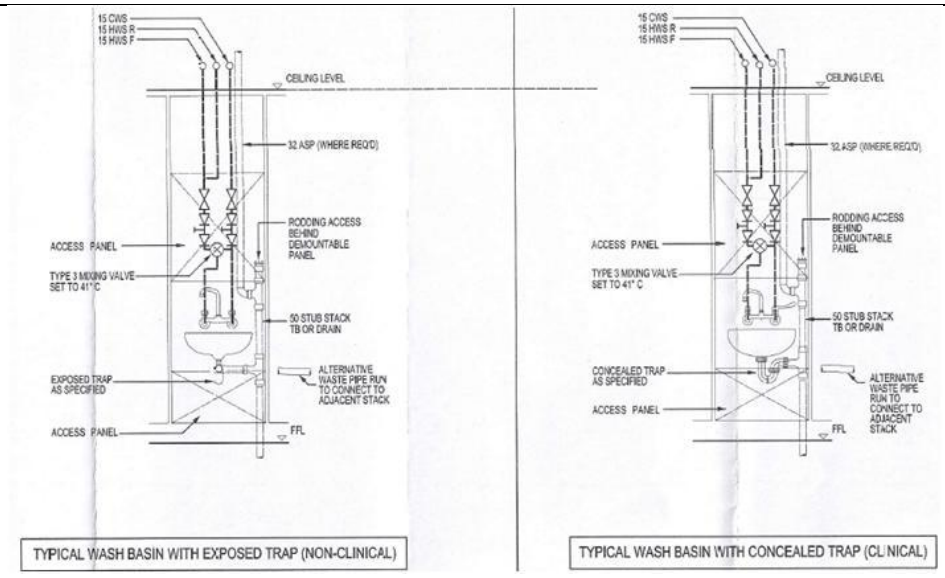
Item	Image	Comments
20		Image from FM First record of shower chlorination. This shows the cold water temperature on the right hand column.
21		Image showing areas served from plant room 21. Hot water noted as 57°C. Some blue crosses noted and unclear if this means failure of the temperature record or equipment.
22	**Brookfield** New South Glasgow Hospitals Project **DESIGN STRATEGY FOR ENGINEERING SYSTEMS RESERVE CAPACITY** In respect of Clause 8.1.3.2 of Volume 2/1 of the ITPD documents the following reserve capacity is proposed for each of the major engineering services systems: **System** / **Proposed Reserve Capacity** / **Description** Cold water storage / 25% capacity / Water storage volume should not exceed 24 hours usage and ideally be less. Storage capacity could be reduced by lowering the ball valve floats. There is 25% additional capacity on the distribution pipework and pump systems, mains and risers, 0% on local pipework systems. Hot water storage / 25% per description 0% in calorifiers / The provision of spare volume capacity in hot water systems is discouraged as this can lead to increased risk of Legionella. Plate heat exchangers and primary heating pipework will include a 25% output reserve. Main runs and risers will include 25% reserve capacity	Image showing spare capacity built into water system.

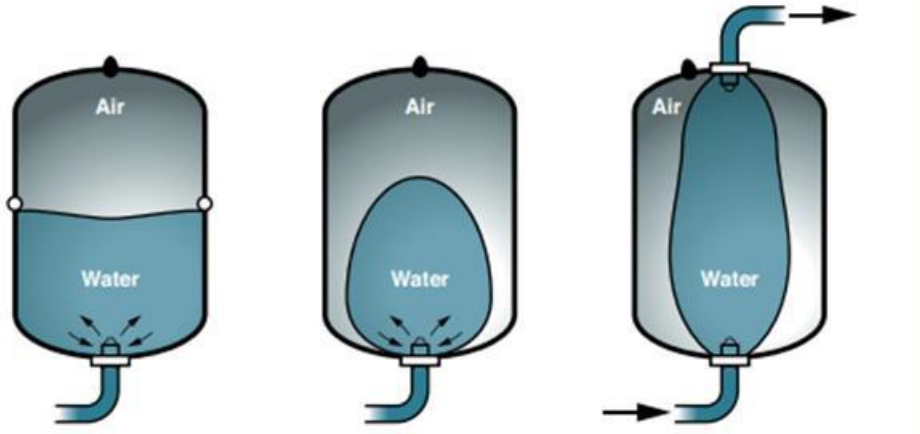
Item	Image	Comments
23	1 | 1 | WHBN1000 | WASH BASIN, clinical, with non touch panel mounted tap/s. 1 No. BAS101 (1) BASIN, medium, hospital pattern, vitreous china, no tap holes, no overflow, integral back outlet, 500W 400D. HTM64LBHM 1 No. OUT052 (1) CONNECTION UNIT, switched, 13 amp 1 No. TAP894 (1) TAP bib, hospital pattern, integral thermostatic mixer, automatic action with sensor operation. HTM64TBH6 1 No. WAS100 (1) WASTE, unslotted flush-grated, metal, 1.1/4 in. HTM64WT1 1 No. WAS1000 (1) TRAP, concealed waste, for back outlet basins.	Image from room datasheet for children's bed room showing guidance requirements for sanitary ware.
24	Customer: NHS & GGHB; Date: 1/08/17; Report No (Part 1): TMV/1/; DMA CANYON OFFICE INFO Site Address: QEU HOSPITAL CHILDREN'S SCHEIHALLION; Responsible Person: TOMMY ROMEO; Site Contact: RAMS Ref No. Additional RAMS ☐	TMT servicing reports showing cold water temperatures close or over 20°C and issues with taps preventing maintenance.

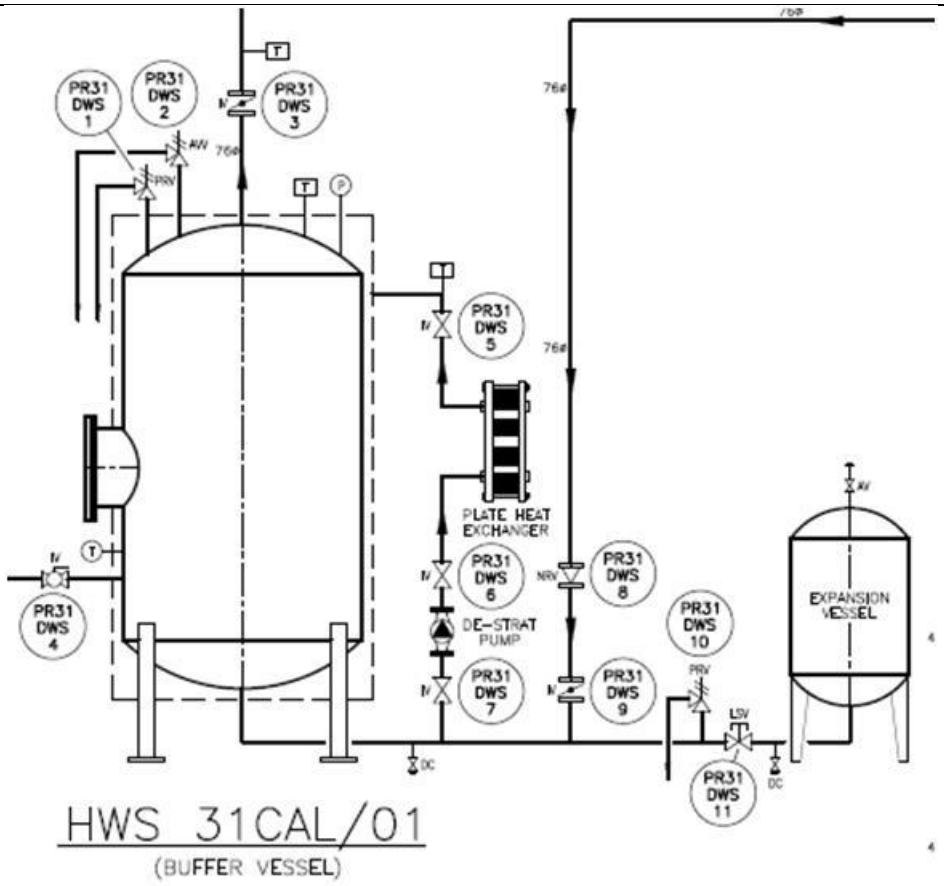
Location/Room No.	TMV ID No.	TMV Make & Model	TMV Type & Size	Temp °C Pre Cold	Temp °C Pre Hot	Temp °C Mix	Fail Safe Test	Filters Clean & Disinfect	Check Valves Working	Isolation Valves	Pressure Test (Bar) Hot	Pressure Test (Bar) Cold	Access & Comments
CHILDREN'S SCHEIHALLION CONSULTING ROOM 3		HORNE OPTITHERM	TMV TAP	20.2	58.9	40.1	N/A	HOT ONLY	N/A	COLD VALVE FAULTY			COLD ISOLATION VALVE FAULTY SO UNABLE TO ISOLATE WATER THERFOR UNABLE TO CARRY OUT APPROPRIATE TESTS
CHILDREN'S SCHEIHALLION CONSULTING ROOM 4		HORNE OPTITHERM	TMV TAP	18.1	58.7	40.3	PASS	YES	YES	YES			THERMAL FLUSH CARRIED OUT
CHILDREN'S SCHEIHALLION DISABLED/NAPPY CHANGE		ARMITAGE SHANKS MONO BLOCK TAP	TMV TAP	19.3	56.1	41.2	N/A	N/A	N/A	NO			NO ISOLATION VALVES AVAILABLE SO UNABLE TO CARRY OUT APPROPRIATE TESTS
CHILDREN'S SCHEIHALLION BED 16		HORNE OPTITHERM	TMV TAP	19.1	58.7	42.0	PASS	YES	YES	YES			THERMAL FLUSH CARRIED OUT
CHILDREN'S SCHEIHALLION BED 16 TOILET		ARMITAGE SHANKS MONO BLOCK TAP	TMV TAP	19.5	56.7	42.7	N/A	N/A	N/A	NO			NO ISOLATION VALVES AVAILABLE SO UNABLE TO CARRY OUT APPROPRIATE TESTS

		Comments
25	  	Images of drain spigot connections from clinical wash hand basins. The left hand image shows corrosion and biofilm. The middle is a non contaminated sample. The right hand side image is the new plastic design for the spigot.

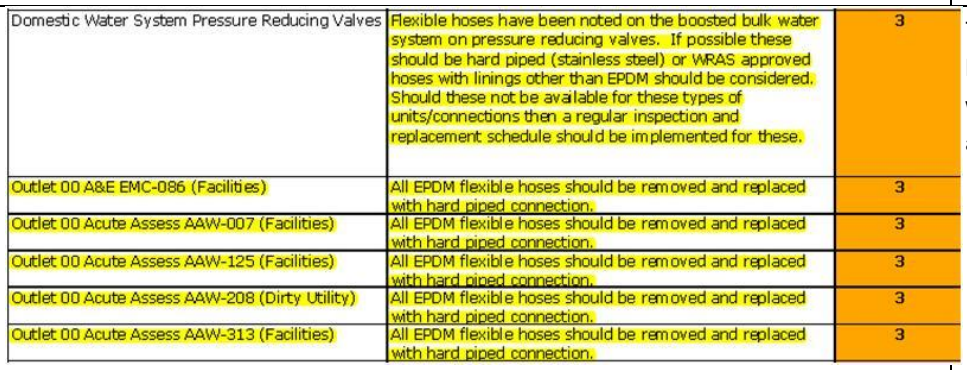
Item	Image	Comments
26		Image of Armitage Shanks Contour 21 and aluminium spigot with drainage connection.
27		Image from NHS GGC CHP report showing plant room 21 DHW flow temperature.

Item	Image	Comments
28		Image from NHS GGC CHP report showing MTHW flow and return temperatures for CHP 1.
29		Image showing the contractors as installed drawing (in part) for the drainage connections detail at the wash hand basins. This is not what is installed.

Item	Image	Comments
30	There are several types of vessel available including diaphragm or bladder type, with fixed and interchangeable (replaceable) bladders, as shown below. These internal bladders are often made of synthetic rubber such as EPDM and may support the growth of microorganisms including legionella, so check to see if these are approved against BS 6920. Vessels with a 'flow through' design should provide less opportunity for water to stagnate and become contaminated (as in the latter design).  **Expansion vessels**	Extract from HSG 274: info box 2.1. The type recommended is the flow through which is not as per installed. This was also recommended in SHTM 04-01 part A 2011.

Item	Image	Comments
31		Extract from Plantroom 31 - Domestic Water Pipework Valve Chart 1 of 3 drawing showing expansion vessel type installed.
32		Image showing the POU fitted to the Horne Engineering tap and the relationship to the sink.

Item	Image	Comments
33	**Comments:** There was bypass pipework set up to run from the Hardgate Road mains to the domestic (Bulk) water supply system connecting in after the Booster Pumps (5.0 Bar set). This was noted during DMAs initial site walk round and reported to Estates. DMA again noted this during the site survey of the CWSTs on 02/04/15 and again reported this to Estates. DMA were advised in mid-April this had been removed by Mercury/Brookfield. This line could potentially have introduced debris to the distribution system which would otherwise have been removed by the filtration units and could be a contributory factor to any out of specification microbiological results.	Text from DMA initial water risk assessment
34	Calorifier 32-03 was offline when DMA had an initial site familiarisation walk-round with Mercury Engineering in early January 2015. This calorifier was still offline when DMA were on site on 21st April 2015. This was creating deadlegs on the cold supply, hot flow and hot return to the calorifier and Estates staff were unable to confirm the reason for this calorifier being offline. This calorifier had been reinstated when DMA revisited on 27/04/15 though Estates not aware of any flushing, pasteurisation or disinfection of calorifier being carried out prior to reinstatement. DMA would recommend the calorifier (and hot system) is disinfected/pasteurised legionella samples taken from the calorifier and system prior to reinstatement to confirm these corrective actions have been effective.	Text from DMA initial water risk assessment
35	Legionella Management | Significant gaps were identified in the Legionella Management on site. Please refer to the Gap Analysis for further information | 2	Text from DMA second water risk assessment
36	There are no records that manufacturers recommendations have been implemented to date regarding commissioning and component changes. Estates advised there is currently no mechanism in place for 'no access' reports to be reactioned to ensure all valves are completed in the necessary time frame.	Text from DMA second water risk assessment
37	**Competency** **11. A list of named management personnel, with the details of their responsibility should be created and added to the on site written scheme for the QEUH.** **12. Lines of communication should be clearly defined and added to the written scheme.** **13. A full written scheme, in accordance with the requirements as outlined in Appendix 2 of the HSG 274 document should be created for he site.** **14. Consideration should be given to creating a form which carries the training details of the on site involved staff.** **15. The involved Estates' staff should ask for copies of proof of competency for contractor's staff.** **16. It is recommended that any contractors who are working on the water systems on site are able to show proof of competency for the work being completed. This would include plumbing contractors who may be used on the site.** **17. NHS GGC should consider what contractor management process should be introduced to ensure the quality and standards of the contractors are acceptable.**	Text from AE audit 2017
38	General System | It may be prudent to consider installing a background dosing system on this site (e.g. Chlorine Dioxide) due to control issues identified during this assessment. | 2	Text from DMA initial water risk assessment

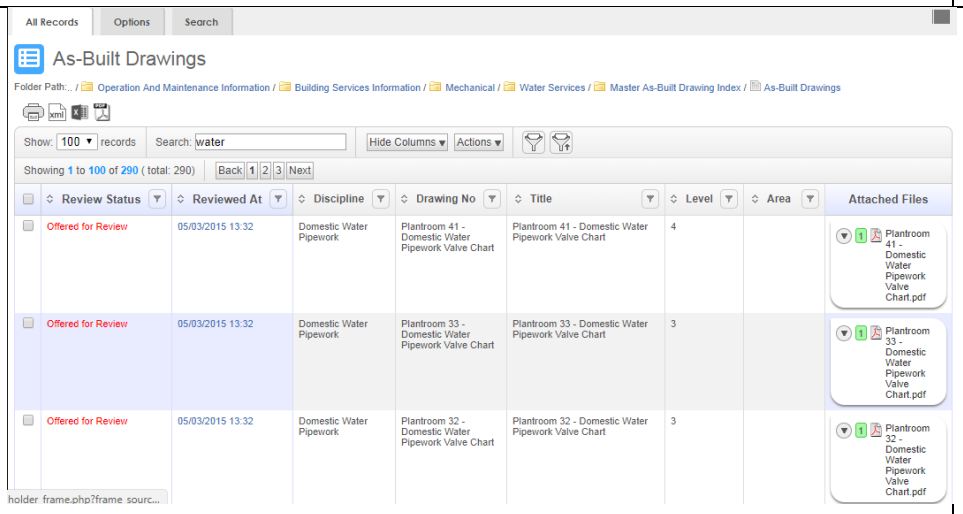
Item	Image	Comments
39		Text from DMA initial water risk assessment
40		Image of BMS Extended log of cold water sensor in level 0.

Domestic Water System Pressure Reducing Valves	Flexible hoses have been noted on the boosted bulk water system on pressure reducing valves. If possible these should be hard piped (stainless steel) or WRAS approved hoses with linings other than EPDM should be considered. Should these not be available for these types of units/connections then a regular inspection and replacement schedule should be implemented for these.	3
Outlet 00 A&E EMC-086 (Facilities)	All EPDM flexible hoses should be removed and replaced with hard piped connection.	3
Outlet 00 Acute Assess AAW-007 (Facilities)	All EPDM flexible hoses should be removed and replaced with hard piped connection.	3
Outlet 00 Acute Assess AAW-125 (Facilities)	All EPDM flexible hoses should be removed and replaced with hard piped connection.	3
Outlet 00 Acute Assess AAW-208 (Dirty Utility)	All EPDM flexible hoses should be removed and replaced with hard piped connection.	3
Outlet 00 Acute Assess AAW-313 (Facilities)	All EPDM flexible hoses should be removed and replaced with hard piped connection.	3

15/04/2018 02:30	22.8
15/04/2018 01:30	22.48
15/04/2018 00:30	21.88
14/04/2018 23:30	20.08
14/04/2018 22:30	20.24
14/04/2018 21:30	22.48
14/04/2018 20:30	22.04
14/04/2018 19:30	20.68
14/04/2018 18:30	20
14/04/2018 17:30	22.88
14/04/2018 16:30	22.56
14/04/2018 15:30	22.32
14/04/2018 14:30	21.8
14/04/2018 13:30	20.12
14/04/2018 12:30	20.36
14/04/2018 11:30	22.8
14/04/2018 10:30	22.8
14/04/2018 09:30	22.8
14/04/2018 08:30	22.8
14/04/2018 07:30	22.8
14/04/2018 06:30	22.8
14/04/2018 05:30	22.8
14/04/2018 04:30	22.8
14/04/2018 03:30	22.8
14/04/2018 02:30	22.8

Item	Image	Comments
41	 	Images of materials found in water tank. Left and image from raw water tank 1A and right hand image from raw water tank 2B.

Item	Image	Comments
42	5.5 Where water quality sampling in a water system confirmed (acceptable) Legionella results less than 100 CFUs/Litre – the Authorised Person (Water) would be informed and provided with copies of the samples in writing and associated record keeping. The Authorised Person (Water) would provide interpretation (with the Consultant Microbiologist when and where required) on the results and confirm if any actions are required. 5.6 Where water quality sampling in a water system confirmed Legionella results in excess of 100, but less than 1,000 CFUs/Litre – the Authorised Person(Water) and Consultant Microbiologist must be informed and provided with copies of the samples in writing. The Consultant Microbiologist would provide interpretation on the results and confirm the necessary actions prior to bringing the water system into use. 5.7 Where water quality sampling in a water system confirmed Legionella results in excess of 1,000 CFUs/Litre immediate action must be taken and the Consultant Microbiologist and Authorised Person (Water) must be informed and provided with copies of the samples in writing. They will immediately confirm the necessary actions prior to re-sampling and bringing the water system into use when (acceptable) Legionella results are reliably less than 100 CFUs/Litre. Note: Where continued water system sampling is required, this would be undertaken on a weekly frequency. 5.8 Where the results of three consecutive weekly water system samples remained below 100 CFUs/Litre, the Authorised Person (Water) and Consultant Microbiologist would be informed and sampling would revert to a monthly sampling frequency. 5.9 Where the results of three consecutive monthly Water System samples remained below 100 CFUs/Litre, the Authorised Person (Water) and Consultant Microbiologist would be informed and sampling would revert to a 3-monthly sampling frequency.	Extract from SHTM 04-01 Part C detailing the TVC testing protocol.

Item	Image	Comments
43		Extract from Intertek interim report showing tests on tap flow straigteners.
44		One example of document which has not been finalised contained within ZUTEC.

sample number	location	asset number	date stamp on sample	200ml SDW added	tvc 1ml	tvc1ml-1	tvc100ml	Pseud 100ml	Estimate total count per item (cfu/straightener	soiling visual		biofilm
1	Ward 9A Room 2	GENW13-004	07/06/2018	yes	>1000	>1000	>1000	>1000	>2000000	HEAVY		5
2	HDU3 Bay 29	CCW-106	21/06/2018	yes	>1000	>1000	>1000	>1000 NTF	>2000000	NO		1
3	Ward 9B Room 95 WHB	GEN16-040		yes	>1000	>1000	>1000	>1000 NTF	>2000000	HEAVY		5
4	Ward 9C Clean Utility WHB	GEN15-081		yes	>1000	>1000	>1000	>1000 NTF	>2000000	NO		2
5	Ward 8A Room 1	GENW9-001	11/06/2018	yes	>1000	>1000	>1000	>1000	>2000000	HEAVY		5
6	Ward 8B Bed 107 WHB	GENW13-13		yes	>1000	>1000	>1000	>1000 NTF	>2000000	HEAVY		5
7	Ward 5C Bed 86 WHB	GENW2-022	14/06/2018	yes	>1000	>1000	>1000	>1000 NTF	>2000000	HEAVY		5
8	Ward 8D Bed 29	GENW10-065	11/06/2018	yes	>1000	>1000	>1000	>1000 NTF	>2000000	LIGHT		5
9	Ward 6B Bed101 WHB	GENW4-023	12/06/2018	yes	>1000	>1000	>1000	>1000 NTF	>2000000	NO		5
10	Ward6D Bed53	GENW2-006	13/06/2018	yes	>1000	>1000	>1000	>1000 NTF	>2000000	HEAVY		5
	due to excessive counts dilution of TVC changed			200ml SDW added	TVC 1ml	TVC 1ml-1	TVC 1ml-2	Pseud 100ml				
11	HDU2 Bed11	CCW-051	19/06/2018	yes	>1000	>1000	350	>1000	7000000	NO		1
12	HDU1 Bay7	CCW-033	19/06/2018	yes	>1000	>1000	250	>1000	5000000	NO		3
13	Ward6C Bed73 WYB	GENW3-040	12/06/2018	yes	>1000	200	600	>1000	12000000	Moderate		5
14	HDU4 Bay35	CCW-085	21/06/2018	yes	>1000	>1000	20	400	400000	NO		2
15	Ward6A Bed2	GENW1-006	12/06/2018	yes	>1000	>1000	>1000	>1000	20000000	HEAVY		5
16	Ward 5B Bed85	GENWD-065	13/06/2018	yes	>1000	>1000	>1000	>1000	20000000	HEAVY		5
17	Ward5A Bed16	GENWA-035	13/06/2018	yes	>1000	>1000	900	>1000	18000000	HEAVY		5

Appendix 3

Health Facilities Scotland / Health Protection Scotland

Healthcare Infection, Incident and Outbreak Reporting

Information required for Final Report on incident at NHS Greater Glasgow and Clyde QEUH March 2018

UPDATED: 28-06-18

Item	Description	Information required	Date required	Date received	Not received	Comments
1	Design information	List of all design standards, guidance and reference documents cited in the contract relevant to the water installation (including SHTM, SHPN, British Standards, Approved Codes of Practice, etc).	11-04-18	01-05-18 partial		Extract from employers requirements section 8.2.8 only.

Item	Description	Information required	Date required	Date received	Not received	Comments
2	Commissioning information	Test results and certificates for incoming water			✓	There is nothing regarding the Scottish Water tests **<u>NHS GGC Response:</u>** To include the test certs once received from BMCL/Capita. Note no certification received but statement from Scottish Water.
		Test results and certificates for water tanks		13-04-18		
		Test results and certificates for hot and cold pipe work		13-04-18		
		Test results and certificates for hot water system		13-04-18		
		Water treatment test results and certification		13-04-18		

Item	Description	Information required	Date required	Date received	Not received	Comments
		Contractors pre handover risk assessment		18-05-18		**NHS GGC response:** As the water system is subject to regular/routine planned preventative maintenance and the contractor has provided PPM and manufacturer information a contractor risk assessment would not be expected.
		Water system handover documentation		01-05-18		

Item	Description	Information required	Date required	Date received	Not received	Comments
		Evidence of any issues with water system during construction or handover		18-08-18		There is nothing in writing of any issues with the water system, pipe work, fitting, fixings, sterilisation, flushing etc. **<u>NHS GGC response:</u>** No evidence found of any issues with water system during construction or handover
		Extent of flexible hose installations		01-05-18 partial		None to be installed under contract but these have been installed in rise and fall sanitary ware and by third party contractor.
		Commissioning documentation for flexible hose installations		01-05-18 partial		None installed under contract but these have been installed in rise and fall. No details of where the third party installation was/is.

Item	Description	Information required	Date required	Date received	Not received	Comments
		Pressure testing records		13-04-18		On Zutec

Item	Description	Information required	Date required	Date received	Not received	Comments
		O&M instructions for water system including any recommendations for PPM		01-05-18 partial	✓	There are no specific recommendations in ZUTEC that I can see for either thermal or chemical water treatment of the system. Other PPM in ZUTEC. There are different access levels within ZUTEC. IGS will recheck when access level changed. **28-06-18** ZUTEC checked. No specific mention of chemical or thermal treatment to the system. Specific recommendations on PPM for sanitary ware and equipment and water sampling and analysis.

Item	Description	Information required	Date required	Date received	Not received	Comments
		Specification for water services pipe work		01-05-18		316 stainless steel and Pegler Yorkshire “XPRESS”
		Records of pipe work inspection during construction		01-05-18		None available **NHS GGC response:** Capita were the appointed Project Supervisors. Capita had representation within the Project Site Offices on an almost daily basis. Capita undertook regular site visits. Capita had regular informal meetings with Brookfield and monthly formal meetings with the NHS Project team. Updates on pipework installation were included within their formal monthly reports.

Item	Description	Information required	Date required	Date received	Not received	Comments
3	Post handover	NHS GGC initial water risk assessment		01-05-18		DMA 2015 **NHS GGC response:** No NHSGGC written scheme (3.1)
		NHS GGC subsequent water risk assessments to date		01-05-18		DMA only **NHS GGC response:** These are required for both critical care and non critical care areas of the RSC and QEUH. First draft was done 2015 and has been a live document since. (3.2)

Item	Description	Information required	Date required	Date received	Not received	Comments
		Authorising Engineer (water) initial audit with recommendations		01-05-18		AE only no follow up **NHS GGC response:** Initial AE audit was not carried out until the hospital was fully operational as agreed with the previous SEM (Jim McFadden). However this was unfortunately delayed and subsequent audit was carried out on 4th May 2017 (3.3). A further audit is planned for June 2018.
		Authorising Engineer (water) subsequent audits with recommendations		01-05-18		None only one audit **NHS GGC response:** Audit date 4th May 2017. A further audit is planned for June 2018. (3.4)

Item	Description	Information required	Date required	Date received	Not received	Comments
		Appointment letters for Competent Persons (water)		18-05-18		**NHS GGC response:** No formal appointments made to date. AP is in process of assessing competent staff.
		Appointment letters for Authorised Persons (water)		18-05-18		**NHS GGC response:** No formal appointments made to date. Copy of AP letter for Mel MacMillan sent to HFS on 6/6/18
		Appointment letters for Designated Person (water) Responsible Person (water) Deputy Responsible Persons (water)			✓	**Additional** **NHS GGC response:-** This are still to outstanding.

Item	Description	Information required	Date required	Date received	Not received	Comments
		Training records for all AP(W) and CP(W)		01-05-18 partial		Training records for 8 operatives in 2018 on HTM not SHTM. Not clear how many operatives are at QEUH. No training records prior to 2018
		Minutes of all water safety group meetings since handover		01-05-18		Minutes of Board Water Safety Group meetings received

Item	Description	Information required	Date required	Date received	Not received	Comments
		Results of any organisms found and water treatment to eradicate same		15-05-18 partial	✓	This relates to before the current incident and post handover Organism results received. Water treatment outstanding. **<u>NHS GGC response:</u>** Results of testing are contained within folder 3.9. Further results after handover to be forwarded when J.Guthrie returns from A/L next week. (3.9)

Item	Description	Information required	Date required	Date received	Not received	Comments
		Cold water temperature records (system)		13-04-18 01-05-18 partial	✓	Critical care areas only received CWS tanks received **<u>NHS GGC response:</u>** Water storage tank trends submitted in folder 3.10. An example of the CW temperatures recorded on taps in non critical areas are also included. Full extensive records available if required. (3.10) IGS note: these are sentinel points from 2015.

Item	Description	Information required	Date required	Date received	Not received	Comments
		Hot water temperature records (system)		13-04-18 01-05-18 18-05-18		Critical care areas only received DHW **<u>NHS GGC response:</u>** Calorifier trend logs submitted in folder 3.11. An example of the HW temperatures recorded on taps in non critical areas are also included. Full extensive records available if required. (3.11) IGS note. These are for 2018. It would be useful to have records indicting deviations in DHW system.

Item	Description	Information required	Date required	Date received	Not received	Comments
		Tap temperature records (mixed, hot, cold)		13-04-18 01-05-18 partial	✓	Critical care areas only received 2015 sentinel **NHS GGC response:** Examples in folder 3.12 (3.12)
		Main filtration system PPM		01-05-18 18-08-18		PPM by third party for filtration plant some for 2016 and 2017. **NHS GGC Response:** Examples in folder 3.13 Next due May 2018. (3.13)
		Water storage tank turnover versus storage volume		01-05-18		Figures for October 2016 hardgate road and govan road **NHS GGC Response** Table contained in folder 3.14 (3.14)

Item	Description	Information required	Date required	Date received	Not received	Comments
		Competency of company and individuals carrying out risk assessment		13-04-18		For DMA NHS GGC response Contained in folder 3.15 (3.15)

Item	Description	Information required	Date required	Date received	Not received	Comments
4	Water treatment	Details of PPM water systems		13-04-18 partial	✓ **Additional** **Additional** **Additional**	Received for critical care areas. PPM for other areas required (excel sheet shows showers for all areas and taps only for critical areas). Who maintains the showers as part of the rise and fall baths and frequency? **NHS GGC Response:** There is possibly only 1 bath affected and this will be checked. Main water tank has a DMA report (2017) which has various points to be addressed...have these been dealt with satisfactorily? **NHS GGC Response:** Order issued for tank cleaning on Feb 2018. Cleaning and disinfection of main water tanks has been scheduled to address any issues. Due to restrictions for isolation and draining of the tanks a

Item	Description	Information required	Date required	Date received	Not received	Comments
		Details of chemical treatments on any part of the water system post hand over			✓	**<u>NHS GGC response:</u>** There were 3 recorded events Pharmacy Aseptic Unit Feb 2016 PICU Dec 2016 Adult Renal June 2016 Records of the actions in relation to these events will be available when J.Guthrie returns from leave.
		Details of thermal treatments on any part of the water system post hand over			✓	
		Details of testing regime (frequency, for which organisms, TVC results, organism results etc)		13-04-18 partial	✓	Sample results from 13-01-18 and 13-02-18 for 4B and critical areas for 2017. Program info required

Item	Description	Information required	Date required	Date received	Not received	Comments
		Details of company taking water samples, training records, methodology.		13-04-18 partial	✓	DMA taking samples in critical care areas; who is taking samples in non critical areas; details of competency, methodology, etc.
5	Horne Taps	Adult hospital commissioning results for taps		13-04-18		
		Children hospital commissioning results for taps		13-04-18		
		PPM records for taps		13-04-18		**NHS GGC Response:** Non critical area TMTs, TSVs have not been included in the service plan. Non-critical area sampling not required as per SHTM04-01.
		Drop tests for taps		13-04-18		
6	Contour Taps	Adult hospital commissioning results for taps		13-04-18		

Item	Description	Information required	Date required	Date received	Not received	Comments
		Children hospital commissioning results for taps		13-04-18		
		PPM records for taps		13-04-18 18-05-18		**NHS GGC Response:** Non critical area TMTs, TSVs have not been included in the service plan.
		Drop tests for taps		13-04-18		
7	Showers	Adult hospital commissioning results for showers		13-04-18		
		Children hospital commissioning results for showers		13-04-18		
		PPM records for showers		13-04-18		
		Drop tests for showers		13-04-18		
		Details on all shower types		13-04-18		
		Records for shower hose and head replacements since handover		01-05-18 partial	✓	No replacement records, but chlorination records 2017

Item	Description	Information required	Date required	Date received	Not received	Comments
8	Wash hand basins (clinical and non-clinical)	Design brief for requirements including dimensions		01-05-18		
		Details of what has been installed		13-04-18		
9	Drains (WHB and Showers)	Records of PPM		18-05-18		**NHS GGC response:** None recorded and no actions required. Estates do not routinely carry out sampling in drains. This would only be done as requested by Infection Control.
		Records of any organisms found and treatment to eradicate.		18-08-18		**NHS GGC Response:** None recorded and no actions required as per SHTM04-01 This would only be done as requested by Infection Control

Item	Description	Information required	Date required	Date received	Not received	Comments
10	Point of use filters	Cleaning regime		13-04-18		**NHS GGC Response:** Current recommendations passed to NHSGG&C from PALL Europe indicate that no cleaning should be carried out on filter casings. This is to eliminate the possibility of cross contamination or breaching the integrity of the filter membrane.
		Replacement regime		13-04-18		Discussed and recorded at meetings

Appendix 4

NHS GGC QEUH and RCH
Incident timeline

Acknowledgements

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Health Protection Scotland

NHS National Services Scotland

Situational Assessment
Wards 2A/B
Royal Hospital for Children
NHS Greater Glasgow and Clyde

Status: Confidential Draft

Contents

Background

NHS Greater Glasgow and Clyde (NHSGGC) are currently investigating and managing a contaminated water system across the Queen Elizabeth University Hospital (QEUH) and Royal Hospital for Children (RHC) with probable linked cases of bloodstream infections associated with wards 2A/2B RHC. During this investigation it was identified that there was a higher than expected level of Healthcare Associated Incidents (HCAI) linked to wards 2A/2B. The National Support Framework (http://www.nipcm.scot.nhs.uk/documents/the-national-support-framework-2017//) was invoked by the Scottish Government HAI/AMR Policy Unit to request Health Protection Scotland (HPS) undertake a review of Ward 2A/2B.

Due to the ongoing water contamination investigation and resultant summary report being prepared by HPS for Scottish Government it was agreed that whilst the review of wards 2A/2B was ongoing the report would not be undertaken until final submission of the water investigation report was completed. The final submission of this report was on 21st December 2018.

Wards 2A/2B RHC is a paediatric haemato-oncology unit, also known as Schiehallion, and houses the National Bone Marrow Transplant (BMT) Unit. The RHC is a 256 bedded childrens hospital which was handed over to the Board on 26th January 2015 with migration of patients occurring between 10h and 14th June 2015 from the previous Yorkhill site. The RHC was fully occupied from 15th June 2015.

All water related issues linked to wards 2A/B are discussed in the water incident report submitted to Scottish Government 21st December 2018 and not within this report. In addition a ventilation review of wards 2A/2B is currently being undertaken and will be covered within a separate NHSGGC report.

Wards 2A/2B closed on 26th September 2018 to allow for a works relating to water contamination to be completed. At this time the opportunity was taken to review the ventilation. Patients were transferred to wards 6A/4B at the Queen Elizabeth University Hospital.

Introduction

Since January 2016 NHSGGC have reported 15 Healthcare Infection Incident Assessment Tool (HIIAT) incidents/outbreaks within wards 2A/2B RHC. Comparative data for this setting (all paediatric hospitals) within NHSScotland identified no reported incidents or outbreaks outwith NHSGGC. The HIIAT allows NHS boards to assess the impact of a healthcare infection incident/outbreak on patients, services and public health and should be used by the Infection Prevention and Control Team (IPCT) or Health Protection Team (HPT) in their assessment of any incident/outbreak within a healthcare setting. In addition it supports a single communication channel for infection incident/outbreak assessment and reporting both internally within an NHS board area and externally to Health Protection Scotland (HPS) and Scottish Government Health and Social Care Department (SGHSCD).

Mandatory HIIAT Green (non-norovirus) reporting for NHS boards was introduced in April 2016; providing a more robust epidemiological picture of incidents and outbreaks across acute healthcare in NHSScotland. A HIIAT assessment is scored Red, Amber or Green according to a four part criteria:

- Severity of illness
- Impact on services

- Risk of transmission
- Public anxiety

Of the 15 HIIATs reported from 2A/2B since 2016 there have been 5 reds, 2 ambers and 8 greens reported to Health Protection Scotland (HPS). Details of the incidents reported are contained in appendix 1. Four of these HIIATs (2 red and 2 green) are attributed to the ongoing water incident. It could be hypothesised that ventilation may have been a contributory factor in several incidents however this cannot be confirmed until a full ventilation review has been completed.

Wards 2A/2B Assessment

Observational assessment walk rounds of wards 2A/2B was undertaken by a Senior Nurse Infection Control from HPS on 18th to 22nd June, 2nd July and 8th August 2018.. During these walk rounds practice and environmental hygiene were observed.

A meeting was held between the Chief Nurse Hospital Paediatrics and Neonatology, Consultant Surgeon and two Nurse Consultants Infection Control (HPS) to discuss ongoing work into central line-associated blood stream infections (CLABSI). This meeting took place on 17th July 2018.

It is noted that overall practice was described as good with no major issues observed or reported. Compliance with standard infection control precautions (SICPS), particularly hand hygiene, use of personal protective equipment and environmental cleanliness was observed to be good. Awareness of infection control practices were high with noteable visibility of the local infection prevention and control team (IPCT).

Ward 2A Overview (Floor plan appendix 2)

- Ward 2A consists of 25 ensuite single rooms.
- There are three distinct areas to the ward; the BMT bedrooms, standard rooms and the remaining Teenage Cancer Trust (TCT) and haemato-oncology rooms.
- The main entrance to the ward is through the entrance at the BMT section of the ward.
- Children with haemato-oncology and haematology disorders are the main patient population within this ward.

Ward 2B Overview (Floor plan appendix 3)

- Ward 2B consists of five consultation rooms and two 4-bed-bay areas.
- Ward 2B has a main waiting area at the reception of the ward with a TCT waiting area beside the TCT bay area.
- Ward 2B cares for children with haemato-oncology and haematology disorders on a Monday to Friday day care basis.

Water
A detailed summary report was prepared and submitted to HAI/AMR Policy Unit on 21st December 2018. This summary report documents all the findings from water-related investigations carried out until the decant of patients from Ward 2A/2B.

Ventilation
Work has been undertaken to convert the positive pressure ventilated lobbied rooms (PPVL) used predominantly for bone marrow transplant recipients into specification compliant positively pressured isolation rooms.

Ventilation within these wards is subject to a review by NHSGGC and will be covered in the resultant report. An SBAR covering initial findings has been prepared at the request of Scottish Government (SG) and submitted to SG by NHSGGC (November 2018).

Chilled beams
Chilled beams were noted to have significant level of dust present in two separate rooms (Ward 2A) there was also discolouration to the edges of the ceiling around the supply. This is potentially due to water contamination and was under review by estates department.

Dripping from the chilled beams had been observed by staff on a number of occasions. This was reported to estates and it has been identified that there were no dew point controls on the chilled beams. A dew point control has been fitted to the central system to alleviate the issue.

Temperature
Ward 2A was observed to be very warm and humid on the day of the visit and staff reported this was common for the ward.

HEPA filtration
The corridors within these wards are not HEPA filtered. The previous facility within Yorkhill hospital was reported to have 8 HEPA filtered rooms with all other rooms being conventionally ventilated.

Pressure stabilisers
Pressure stabilisers were noted in the rooms and also to the corridor of all the BMT rooms. There was no noted issue with overall pressures during this time however some of the stabilisers were noted to have no oscillation when the doors were opened.

Air Changes
It is noted from an SBAR prepared by NHSGGC on 12th November 2018 that the single room accommodation has a nominal air change rate of 2.5 air-changes per hour (ACH).

Air flow/pressure
The single rooms are negative to neutral pressure relative to the ward corridor. There is a further potential risk whereby extract air via the ensuite toilets may combine with the air supply passing through the thermal wheel which may result in an increased chance of cross contamination between single rooms.

All aspects of ventilation including the mixing of extract air with air supply and the potential resultant cross contamination risk will be explored as part of the ventilation review by NHSGGC.

Standard Infection control precautions (SICPs)
Compliance with SICPs was noted to be good, including hand hygiene and the use of personal protective equipment. A programme of monthly SICPs monitoring is in place. All SICPs audits reviewed at the time of the visit were of an optimal score. The IPCT undertake environmental audits in line with the agreed NHSGGC IPCT monitoring programme. At the time of the walkround it was reported that both wards had been given a GREEN audit score at the last IPCT audit. Follow up audit results from August 2018 have been reported as 96% (GOLD) for ward 2A and 98% (GOLD) for ward 2B.

Central Venous Line Management

Significant work has been undertaken across RHC relating to line management. A central venous line quality improvement project steering group was formed in May 2017 following a noted increase in line infections. The group collected data on central line-associated blood stream infections (CLABSI) on a week-by-week basis on lines inserted on the RHC site and includes all patients within the haemato-oncology cohort (including those cared for at home, shared with other hospital sites and inpatients). It was reported that the figures for CLABSI (outwith the BSIs identified as part of the water related incident) are reducing. The group is led by the Chief Nurse (RHC) and a consultant paediatric surgeon.

HPS undertook an epidemiological review of all positive blood samples from patients recorded as being admitted to wards 2A/2B and compared these to samples obtained prior to the move from Yorkhill and those obtained from patients in other areas of the hospital. A detailed report on the findings is included in appendix 4.

Summary

Any issues identified during the walkround visits were reported to staff at the time to ensure they were addressed. Overall there were no significant practice related concerns identified and awareness of infection prevention and control by all staff was high. There was a good presence of the infection prevention and control team on both wards with daily visits (Monday to Friday) being undertaken. A joint weekly walkround with infection control staff, nursing staff, facilities and estates staff is undertaken in an attempt for early identification of any issues which require to be addressed.

Based on the ward reviews and the epidemiological data presented in this report it is hypothesised that the increased number of HIIAT reports could all be linked to environmental factors and are not considered to be indicative of poor or compromised practice.

Recommendations

Consideration should be given to:

- The ventilation review underway within wards 2A/2B is completed with the involvement of the IPCT.
- A ventilation review is undertaken in other areas across RHC/QEUH in particular areas where high risk patients are to ensure compliance with national guidance.
- Issues identified within the ventilation review which are considered by the IPCT to pose an increased risk of cross infection should be addressed and signed off by the IPCT prior to repatriation of the patients.
- High visibility of IPCT within the wards should continue.

- CLABSI work continues.
- IPCT continue to observe infection rates and trigger breaches and report as per HIIAT where required.

Appendix 1: HIIAT Assessments

NHSScotland Incident and Outbreak Summary Ward 2A RHC (January 2016- Dec 2018).

NHS Greater Glasgow and Clyde have reported a total of 10 outbreaks and incidents for the clinical setting paediatric haemato-oncology. Of the 15 incidents and outbreaks HIIAT assessed; 5 were Red, 2 were Amber and 8 were Green. The data is displayed in the tables below providing a breakdown of the outbreaks reported by annual period with exception of the current period to date for 2018 and HIIAT Green in 2016 following introduction of mandatory report (non-Norovirus) from April 2016. Comparative data for this setting within NHSScotland identified no reported incidents or outbreaks outwith NHS Greater Glasgow and Clyde.

2018:

Table 1 NHS Greater Glasgow & Clyde, RHC haemato-oncology (ward 2A), HIIAT RED 2018 – Total (2)		
Date reported	**Organism**	**Infection Category**
01/03/2018	*Pseudomonas aeruginosa* or *Cupriavidus pauculus*	BSI
18/05/2018	*Stenotrophomonas maltophilia*	BSI

Table 2 NHS Greater Glasgow & Clyde, RHC haemato-oncology (ward 2A), HIIAT AMBER 2018 – Total (1)		
Date reported	**Organism**	**Infection Category**
10/04/2018	Astrovirus	Respiratory

Table 3 NHS Greater Glasgow & Clyde, RHC haemato-oncology (ward 2A), HIIAT GREEN 2018- Total (4)		
Date reported	**Organism**	**Infection Category**
03/05/2018	Vancomycin- Resistant *Enterococci*	GI
18/05/2018	*Enterobacter cloacae*	BSI
20/07/2018	*Aspergillus fumigatus*	Respiratory
05/09/2018	Various	BSI

2017:

Table 4 NHS Greater Glasgow & Clyde, RHC haemato-oncology (ward 2A), HIIAT RED 2017 – Total (3)		
Date reported	**Organism**	**Infection Category**
07/03/2017	*Aspergillus fumigatus*	Airborne
13/04/2017	Rotavirus	GI
26/07/2017	*Stenotrophomonas*	BSI

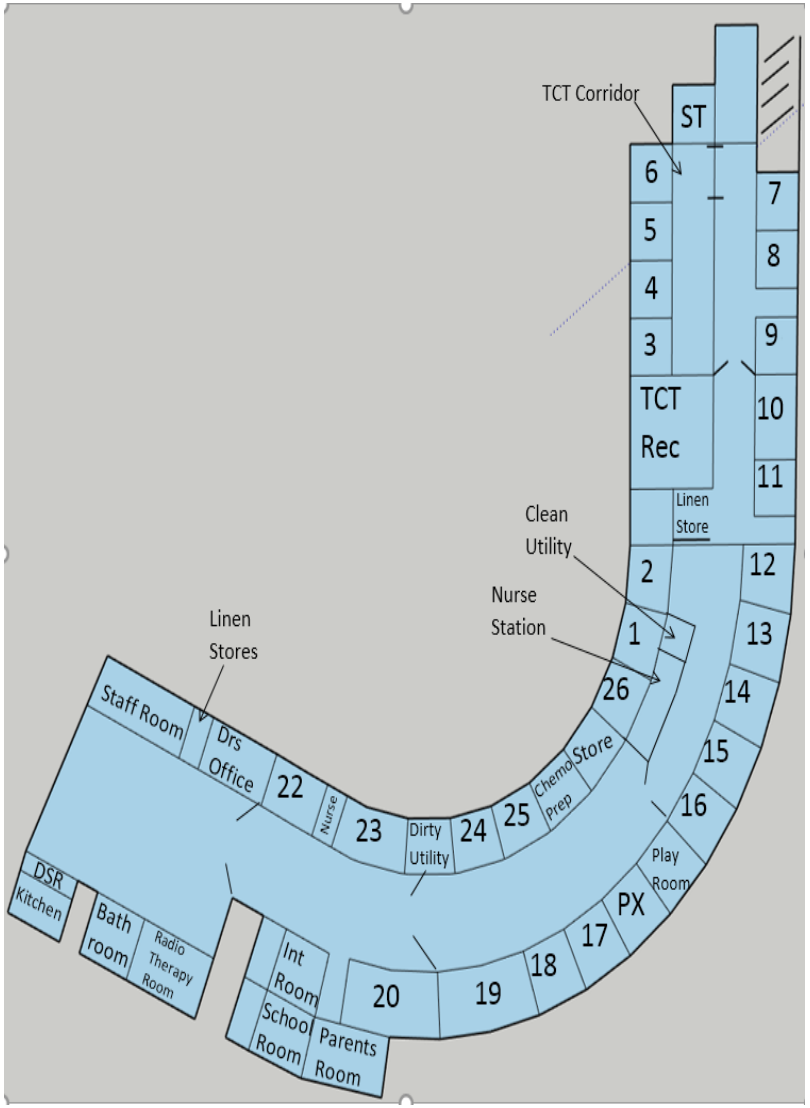
Table 5 NHS Greater Glasgow & Clyde, RHC haemato-oncology (ward 2A), HIIAT GREEN 2017 – Total (3)		
Date reported	**Organism**	**Infection Category**
03/03/2017	*Elizabethkingia miricola*	BSI
03/03/2017	Mixed	BSI
31/05/2017	Norovirus	GI

2016:

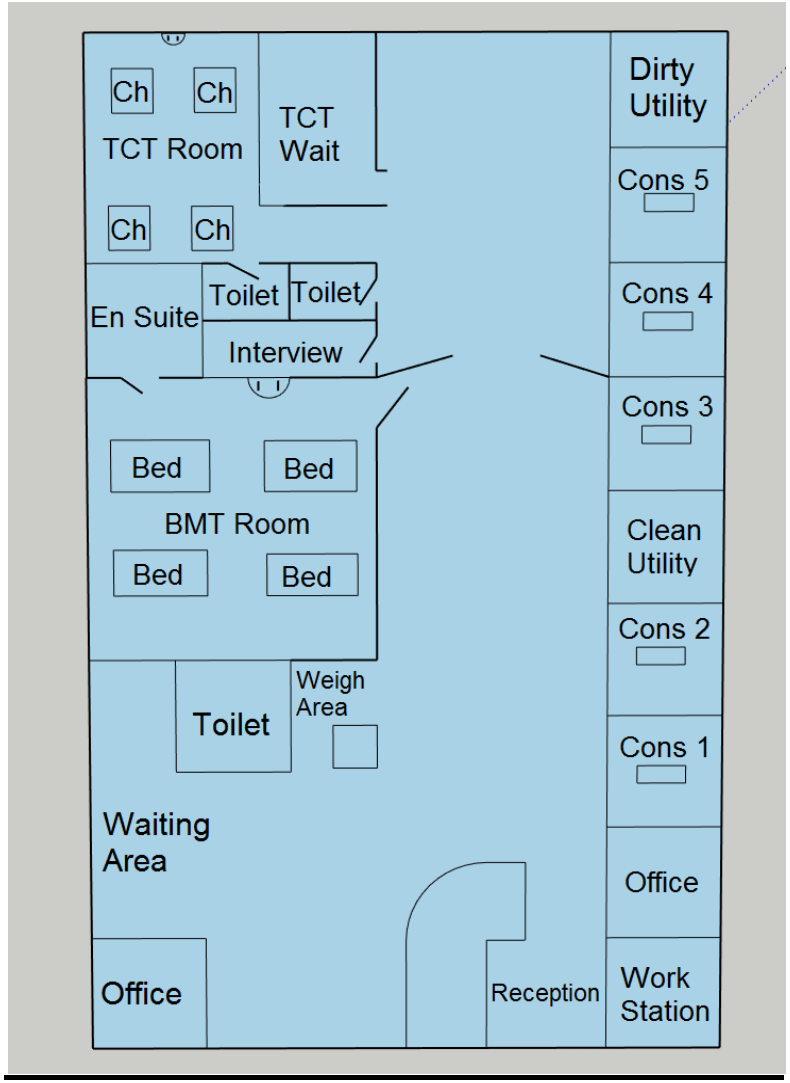
Table 6 NHS Greater Glasgow & Clyde, RHC haemato-oncology (ward 2A), HIIAT AMBER 2016- Total (1)		
Date reported	**Organism**	**Infection Category**
05/08/2016	*Aspergillus*	Respiratory

Table 7 NHS Greater Glasgow & Clyde, RHC haemato-oncology (ward 2A), HIIAT GREEN 2016- Total (1)		
Date reported	**Organism**	**Infection Category**
04/08/2016	Vancomycin- Resistant *Enterococci*	GI

Appendix 2: Ward Floor Plan 2A



Appendix 3: Ward Floor Plan 2B



Appendix 4: Health Protection Scotland - Epidemiology Report, December 2018

Royal Hospital for Children, NHS Greater Glasgow & Clyde

Background

Health Protection Scotland (HPS) were asked to support NHS Greater Glasgow and Clyde (NHSGGC) with the ongoing investigation of the potentially contaminated water system at the Royal Hospital for Children (RHC). The RHC opened in June 2015 replacing Yorkhill Hospital (YH). The patient population that was cared for in Schiehallion ward and Ward 7A of Yorkhill Hospital are now cared for in Wards 2A and 2B of RHC. The purpose of this report is to describe the incidence of positive blood cultures in the patient population cared for in these wards and more widely across RHC/YH hospitals, before and after the move to the RHC.

Methods

For the purposes of this report, the patient population was categorised into two groups:

- 2A/2B Group
    - Patients cared for in Yorkhill Hospital (YH) Schiehallion or Ward 7a; Royal Hospital for Children (RHC) Wards 2A and 2B; patients cared for in haematology/oncology specialties including A&E admissions with previous admission to RHC haematology/oncology specialties.
- RHC Other Group:
    - Patients cared for in other specialties in RHC/YC

Case and episode definitions

Data were extracted from the Electronic Communication of Surveillance in Scotland (ECOSS) system. An extract of all positive blood cultures for any patient under 16 years of age in NHSGGC was taken from ECOSS on the 13th June 2018 with an update taken on 20th August 2018. The case definition was a positive blood culture reported in patients aged less than 16 years in RHC/YC between July 2013 and June 2018. An episode was defined as one positive sample per species in a rolling 14-day period.

Microbiology

Positive blood cultures of the following micro-organisms were included:

- Gram-negative bacteria
- Gram-positive bacteria
- *Staphylococcus* species
- Environmental bacteria (all species of the following: *Achromobacter; Acinetobacter; Aeromonas; Brevundimonas; Brevibacillus species; Brevundimonas; Burkholderia; Chryseobacterium; Citrobacter; Cupriavidus; Delftia acidovorans; Elizabethkingia; Enterobacter; Klebsiella; Pantoea; Pseudomonas; Rhizobium; Rhodococcus; Serratia; Sphingomonas; Stenotrophomonas).*

- Non environmental bacteria (all species of the following: *Abiotrophia; Actinomyces; Aerococcus; Bacillus; Bacteroides; Bifidobacterium; Brevibacterium; Capnocytophaga; Clavibacter; Clostridium; Corynebacterium; Dermacoccus; Dietzia; Enhydrobacter; Enterococcus; Escherichia; Fusobacterium; Gemella; Granulicatella; Haemophilus; Kingella; Kocuria; Lactobacillus; Lactococcus; Leclercia; Leuconostoc; Microbacterium; Micrococcus; Moraxella; Mycobacterium; Neisseria; Paenibacillus; Propionibacterium; Proteus; Raoultella; Roseomonas; Rothia; Salmonella; Staphylococcus; Streptococcus; Veillonella).*
- Fungi (all species of the following: Candida; Rhodotorula).

The following species were previously isolated in water samples from 2A/2B: *Achromobacter*;*Acinetobacter; Brevundimonas*;*Burkholderia; Chryseobacterium; Comamonas; Cupriavidus; Delftia acidovorans; Elizabethkingia; Pantoea; Pseudomonas; Rhizobium; Sphingomonas*;*Stenotrophomonas*.

The following species were previously isolated in drain samples from 2A/2B: *Citrobacter; Cupriavidus; Delftia acidovorans; Enterobacter; Klebsiella; Pantoea; Pseudomonas; Serratia; Stenotrophomonas.*

Analytical methods

The total numbers of episodes of positive blood cultures in the included micro-organisms were described and polymicrobial episodes, where more than one species was identified in the blood sample, were compared in the 2A/2B Group with the RHC Other Group. Monthly incidence rates were calculated using bed-days at specialty level as the denominator. These data were obtained from the Information Services Division ISD(S)1 data source. The denominators for the 2A/2B Group were the monthly number of bed-days for haematology/oncology specialties in RHC/YH. The monthly bed-days for all other specialties in RHC/YH were used as the denominators for the RHC Other Group.

The incidence rates between July 2013 and June 2018 were analysed using statistical process control (SPC) U charts.[1] The SPC charts describe the incidence of positive blood cultures over time with the opening of the RHC represented in the charts with a vertical black line. In addition, the following control measures have been added to the 2A/2B chart – filters added to taps marked as an orange vertical line and cleaning of drains marked as purple vertical line.

The incidence rates for Gram-negative bacteria, Gram-positive bacteria, environmental bacteria and fungal blood cultures before and after the move to RHC were calculated and compared using rate ratios. In addition, two SPC charts were created each for Gram-negative, Gram-positive and environmental bacteria positive blood cultures; one for 2A/2B Group and one for the RHC Other Group. The centreline of the SPC was calculated as the median of the monthly rates between July 2013 and June 2018. The following SPC rules were applied:

TABLE 1: Statistical Process Control (SPC) rules

Rule	Description	Marker
Outlier	Data point(s) exceeding the upper or lower control limit (as 3 standard deviations)	Red diamond
Trigger point	Data point(s) exceeding the upper or lower warning limit (as 2 standard deviations)	Yellow triangle
Shift	A run of 8 or more consecutive data points above or below the centreline	Circle drawn round points
Trend	A run of 6 or more consecutive data points either increasing or decreasing.	N/A

The incidence rate of positive blood cultures over the 5-year period and the latest two-year period were compared with the combined incidence rate of the other two Scottish children's hospitals (Royal Aberdeen Children's Hospital (NHS Grampian) and Royal Hospital for Sick Children (NHS Lothian)). These were compared by calculation of rate ratios and accompanying p-values.

Results

Episodes

A total of 1,786 episodes were identified in 1,149 patients in RHC/YH over the five-year period from July 2013 to June 2018. In the 2A/2B Group, there were 542 episodes in 234 patients (range 1 - 23 episodes per patient) with a median age of 4 years. In the RHC Other Group there were 1,244 episodes in 927 patients (range 1 – 17 episodes per patient) with a median age < 1 years. The number of episodes in each patient group is described in TABLE 2. As the episode definition is by species, a patient could have more than one episode at any one time. TABLE 2 also describes the number of polymicrobial episodes when more than one species was identified in blood sample(s). Patients in the 2A/2B group were more likely to have a polymicrobial episode of positive blood culture (p<0.001).

TABLE 2: Total number of episodes (n=1,786) broken into each subgroup of 2A/2B Group and RHC Other Group over 5 years

	2A/2B Group			RHC Other Group		
	Monomicrobial (n = 413)[1]	Polymicrobial (n = 129)[2]	Total (n= 542)	Monomicrobial (n = 1,101)[1]	Polymicrobial (n = 143)[2]	Total (n=1,244)
Gram-negative bacteria	110 (65%)	59 (35%)	169	193 (85%)	35 (15%)	228
Gram-positive bacteria	291 (82%)	66 (18%)	357	884 (89%)	105 (11%)	989
Staphylococcus species	208 (87%)	30 (13%)	238	643 (94%)	41 (6%)	684
Environmental	77 (61%)	50 (39%)	127	101 (81%)	23 (19%)	124
Non-Environmental	324 (81%)	75 (19%)	399	976 (89%)	117 (11%)	1,093
Fungi	12 (75%)	4 (25%)	16	24 (89%)	3 (11%)	27

[1] Monomicrobial was only one species isolated on the episode reporting date.
[2] Polymicrobial if more than one species was isolated from cultures of blood samples on the same day as the episode reporting date.

Incidence rates

Figures 1 to 3 describe the incidence rates using SPC charts showing the incidence of positive blood cultures before and after the move to the RHC (23 months of data from YH and 37 months from RHC).

Figure 1 describes the incidence of Gram-negative blood cultures in both patient groups. The incidence of Gram-negative blood cultures in the 2A/2B Group prior to the move and in the months following were below the centreline of the SPC.

From March 2017, there was a run of 10 months/data points above the centreline identifying an upward shift in the rate with one point above the upper warning limit (UWL).

In March and May 2018, the 2A/2B Group had a rate above the upper control limit (UCL) highlighting a higher than expected incidence of positive blood cultures.

No shift in rates was observed in the RHC Other Group however the rate was above the UWL in April 2014, February 2016 and April 2017. In addition, comparison of the overall incidence of Gram-negative blood cultures before and after the move to RHC indicated the rate was higher after the move in the 2A/2B Group (RR = 1.47, CI: 1.05 to 2.04, p = 0.023) and did not change in the RHC Other Group (RR = 1.15, CI: 0.87 to 1.52, p = 0.34).

FIGURE 1: SPC charts of Gram-negative blood culture incidence rates per 1,000 total occupied days for 2A/2B Group and RHC Other Group.

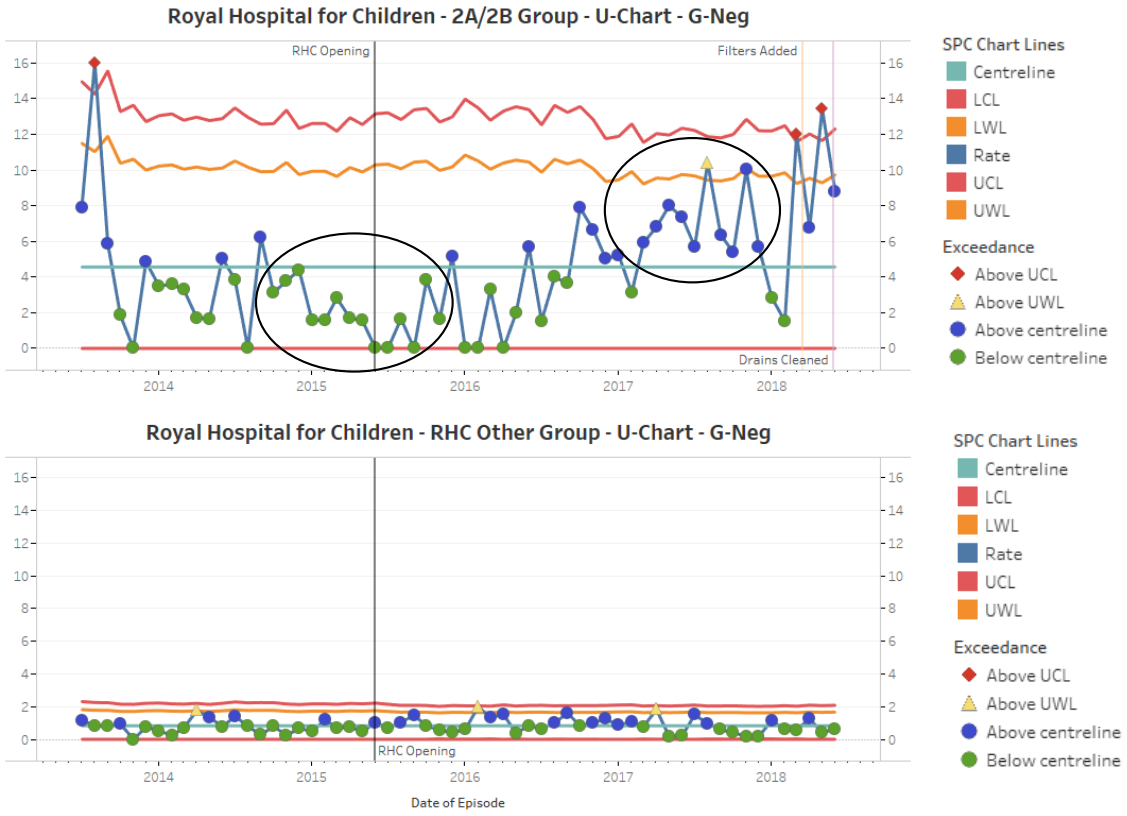
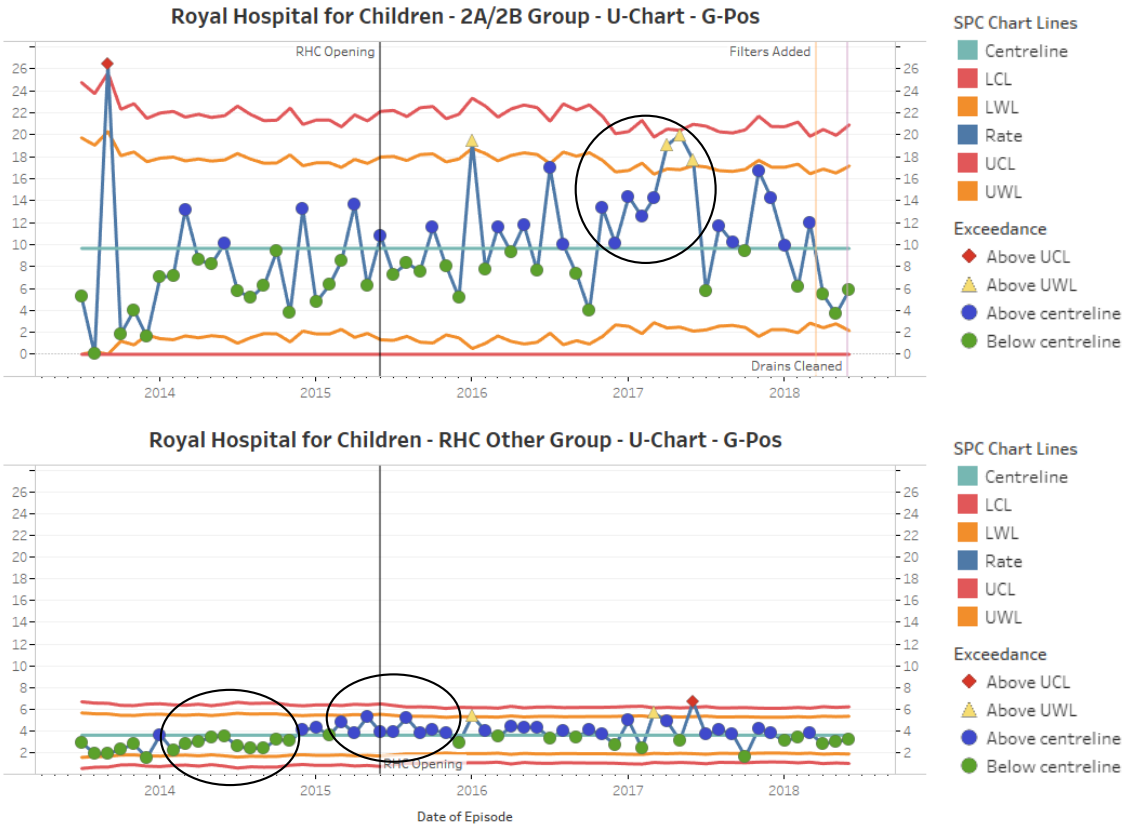


Figure 2 describes the incidence of Gram-positive blood cultures in both patient groups.

There was an upward shift in incidence of Gram-positive blood cultures in the RHC Other Group prior to the move with rates above the UWL in January 2016 and March 2017 and an outlier (above the UCL) in June 2017.

In 2A/2B Group, there was an upward shift after the move and the rate was above UWL in January 2016, and in April, May and June 2017. *Staphylococcus* species accounted for 52% of the Gram-positive blood culture episodes with 45% of those being *Staphylococcus epidermidis*. In addition, comparison of the overall incidence of Gram-positive blood cultures before and after the move to RHC indicated the rate was higher after in both the 2A/2B Group (RR = 1.43, CI: 1.14 to 1.81, p = 0.002) and the RHC Other Group (RR = 1.23, CI: 1.07 to 1.41, p = 0.003) .

FIGURE 2 SPC charts of Gram-positive blood culture incidence rates per 1,000 total occupied days for 2A/2B Group and RHC Other Group.



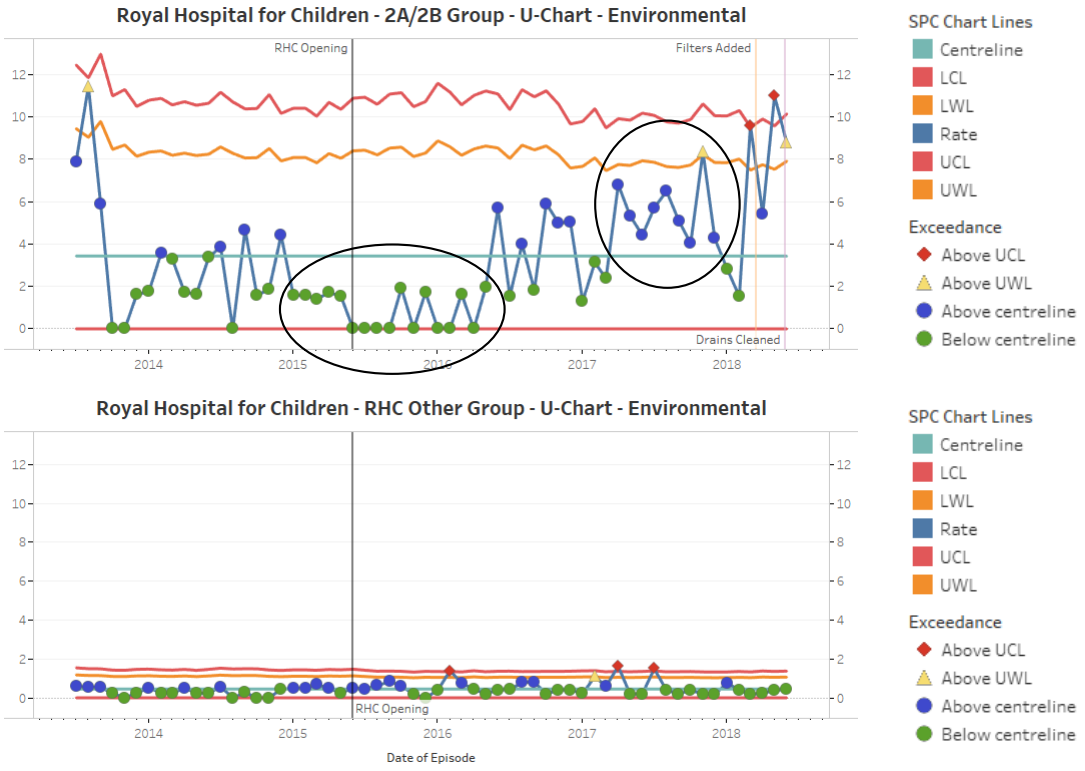
The incidence of positive blood culture caused by species of environmental bacteria (described in the methods section) which included all species isolated in water or drain samples taken from 2A/2B are shown in Figure 3.

In the 2A/2B Group, the SPC chart shows a shift below the centreline for 17 months from January 2015 to May 2016, then a shift above the centreline from April 2017 to December 2017. The rate was also above the UCL, and therefore higher than expected, in March and May 2018 and was above the UWL in November 2017 and June 2018.

There were no shifts in the incidence rates in the RHC Other Group, though the incidence was above the UCL in February 2016, April 2017 and July 2017 and above the UWL in February 2017.

In addition, comparison of the overall incidence of environmental bacteria positive blood cultures before and after the move to RHC indicated the rate was marginally higher in both the 2A/2B Group (RR=1.45, CI 0.98 to 2.13, p=0.06) and RHC Other Group (RR = 1.52, CI: 1.02 to 2.29, p=0.04) however the 2A/2B group the increase was not significant (p >0.05) which may be due to the small sample size.

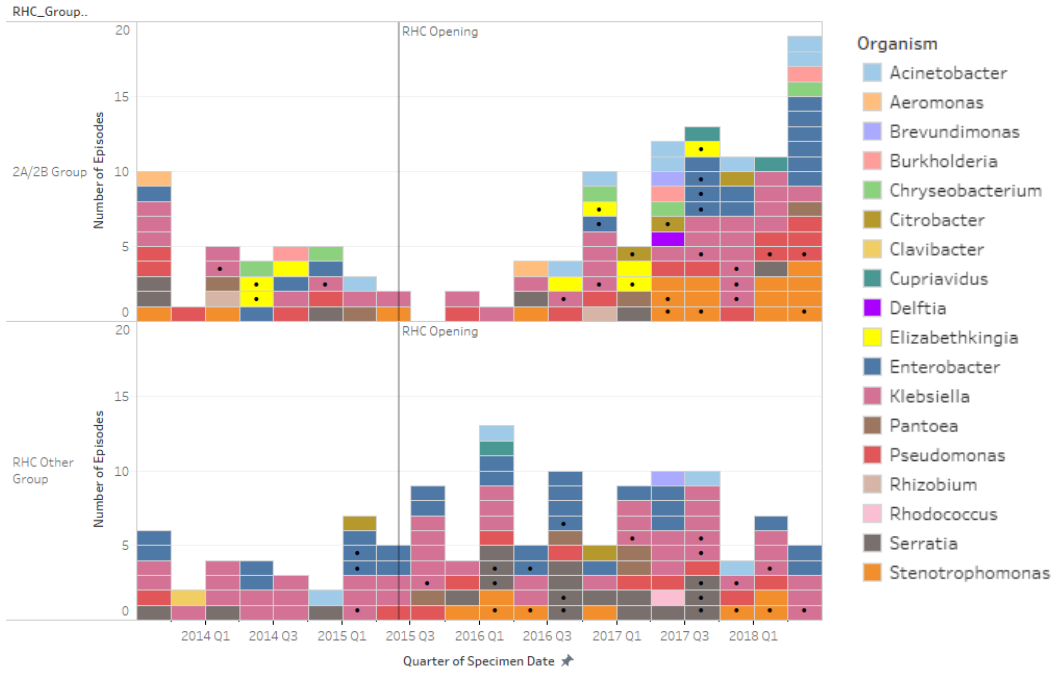
FIGURE 3: SPC charts of environmental bacteria blood culture incidence rates per 1,000 total occupied days for 2A/2B Group and RHC Other Group.



A comparison of the overall incidence of fungal positive blood cultures before and after the move to RHC indicated the rate did not change after the move in either group (2a2b group RR = 1.65, CI: 0.53 to 5.12, p = 0.40; RHC Other group RR = 0.86, CI: 0.40 to 1.89; p = 0.71).

Figure 4 describes the environmental bacteria blood culture isolates in both groups. The episodes with dots represent the first and recurrent episodes of the same species in the same patient. There were 20 patients with two episodes, one patient with three episodes and one patient with five episodes.

FIGURE 4: Quarterly episodes of environmental organism blood cultures in 2A/2B group and RCH other group. Dots represent the first and recurrent episodes of the same species from the same patient.



Comparison with other health boards

When comparing the overall rate over 5 years at RCH/YH to the combined rate of the other two Scottish children's hospitals (Royal Aberdeen Children's Hospital (NHS Grampian) and Royal Hospital for Sick Children (NHS Lothian)), the incidence of positive blood cultures in RCH/YH was higher compared with the other hospitals for environmental bacteria (RR = 1.70, CI: 1.34 to 2.16, $p < 0.001$) and fungi (RR = 5.36, CI: 2.12 to 13.53, $p < 0.001$), but lower for Gram-positive bacteria (RR = 0.71, CI: 0.66 to 0.77, $p < 0.001$) and non-environmental bacteria (RR = 0.79, CI: 0.73 to 0.85, $p = 0.001$). There was no difference in the rates of Gram-negative blood cultures (RR = 1.12, CI: 0.95 to 1.33, $p = 0.16$).

When compared over 2 years (July 2016 to June 2018), the rate of positive blood cultures was higher in RCH/YH for environmental bacteria (RR = 2.74, CI: 1.47 to 5.10, $p < 0.001$), Gram-negative bacteria (RR = 1.29, CI: 1.01 to 1.66, $p = 0.038$) and fungi (RR = 12.26, CI: 1.65 to 90.97, $p < 0.001$)) and lower for Gram-positive bacteria (RR = 0.81, CI: 0.72 to 0.92, $p = 0.001$) , and non-environmental bacteria (RR = 0.79, CI: 0.70 to 0.89, ($p<0.001$).

Summary and Recommendations

In summary, the overall incidence of Gram-negative, Gram-positive and environmental bacteria blood cultures increased in the 2A/2B Group after the move to the RHC. The RHC Other Group, the incidence of Gram-negative bacteria and fungal blood culture did not change and the incidence of Gram-positive and environmental bacteria blood cultures increased. SPC charts provide an alternative method of analysis that identifies variation at a level of detail not provided by comparison of incidence rates before and after the move to RHC. The SPC charts indicated that the Gram-negative, Gram-positive and environmental bacteria blood culture incidence rates in the 2A/2B Group were higher than expected following the move to RHC. The same changes in the incidence of blood cultures were not observed in the RHC Other Group. Whilst this conclusion must be interpreted with some degree of caution, as changes in the patient population have not been accounted for in this analysis, the shift in the incidence identified by the SPC charts indicates that the trends in blood culture incidence changed after this time.

Patients in the 2A/2B Group were more likely to have a polymicrobial episode than patients in the RHC other group. This was highest in the patients with a positive blood culture of environmental bacteria where nearly 40% had a polymicrobial blood culture. This is similar to figures reported in the literature with higher risk of polymicrobial bloodstream infection being associated with younger age groups and presence of central venous catheter.[3-6] The rate of environmental bacteria and fungal blood cultures were higher at RHC/YH than the other Scottish paediatric hospitals over 5 years and over the latest 2-year period. In contrast, the incidence of Gram-positive blood cultures, often considered to be associated with devices and device care, was lower in RHC/YH compared with the other Scottish paediatric hospitals.

Ward 2A and 2B have been closed since the 26th September 2018. It is recommended that when the wards re-open that all positive blood cultures are monitored in particular those related to an environmental organism.

Limitations

There are a number of limitations associated with the use of ECOSS blood culture data. All positive blood samples apart from those reported through mandatory surveillance programmes are non-validated records. The cases may include contaminants, and may include non-blood cases which are incorrectly mapped to a blood sample within either the laboratory system or within ECOSS. From the data collected through the enhanced *Staphylococcus aureus* bacteraemia (SAB) surveillance programme, 10% of episodes in under 16s were classed as contaminants[2] whereas the enhanced *Escherichia coli* bacteraemia (ECB) surveillance the figure was less than 1% (unpublished data).

The cases were identified using only laboratory data without any clinical review of patients. It is not possible to determine whether changes in incidence are confounded by changes in the patient population and their underlying medical conditions. Duplication per species in ECOSS may mean that a patient is recorded as having more than one episode of positive blood culture in a 14-day period leading to an overestimate of the number of episodes. The breakdown of polymicrobial samples only included isolates recorded on the same day as the episode reporting date which may underestimate the numbers of polymicrobial episodes.

In addition, the comparison between RCH/YC and paediatric hospitals in other health boards should also be interpreted with caution. Differences in the patient population between the RHC/YC and the other children's hospitals may introduce bias to the comparison.

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NHS National Services Scotland

Review of NHSGG&C paediatric haemato-oncology data

Health Protection Scotland

Report date
October 2019

This is management information and not official statistics

Status: Confidential Draft

This is a Management Information publication

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Contents

Introduction

Health Protection Scotland (HPS) supported NHS Greater Glasgow and Clyde (NHSGG&C) with a recent water related incident (March 2018 – September 2018) investigating and managing a contaminated water system across the Queen Elizabeth University Hospital (QEUH) and Royal Hospital for Children (RHC) with probable linked cases of bloodstream infections associated with wards 2A/2B RHC. Yorkhill Hospital (YH) relocated into the RHC in June 2015. Wards 2A/2B within RHC houses the haemato-oncology unit, also known as Schiehallion, the National Bone Marrow Transplant (BMT) Unit and the Teenage Cancer Trust (TCT). In September 2018, to allow remediation works to be undertaken in 2A/2B, patients were transferred to QEUH ward 6A and three rooms were allocated within the adult BMT of ward 4B for the paediatric BMT unit. To accommodate this move, adults from 6A were transferred to Gartnavel General. A **summary report** of the initial incident (Jan –Sept 2018) is available from Scottish Government web page.

Whilst a suspected increase in environmental Gram-negative blood cultures within ward 6A is investigated, admissions have been restricted since 1st August 2019.

The aim of this report is to review NHSGG&C paediatric haemato-oncology data and investigate the suspected increase in environmental Gram-negative blood cultures in the paediatric haemato-oncology population.

The objectives of this review are to:

- To describe the differences in the datasets currently being used to investigate cases of bacteraemia in patients cared for the in paediatric haemato-oncology wards in NHSGG&C.
- To review the environmental Gram-negative blood cultures in the paediatric haemato-oncology population.
- To identify whether there is a change in the type of reported environmental Gram-negative blood cultures in the paediatric haemato-oncology population.

Methods

The following data sets were provided for the review by NHSGG&C, further details can be found in Appendix 1 – Background information.

NHSGG&C data sets:

NHSGG&C CLABSI surveillance data

An extract was provided from the central line associated bloodstream infection (CLABSI) surveillance system for date range January 2015 –September 2019. CLABSI uses Centers for Disease Control (CDC) classification

> *'A CLABSI is a primary BSI in a patient that had a central line within the 48-hour period before the development of the BSI and is not bloodstream related to an infection at another site. However, since some BSIs are secondary to other sources other than the central line (e.g., pancreatitis, mucositis) that may not be easily recognized, the CLABSI surveillance definition may overestimate the true incidence of CRBSI'*

Paediatric haematology oncology patients were identified using theatre management system 'Opera' to obtain information on all patients who received a new central venous device at NHSGG&C and combining haematology oncology diagnosis via the Clinical Portal. This data was de-duplicated on a 7 day case definition per organism. Exclusion criteria include patients who have their central venous device inserted at another hospital even if the majority of their care was at RHC or if the patient was transferred to RHC with a CLABSI.

NHSGG&C ECOSS extract

Gram-negative extract was provided for data obtained locally from Electronic Communication of Surveillance in Scotland (ECOSS) for date range July 2013 – September 2019.

NHSGG&C Microbiology laboratory information management system (LIMS) Surveillance data

Microbiology laboratory information management system (LIMS) extract for date range June 2014 – September 2019. The dataset had been de-duplicated at species level by NHSGG&C. This is a dataset obtained through 'Telepath' the LIMS using a named consultant therefore linking cases from other hospitals/outpatients/previous admission/or coded elsewhere in the hospital which are linked to the unit through the consultant in charge of their care.

HPS dataset - ECOSS extract

A data extract from ECOSS system of all blood samples in children less than 18 years of age from 2013 to present was obtained the 7th October 2019. The following fields were used to assign the location of the samples. NHS Health Boards are coded by the location of the submitting laboratory. Additional hospital/ward data was derived from the ECOSS Unit Location field, or where incomplete free text within the medical specialty and requesting location fields were used to generate a final hospital list to be mapped against the total occupied bed days to generate hospital level rates.

For NHSGG&C hospitals, the free text within the unit location, medical specialty and requesting location fields are used to derive a location and ward within the hospital where the positive blood culture aspirated was associated, to find any specimens with a connection to wards 6A and 4B in the QEUH, ward 2A or 2B within RHC, or the equivalent within Schiehallion ward in Yorkhill hospital. In ECOSS the reporting laboratory codes for wards 6A and 4B were coded to RHC following the move to QEUH.

Positive blood cultures of the following micro-organisms were grouped. A full breakdown of the grouping is detailed in the Appendix 1:

- **Gram-negative bacteria**
- **Gram-positive bacteria**
- **Environmental bacteria group** all species of the following: *Achromobacter; Acinetobacter; Aeromonas; Brevibacillus species; Brevundimonas; Burkholderia; Cedecea; Chryseobacterium; Chryseomonas; Clavibacter; Comamonas; Cupriavidus; Delftia acidovorans; Elizabethkingia; Flavimonas; Gordonia; Pseudomonas; Pseudoxanthomonas; Psychrobacter; Ralstonia; Rhizobium; Rhodococcus; Roseomonas; Sphingomonas; Stenotrophomonas and atypical mycobacteria).*
- **Environmental including Enteric (ENT) group** - Environmental bacteria including following enteric organisms which as well as the environmental list above includes species of the following *Citrobacter; Enterobacter; Klebsiella; Pantoea; Serratia.*

Fungi (all species of the following: Candida; Rhodotorula) were excluded as it could not be established if all positive fungi blood cultures were being processed through ECOSS.

The following organisms grouped by genus, were previously isolated in water samples from ward 2A/2B: *Acinetobacter; Burkholderia; Chryseobacterium; Cupriavidus; Delftia acidovorans; Elizabethkingia; Pantoea; Pseudomonas; Rhizobium; Stenotrophomonas*.

The following organisms grouped by genus, were previously isolated in drain samples from ward 2A/2B: *Citrobacter; Cupriavidus; Delftia acidovorans; Enterobacter; Klebsiella; Pantoea; Pseudomonas; Serratia; Stenotrophomonas.*

Case definition

The trends in bacteraemia in this patient population were assessed using the HPS ECOSS data extract of positive blood cultures.

The study population includes patients less than 18 years of age cared for in the paediatric haematology oncology specialty in NHSGG&C (including new and existing patients).

A species level case definition was used in previous investigations and this was repeated for this review in order to make comparisons with the NHS GG&C datasets.

In order to account for the diversity of organisms likely to be identified if there is an environmental source and to account for polymicrobial episodes, case definitions were developed at group level. These groups are defined as an environmental bacteria group, environmental including enteric bacteria group and Gram-negative group. These groups are not mutually exclusive; therefore the trends analysis should be interpreted as such. A case definition for Gram-positive bacteraemia was also developed to provide context to the trends in the other groups.

From this population the proposed case definition of a case is defined as a patient with:

1) A positive blood culture of a single organism that has not been previously isolated from the patient's blood within the same 14 day period (i.e. 14 days from date last positive sample obtained).
2) A positive blood culture for any organism defined as environmental bacteria group (detailed above) that has not been previously isolated with same or other environmental bacteria group organism in the patient's blood within the same 14 day period.
3) A positive blood culture for an environmental including enteric bacteria group (detailed above) that has not been previously isolated with same or other environmental including enteric bacteria group organism in the patient's blood within the same 14 day period.
4) A positive blood culture where Gram-negative bacteria has been isolated in 14 day period that has not been previously isolated with same or other Gram-negative organism within the same 14 day period.
5) A positive blood culture where Gram-positive bacteria has been isolated in 14 day period that has not been previously isolated with same or other Gram-positive organism within the same 14 day period.

As per the case definition and to align with other national bacteraemia surveillance, a standard 14 day rolling deduplication was applied to the HPS ECOSS dataset. All positive blood cultures were included with the exception of post mortem blood, any quality test samples, foetal samples or non-human samples.

Denominator data

HPS use extracted data from ISD(1) provided by Information Services Division (ISD) for routine published reports. Due to unavailability of data for September 2019 data from August 2019 were used as a proxy.

Full details of ISD data collection can be obtained from
http://www.isdscotland.org/Products-and-Services/Data-Support-and-Monitoring/ISDS1/

The activity data extract provided information on occupied bed days and bed occupancy of haematology and oncology from July 2013 to August 2019. In addition, it provided data on combined haemato-oncology day cases and outpatient appointments. The outpatient figures included patents who did not attend (DNA).

Incidence Rate

Rate per 1,000 total occupied bed days (TOBDs) = (Number of cases of positive blood culture of given case definition in hospital(s) or speciality /TOBDs in hospital(s) or speciality x 100,000). Incidence rates for the whole of RHC (including positive blood cultures and bed days of wards 6A and 4B following the move to QEUH) were compared with combined rates from the Royal Hospital for Sick Children in Lothian and the Royal Aberdeen Children's Hospital in Grampian. R was used to calculate rate ratios (RR) with corresponding exact 95% Confidence Intervals (95%CI).

SPC Charts

Hospital and specialty data were analysed using Byars method for statistical process control (SPC) U-charts using the rules detailed in Table 1. The mean, trigger/warning (+2 standard deviations) and upper control limits (+3 standard deviations) are presented. These control lines vary by month due to variations in the TOBD denominator. The mean was calculated from the data prior to the move to RHC when available (HPS and NHSGG&C Gram-negative data). Further information on SPC charts can be found at :
http://www.isdscotland.org/Health-Topics/Quality-Indicators/Statistical-Process-Control/

Table 1: Statistical Process Control (SPC) rules.

Rule	Description	Marker
Outlier	Data point(s) exceeding the upper or lower control limit (as 3 standard deviations)	Red diamond
Trigger point	Data point(s) exceeding the upper or lower warning limit (as 2 standard deviations)	Yellow triangle
Shift	A run of 8 or more consecutive data points above the centreline	Circle drawn round points
Trend	A run of 6 or more consecutive data points either increasing or decreasing.	N/A

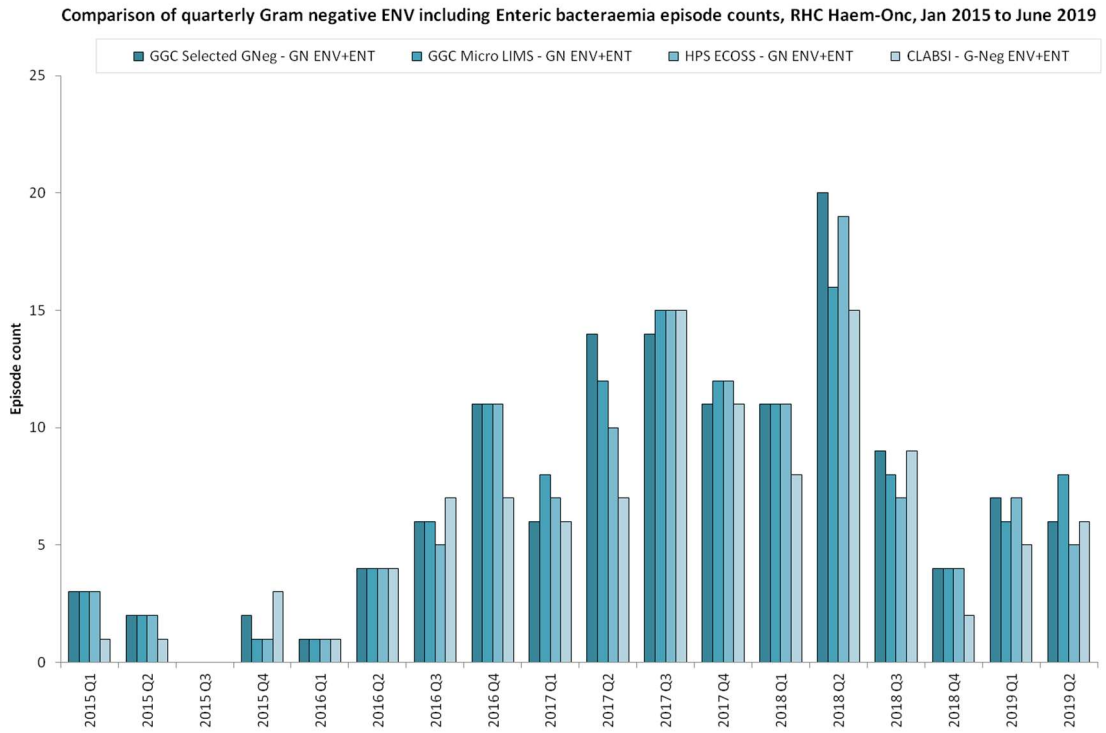
Results and Commentary

Comparison of datasets (species level)

In order to validate the datasets provided by NHSGG&C they were compared with an extract taken by HPS (ECOSS extract) a single organism at species level case definition (**1**) was used so all isolates could be compared. The datasets that were provided all contained data covering the period from January 2015 to June 2019. Figure 1 shows the differences between the datasets when selected environmental Gram-negative organism were compared. The main difference found between the datasets are detailed in Table 2 and Table 3.

It is important to note that each dataset used different case definitions and methods to identify patients who had samples taken or treatment in RHC haemato-oncology unit which accounts for most of the discrepancies identified between datasets.

Figure 1: Comparison of NHSGG&C selected Gram-negative quarterly counts of species level case definition (1) for NHSGG&C and HPS datasets from 2015 Quarter 1 to 2019 Quarter 2.



1. Source of data is Electronic Communication of Surveillance in Scotland (ECOSS), NHSGG&C central line associated bloodstream infection (CLABSI) surviellance system, and NHSGG&C laboratory information management system (LIMS).

Table 2: NHSGG&C CLABSI surveillance data and possible reasons for dataset not matching for the time period January 2015 and September 2019.

HPS episodes without corresponding NHSGG&C episode (n=118, 20.8%)	NHSGG&C episodes without corresponding HPS episode (n=56, 12.4%)
Possible contaminants (n=48, 40.7%) (only one result available for common skin contaminants coagulase-negative staphylococci, *Micrococcus spp., Propionibacterium acnes, Bacillus spp., Corynebacterium spp*.)	Location mapping 53.6% (n=30) could not be identified as belonging to the RHC haematology oncology cohort based on the details of their ECOSS result.
Differences in inclusion and exclusion criteria in CLABSI data - 48.3% (n=57) were either known pathogens or had more than one positive and were included in the other NHSGG&C datasets.	Using de-duplication of 7 rather than 14 days - 23.2% (n=13)
Using de-duplication of 7 rather than 14 days - 5.9% (n=7).	Missing in ECOSS -10.7% (n=6) of results were not in ECOSS but were included in the NHSGG&C Micro LIMS dataset.
Location errors 5.1% (n=6) were not included in any of the NHSGG&C datasets therefore it is likely that they were not part of the true RHC Haem-On cohort.	18 years of age or above excluded by HPS – 12.5% (n=5)

1. Source of data is Electronic Communication of Surveillance in Scotland (ECOSS) and NHSGG&C central line associated bloodstream infection (CLABSI) surviellance system.

Table 3 NHSGG&C Microbiology LIMS surveillance data and possible reasons for dataset not matching for the time period June 2014 and September 2019.

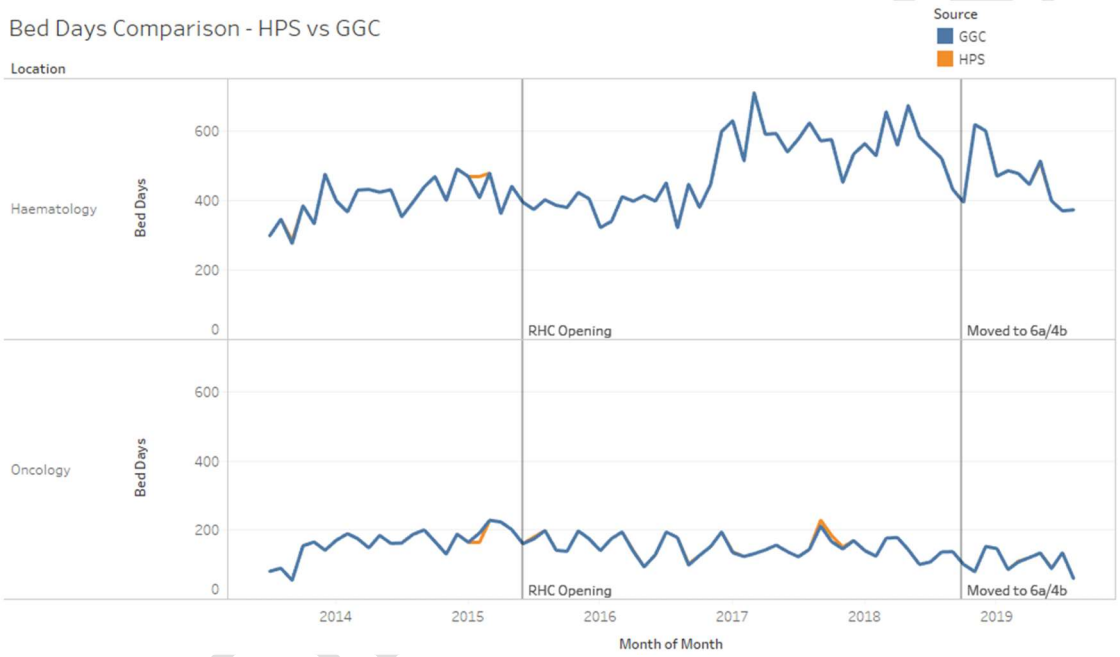
HPS episodes without corresponding NHSGG&C episode (n=42, 6.8%)	NHSGG&C episodes without corresponding HPS episode (n=85, 12.9%)
HPS episodes with corresponding results listed in NHS GGC CLABSI dataset but missing in Micro LIMS data (n=25, 59.5%)	Micro LIMS data included 24 (28.2%) episodes that should have been excluded using the 14 day species de-duplication rule.
Episodes missing from both the NHSGGC Micro LIMS and CLABSI datasets (n=15, 35.7%). Six of these specimens were not collected from haem-oncology wards so were unlikely to be part of the true RHC Haem-Onc cohort and can be excluded from surveillance. Five were possible contaminants with only one result available in ECOSS and can be excluded from surveillance. Three were known enteric pathogens and aspirated in haem-oncology wards. One was an environmental organism which was also included in the NHSGGC selected Gram-neg dataset.	Location mapping 29.4% (n=25) could not be identified as belonging to the RHC haematology oncology cohort based on the details of their ECOSS result. Ten of these patients had their start of episode specimens taken in different hospitals across six health boards.
ECOSS result not updated with species name, these should be excluded as episodes during deduplication (n=2, 4.8%)	18 years of age or above excluded by HPS – 4.7% (n=4)
	Non-blood culture specimens excluded by HPS – 5.9% (n=5). This included four bone marrow specimens and one pus.
	Missing in ECOSS -30.6% (n=26) of results were not in ECOSS. Of these 10 were included in the NHSGG&C CLABSI dataset.

1. Source of data is Electronic Communication of Surveillance in Scotland (ECOSS) and and NHSGG&C laboratory information management system (LIMS).

Review of denominator data

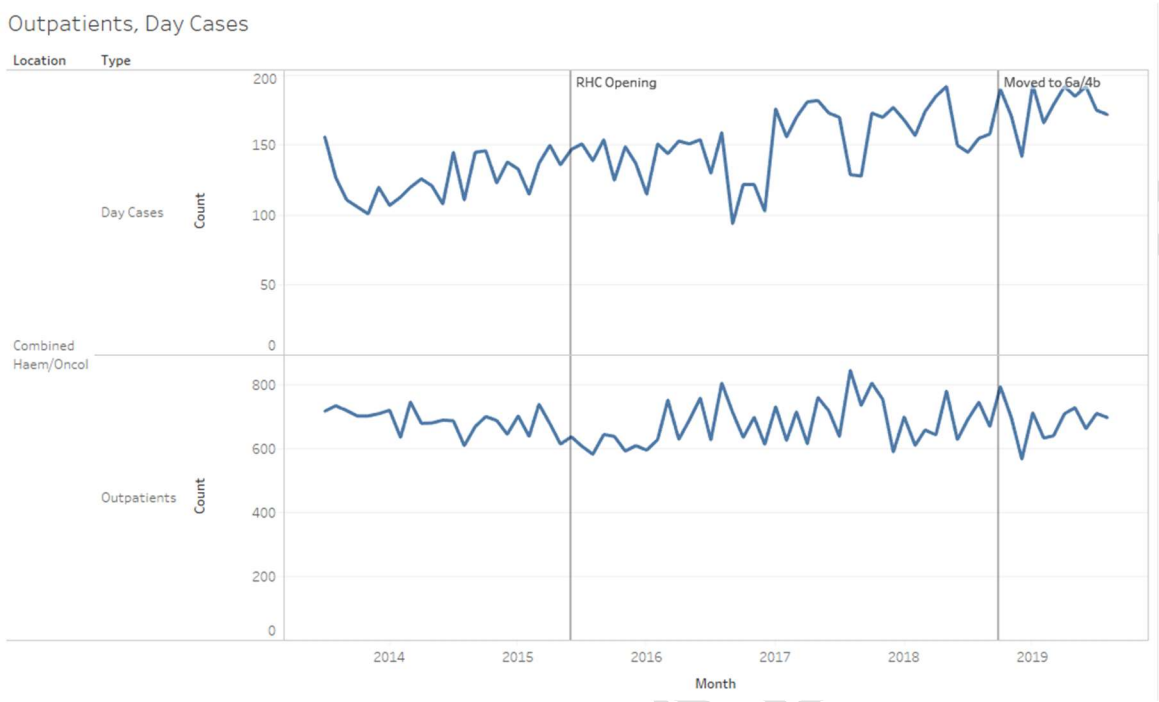
The NHSGG&C activity data was also validated by comparing it to data held by HPS provided by Information Services Division (ISD) and only minor differences were shown (Figure 2). An increase in occupied bed days' activity occurs in haematology in December 2016 which was not mirrored in the oncology figures. Activity data for day cases and outpatients including patients that did not attend (DNA) is shown in Figure 3 showing a gradual increase in day cases following the move to RHC.

Figure 2: Review of total occupied bed days by haematology and oncology specialities for the time period July 2013 to August 2019.



1. Total occupied bed days: Activity data (provided by NHSGG&C) & Information Services Division ISD(S)1 (HPS).

Figure 3: Day cases and outpatient appointments (including did not attend) of combined haematology and oncology activity from July 2013 to August 2019.



1. Activity data provided by NHSGG&C.

Case level data

From the data obtained by HPS from ECOSS there were 688 positive blood culture episodes at species level (case definition 1) for under 18 paediatric haematology oncology population in NHSGG&C linked to RHC between July 2013 and September 2019. From the 688 species level cases, 167 episodes were classed as environmental including enteric group from 97 different patients. Approximately one third (33.5%, n=56) of the species episodes reported formed part of polymicrobial environmental gram negative bacteraemia episodes.

For case definition 2, there were 70 cases of environmental organisms, and when expanding this group to include enteric organisms (case definition 3), there were 132 cases.

When deduplicating at Gram-stain level (case definitions 4 and 5), there were 390 cases of Gram-positive group organisms and 176 cases of Gram-negative group organisms.

Using the Gram-negative case definition an upward shift with a run of ten data points above the mean was observed from March to December 2017, with the upper warning limit (UWL) breached in August 2017, March 2018, May 2018 and again in September 2019 (Figure 4).

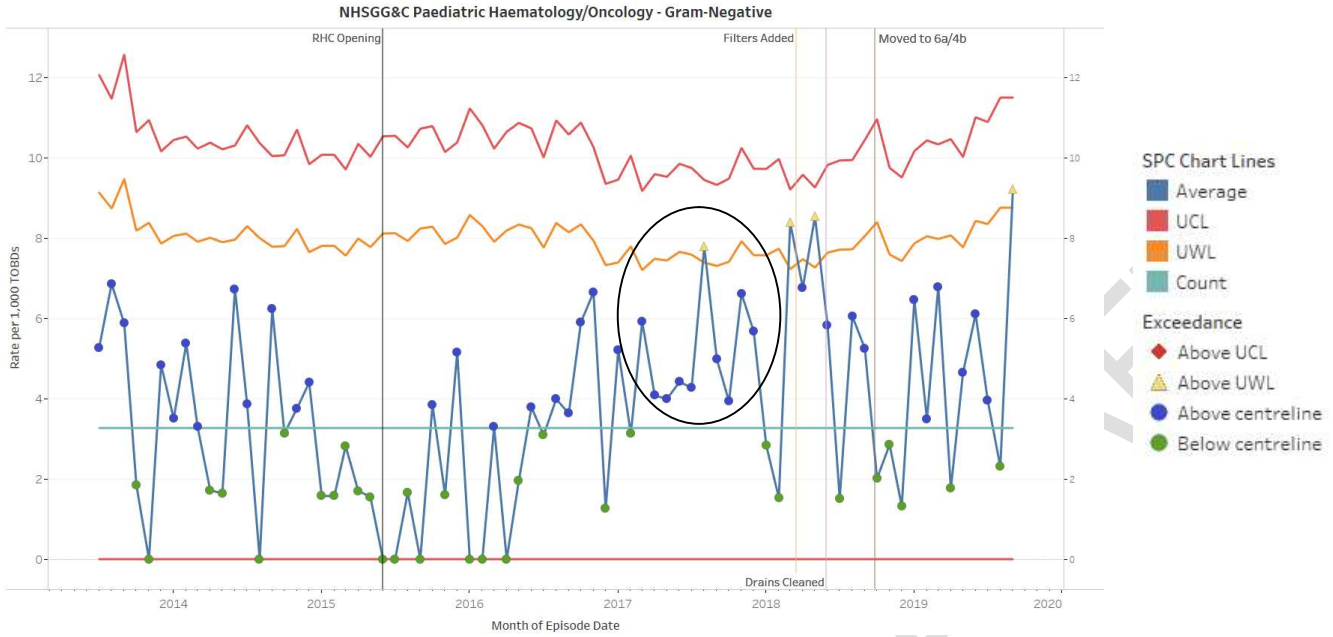
Figure 5 shows the SPC chart for the environmental group case definition. The UWL was breached in June 2018. The environmental group was extended to include selected enteric organisms such as species of *Enterobacter; Klebsiella* that were linked with drain contamination. The environmental including enteric group is described in Figure 6, showing the UWL was breached in March 2018 and March 2019.

Figure 7 describes the incidence of Gram-positive blood cultures in paediatric haematology oncology population. There was no upward shift in rates following the move to RHC however the upper control limit (UCL) was breached in January 2016, January 2017, April 2017 and June 2017. With rates above the UWL July 2016, May 2017, November 2017 and December 2017. Following the increase in activity at the RHC shown in Figure 7 with six out of twelve data points in 2017 breached a trigger limit (UWL or UCL). The rate now appears to be similar to that observed prior to the move to RHC with seven out twelve data points having a rate below the mean rate in the last year.

A summary of the SPC shifts and triggers shown in Figure 4 to Figure 7 is provided in Table 4.

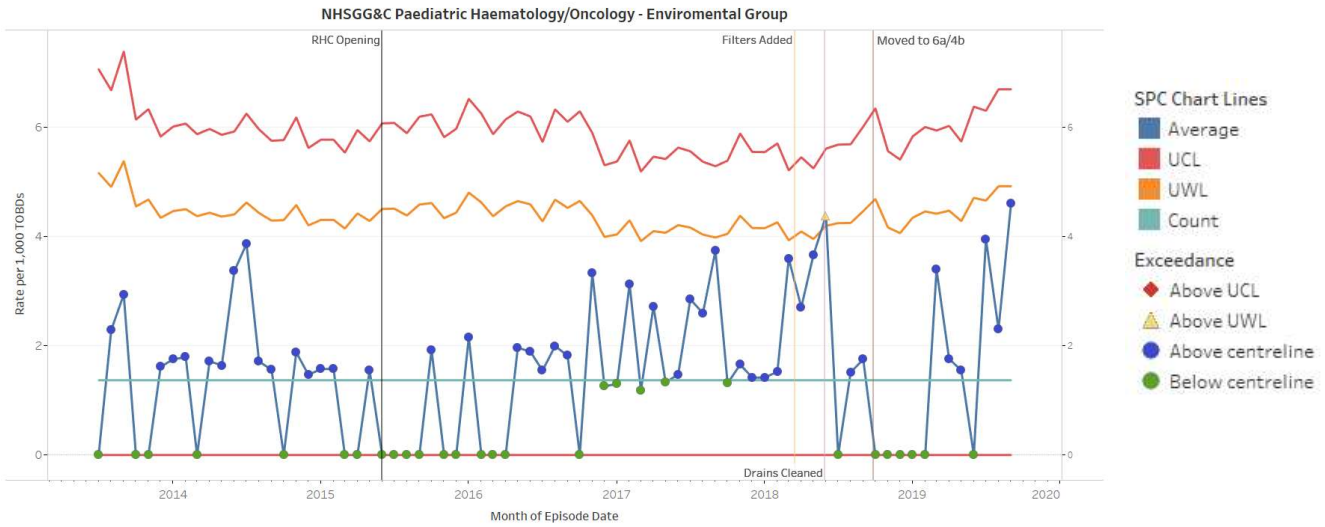
No change was observed when crude comparisons were made between the rates with the exception of the Gram-positive group (p=0.04) which significantly decreased when comparing the overall incidence before and after the move to RHC.

Figure 4: SPC chart using the Gram-negative case definition for HPS data from the July 2013 to September 2019.[1]



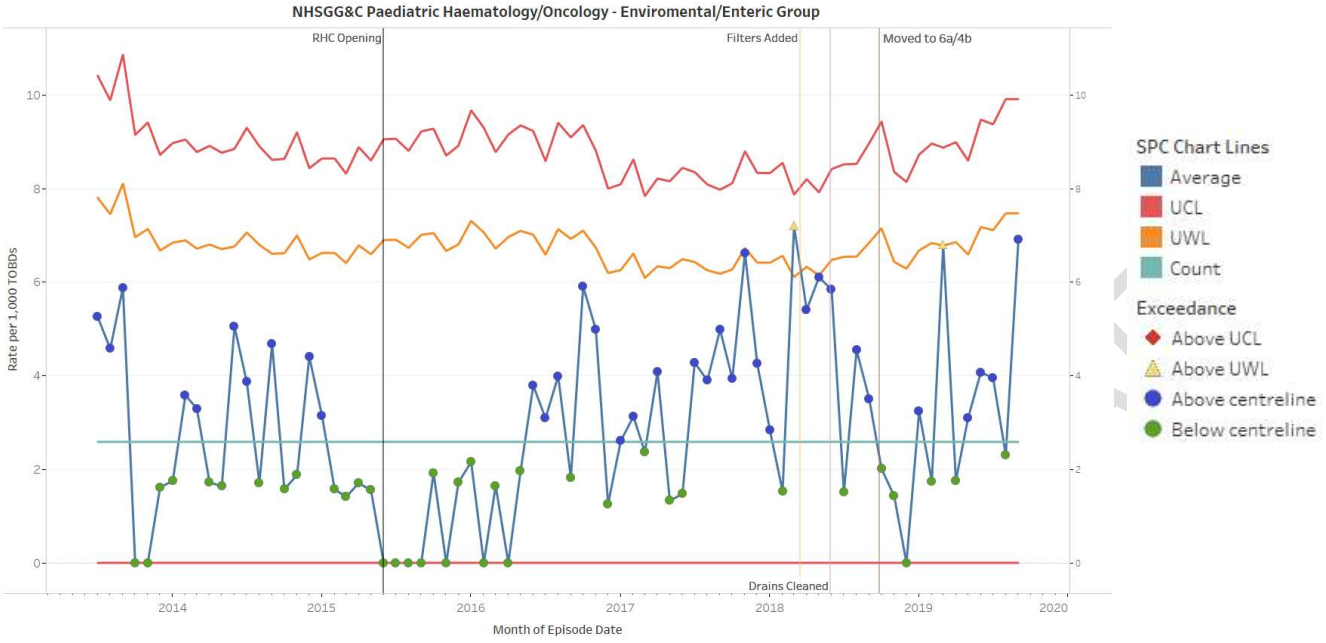
1. Source of data is Electronic Communication of Surveillance in Scotland (ECOSS) & Total occupied bed days: from activity data provided by NHSGG&C.

Figure 5: SPC chart using the environmental group case definition for HPS data from the July 2013 to September 2019.[1]



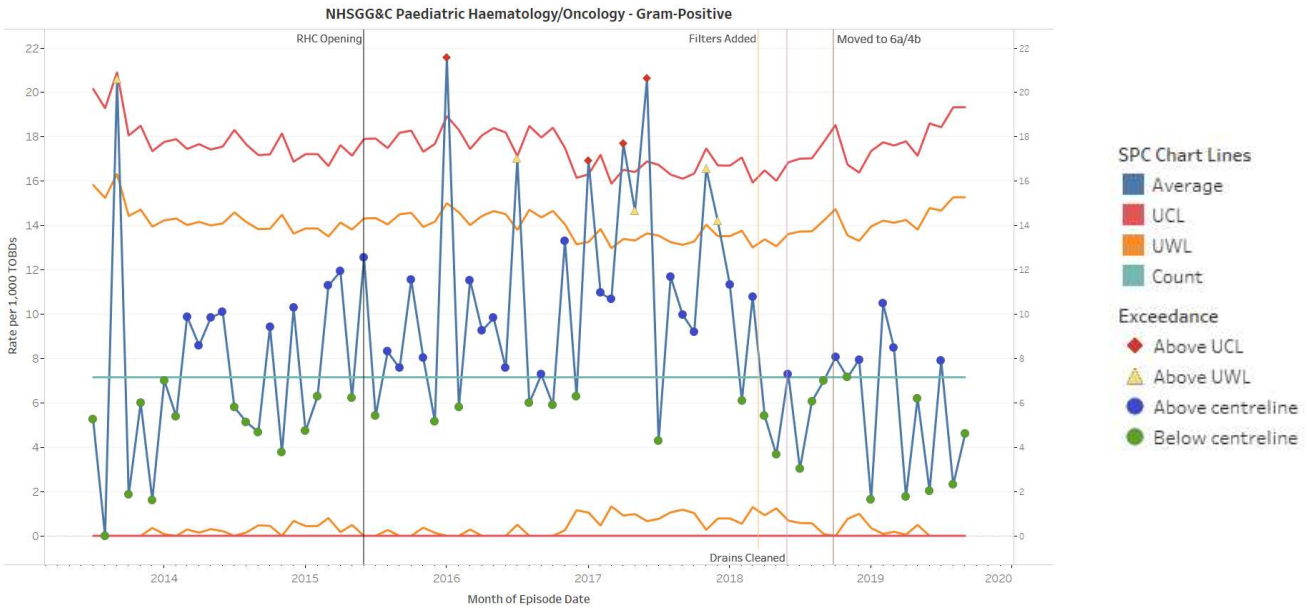
1. Source of data is Electronic Communication of Surveillance in Scotland (ECOSS) & Total occupied bed days: from activity data provided by NHSGG&C.

Figure 6: SPC chart using the environmental including enteric group case definition for HPS data from the July 2013 to September 2019.[1]



1. Source of data is Electronic Communication of Surveillance in Scotland (ECOSS) & Total occupied bed days: from activity data provided by NHSGG&C.

Figure 7: SPC chart using the Gram-positive case definition for HPS data from the July 2013 to September 2019.[1]



1. Source of data is Electronic Communication of Surveillance in Scotland (ECOSS) & Total occupied bed days: from activity data provided by NHSGG&C.

Table 4: Summary table listing SPC shifts, trigger points (UWL breach) and outliers(UCL breach) following the move to RHC using HPS data from July 2013 to September 2019.[1]

Year	Gram-positive	Gram-negative	Environmental	Enviro/Enteric
2015				
2016	Jan 2016 (UCL)			
	July 2016 (UWL)			
2017	Jan 2017 (UCL)	Upward shift (Mar 2017 – Dec 2017)		
	April 2017 (UCL)	Aug 2017 (UWL)		
	May 2017 (UWL)			
	June 2017 (UCL)			
	Nov 2017 (UWL)			
	Dec 2017 (UWL)			
2018		March 2018 (UWL)	June 2018 (UWL)	March 2018 (UWL)
		May 2018 (UWL)		
2019		Sept 2019 (UWL)		March 2019 (UWL)

1. Source of data is Electronic Communication of Surveillance in Scotland (ECOSS) & Total occupied bed days: from activity data provided by NHSGG&C.

Comparison with other health boards

When comparing the overall hospital rate of positive blood cultures since the move to RHC (June 2015 to September 2019) to the combined rate of the other two Scottish children's hospitals (Royal Aberdeen Children's Hospital (NHS Grampian) and Royal Hospital for Sick Children (NHS Lothian)), the incidence of positive blood cultures, using the case definitions 2 to 5, was higher in RHC for environmental including enteric group (RR= 1.86 95%CI 1.42-2.47, p<0.001), but lower for Gram-positive group (RR=0.76, 95%CI 0.70-0.83, p<0.001). There was no difference in the rates of Gram-negative group (RR=1.18, 95%CI 0.96-1.42, p=0.07) or environmental group (RR=1.42, 95%CI 0.94-2.16, p=0.11).

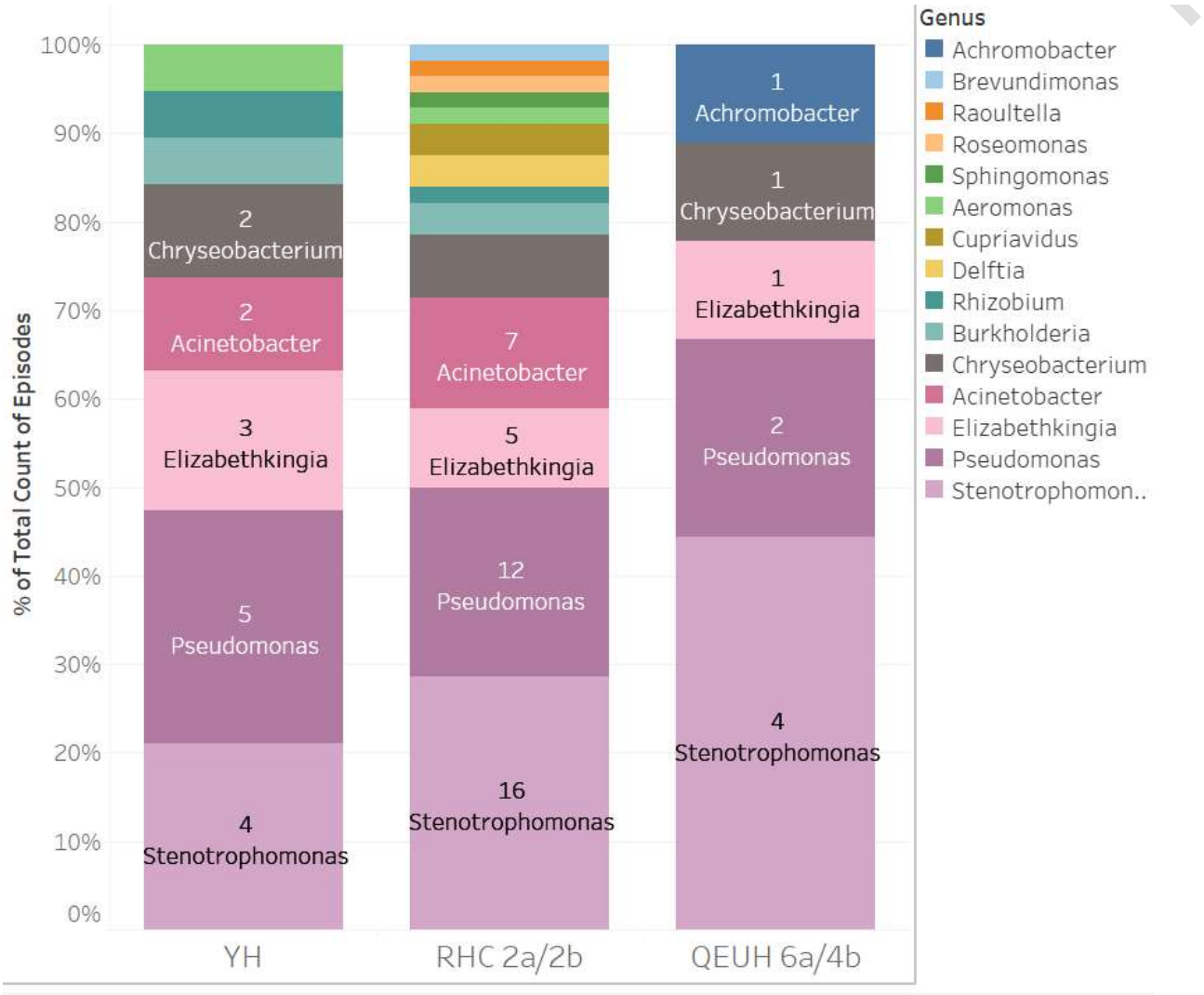
When compared over two years (October 2017 to September 2019), the rate of positive blood cultures was higher in RHC for environmental including the enteric group (RR=1.70, 95%CI 1.17-2.53, p<0.005) and Gram-negative group (RR=1.31, 95%CI 1.00-1.73, p=0.05) but lower for the Gram-positive group (RR=0.74, 95%CI 0.66-0.84, p<0.001). There was no difference in the rates of the environmental group (RR=1.36, 95%CI 0.77-2.52, p=0.39).

In the last year following the move to QEUH (October 2018 to September 2019) there was no difference in the rate for Gram-negative group (RR=1.23, 95%CI 0.85-1.80, p=0.30), environmental including the enteric group (RR=1.26, 95%CI 0.74-2.18, p=0.44) or environmental group (RR=0.93, 95%CI 0.41-2.23, p=1) however the rate was lower for the Gram-positive group (RR=0.77, 95%CI 0.64-0.93, p=0.005).

Diversity of Environmental Organisms

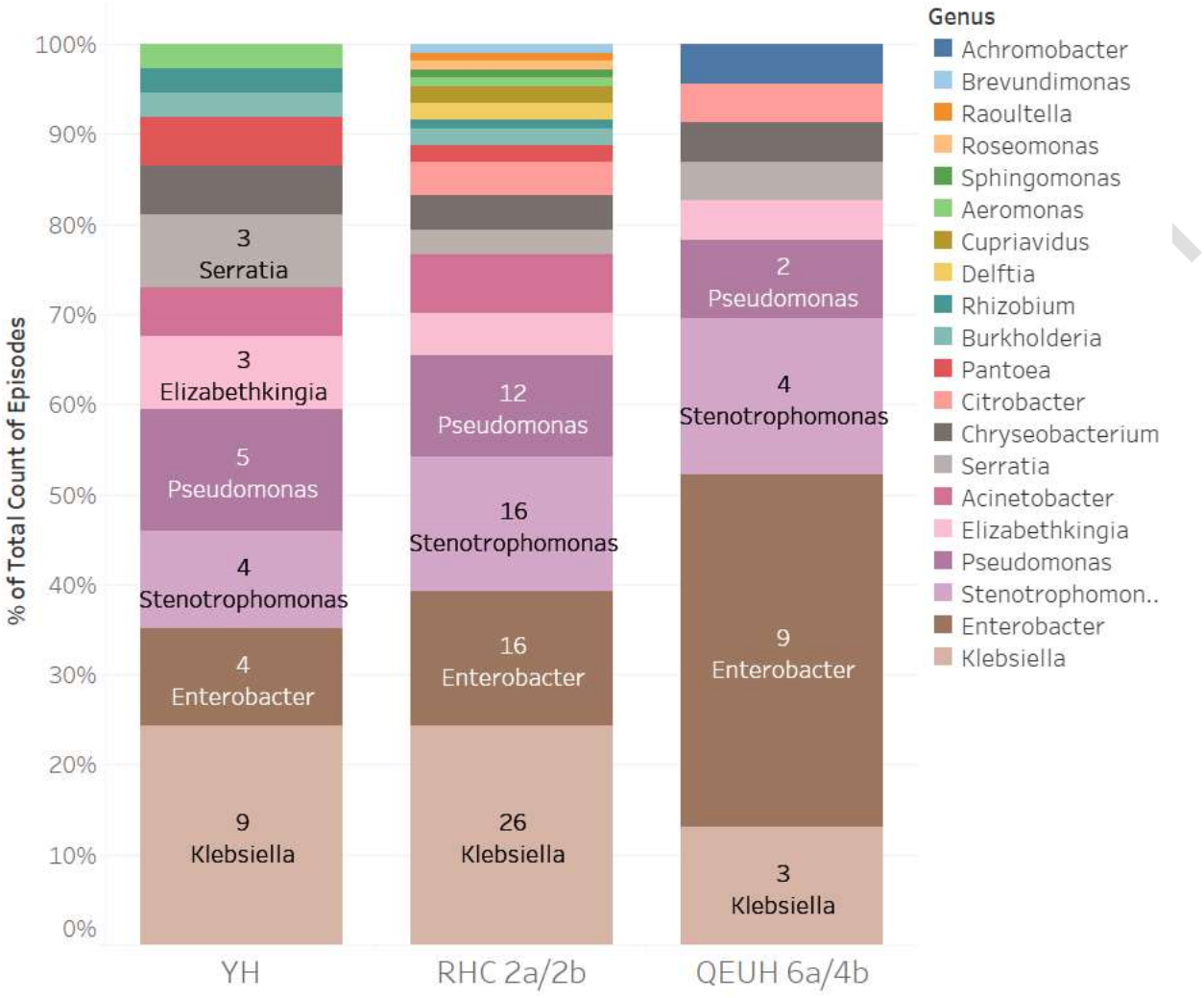
The diversity of organisms isolated in the haemato-oncology unit prior and post move to RHC for the environmental group and the environmental including enteric group are shown in Figure 8 and Figure 9.

Figure 8: Organisms identified at YH and ward 2A & 2B (RHC) and ward 6A & 4B (QEUH) de-duplicated at species level for the environmental group; data shown per genus from July 2013 to September 2019.[1,2]



1. Source of data is Electronic Communication of Surveillance in Scotland (ECOSS)
2. YH data includes data from July 2013 to May 2015 (n= 19), RHC wards 2A &2B includes data from June 2015 to September 2018 (n= 56) and QEUH wards 6A & 4B (n= 9).

Figure 9: Organisms identified at YH and ward 2A & 2B (RHC) and ward 6A & 4B (QEUH) de-duplicated at species level for the environmental including enteric group; data shown per genus from July 2013 to September 2019.[1,2]



1. Source of data is Electronic Communication of Surveillance in Scotland (ECOSS)
2. YH data includes data from July 2013 to May 2015 (n= 37), RHC wards 2A &2B includes data from June 2015 to September 2018 (n= 107) and QEUH wards 6A & 4B (n= 23).

Caveats

There are a number of limitations associated with the use of ECOSS blood culture data. Blood samples are non-validated records. The cases may include interim results, contaminants, and may include non-blood cases which are incorrectly mapped to a blood sample within either the laboratory system or within ECOSS. Location mappings within ECOSS records may also be prone to error and it may be difficult to capture all haemato-oncology patients admitted to other RHC or YH wards who subsequently had a positive blood culture. Gram-negative blood culture data may be incomplete for September 2019 and non tuberculous mycobacteria data may be incomplete from July 2019 onward as samples are still to be reported. Due to uncertainty over positive fungal blood samples coming into ECOSS they were excluded from this review.

Improvements in speciation, for example using MALDI-TOF technologies, may change the identification over time. Species level case definitions may result in a patient having more than one episode of positive blood culture in a 14 day period.

Environmental bacteria grouping include bacteria commonly found in the environment however they may also be associated with normal human microbiome and laboratory surveillance is unable to distinguish.

It is not possible to determine whether changes in episodes are confounded by changes in the patient population and their underlying medical conditions.

The rates used to compare the overall rate at RHC following the move to QEUH to the combined rate of the other two Scottish children's hospitals used an estimated denominator (Total Occupied Bed Days) for September 2018 by taking the proportion of days following the move.

In the monthly analysis of environmental bacteria positive blood cultures, the numbers are small and should be treated with caution.

The main reasons documented about discrepancies in the review of datasets were only the most likely reason and due to time constraints were not further investigated.

Summary and Recommendations

This report provides a review of datasets currently being used in NHSGG&C and HPS to support the investigation of this incident; an updated description of trends in positive blood cultures; and a description of the diversity of organisms.

One of the key objectives of this review was to assess the NHSGG&C datasets and provide assurance that the data provides an accurate reflection of the current epidemiological situation in this patient population and where differences exist, to understand reasons and assist with the interpretation. The results from this exercise suggest that the datasets currently used by NHSGG&C provide important intelligence that is aligned with the microbiological data held nationally in ECOSS. There are pros and cons to each of the datasets. The ECOSS and LIMS microbiology datasets do not provide clinical information relating to the cases, without this it is difficult to ensure that the blood cultures are true cases of clinical bacteraemia and there is limited epidemiological and clinical information to support investigation. The CLABSI dataset includes clinical information but has strict case definitions that may exclude cases of bacteraemia associated with the haemato-oncology specialty including those presenting in the first 48 hours of admission and those where the line was inserted in another unit.

Reviewing monthly SPC charts has been shown to be an appropriate method in identifying triggers and outliers when a stable period can be used to set the mean. In this review, the crude incidence rates before and after the move did not reflect the variation in incidence over time within this population. The changes in activity, in particular the occupied bed days, have highlighted the importance of considering activity when interpreting charts and where possible to use incidence rates in SPC charts. The use of grouped case definitions have allowed the data to be reviewed without reporting bias of selecting significant organisms or over reporting when multiple organisms are isolated from the one patient.

The SPC charts included in this report describe that there has been instances of variation outside what would normally be expected in this patient population, the latest was a breach of an upper warning limit for Gram-negative blood culture episodes in September 2019. The characterisation of these cases alongside understanding in the context of environmental microbiology is critical to understanding and managing risk.

The purpose of developing triggers that identify areas where the number of cases is out with what would normally be expected due to random variation, is to identify when it is appropriate to instigate a local investigation into the possible increase in cases. In order to ensure that appropriate action is taken, high sensitivity where there is a high degree of suspicion for increased number of cases is important, particularly in such a vulnerable population. For this reason, the use of microbiological laboratory data rather than the CLABSI data would provide a more sensitive measure for identifying areas for local investigation.

Triggers for areas where there is a need to monitor infectious agents with a possible environmental source that are based on groups of organisms rather than single species triggers likely provides a better measure. This is due to the complex microbiology of

environmental sources. The data presented in this report provide a starting point for supporting the development of appropriate triggers for environmental pathogens. The organisms included in the environmental category can be reviewed following the comprehensive literature reviews being undertaken by HPS for Chapter 4 of the National IPC Manual.

These analyses also indicate that approximately a third of cases of positive blood culture of environmental organisms had a polymicrobial episode. This observation provides an indication of the complexity of the interpretation of microbiology data in the absence of clinical data for this patient population. In addition, there were patients who had multiple episodes of positive blood cultures with different organisms over extended periods of time. Again, the interpretation of the data requires clinical data collected systematically to support interpretation of both unusual clinical pictures and breaches in the limits in SPC charts. The microbiological and clinical data should also be set in the environmental context including the environmental microbiology results such as water and ventilation sampling.

The data presented in this report do not provide evidence of single point of exposure and there is a need to continually monitor the risk in this patient population. There is no immunity to the organisms under investigation, therefore all patients within this cohort are at risk from developing gram negative bacterium due to their co morbidities and treatment plan. The control measure of restricting clinical services for newly diagnosed patients over existing patients should now be reconsidered.

The following recommendations should be considered:

- NHS GG&C should systematically collect clinical data on cases to describe risk in this patient population and ensure ongoing monitoring is in place.
- NHS GG&C should further characterise of cases in terms of “person” and “place” to support understanding when there are more cases than normally expected.
- NHS GG&C should consider the epidemiological characterisation of cases in the context of environmental risks and incidents e.g. water testing results, ventilation testing results.
- NHS GG&C should consider the data provided in the context of the findings from the action plan
- NHS GG&C should consider current control measures around restriction on services for newly diagnosed patients.
- HPS will review the categorisation of environmental organisms following the literature reviews for Chapter 4 of the NIPCM.
- HPS will further support the development of an appropriate trigger for ongoing monitoring.
- HPS should consider these findings when developing methods to support other boards in monitoring infection risk associated with environmental organisms.

Glossary

BMT	Bone Marrow Transplant
CDC	Centers for Disease Control
CLABSI	Central line associated bloodstream infection
CI	Confidence intervals
DNA	Did not attend
ECOSS	Electronic Communication of Surveillance in Scotland
ENT	Enteric
HPS	Health Protection Scotland
ISD	Information Services Division
LIMS	Laboratory information management system
NHSGG&C	NHS Greater Glasgow and Clyde
QEUH	Queen Elizabeth University Hospital
RR	Rate ratios
RHC	Royal Hospital for Children
SPC	Statistical Process Control
TOBD	Total occupied bed days
UCL	Upper control limit
UWL	Upper warning limit
YH	Yorkhill Hospital

List of Tables

List of Figures

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Further Information

Further Information can be found on the HPS website.

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Appendices

Appendix 1 – Background information

NHS GG&C supplied methods statement for Royal Hospital for Children Blood Stream infections for HPS review.

CLABSI

CLABSI data is prepared according to the following protocol, agreed by the RHC CLABSI Quality Improvement Group:

The QI group refer to CLABSI as defined according to the CDC classification as:

> *'A CLABSI is a primary BSI in a patient that had a central line within the 48-hour period before the development of the BSI and is not bloodstream related to an infection at another site. However, since some BSIs are secondary to other sources other than the central line (e.g., pancreatitis, mucositis) that may not be easily recognized, the CLABSI surveillance definition may overestimate the true incidence of CRBSI'*

The data includes all patients within the haemato-oncology cohort, so inclusive of those cared for at home by the outreach nurses, those attending day care and those who are inpatients in ward 2A including Bone Marrow Transplant, and teenage cancer patients.

CLABSI Data Collection Process:

1) ALL patients receiving a new central venous device at Yorkhill/Glasgow Royal Hospital for Children between January 2015 and July 2019 were collated (using Opera data to look at every operation done in every theatre every day in the Children's Hospital)

2) Out of this group, only the haematology/oncology patients were kept (searching for and confirming a diagnosis via Clinical Portal)

3) The total line day data was obtained by counting the number of days each line was in situ

4) Each patient was analysed monthly or twice monthly looking at positive microbiology culture results from either a central line or a peripheral venous sample whilst a central line was in situ (via Clinical Portal)

5) Any positive microbiology result with a concurrent illness (IE chest infection or urinary tract infection) was excluded (again via Clinical Portal and the electronic notes)

6) If a culture positive result occurred repeatedly in the 7 days following the first positive culture and the organism was the same, this was excluded (IE a patient with a Staph Aureus infection on 5/9/18 and a subsequent culture positive Staph Aureus on 7/9/18 was only counted as ONE infection); a second Staph Aureus infection on 13/9/18 would be

counted as TWO infections in total as one would presume that a week of treatment should have effectively treated the first organism.

7) If, however, a second culture positive result occurred in the 7 days following the first positive culture and the organism was different, this was included (IE a patient with a Staph Aureus infection on 5/9/18 and a subsequent culture positive pseudomonas infection on 7/9/18 was counted as TWO infections in total).

8) Patients receiving their Hickman/Broviac Line, Port, or Haemodialysis line in a unit other than the Royal Hospital for Children in Glasgow were excluded. This point was discussed at the first CLABSI QI meeting and it was felt that these (few) patients that had lines inserted elsewhere but were treated in Glasgow could not be analyzed in the same fashion as those receiving the majority of their care (from line insertion to treatment to line removal) here in Glasgow.

9) Patients shared care in local district general hospitals who presented locally initially with a CLABSI and were subsequently transferred to Glasgow did not have that single line infection counted for similar reasons (we would be looking at the management of care in the district general hospital and thus would not be able to analyze them in the same methodology).

To produce the total CLABSI/Gram negative CLABSI chart as shown in the presentation, each line was checked to assign he organism to either gram positive, gram negative or fungus. The same denominator (line days) was used.

Where there were multiple organisms in a single line, the first named organism was used for classification. One organism was not classified, as it can exist as gram positive, gram negative or gram neutral.

CLABSI funnel plot

The funnel plot was produced using the PHE fingertips funnel plot for rates tool. The data used was the gram negative counts, and line day denominator used in the other CLABSI charts. The plot was produced using the instructions included in the tool. As there is no long term stable average, and in recognition of the quality improvement project, the central line was set to the aim of 1 per 1000 line days.

Epicurves

The ECOSS system was queried to obtain data on positive blood cultures for selected gram negative organisms reported from the GLA:SGH or GLA:GRI laboratories, age <16. The initial extract (during the water/drains incident 2018) was for date of report from July 2013 to June 2018. Further extracts were made periodically. The list of gram negatives was provided by the NHS GGC lead Infection Control Doctor, and is contained in the appendix to this document. This list is based on organisms identified during the water/drains incident.

Following further discussion since the initial extract, *Citrobacter* and Aeromonas were added to that list. To increase sensitivity, data were pulled from ECOSS on basis of genus, rather than species.

Following extraction, the following exclusions were applied:

- Results from neonatal, maternity and pathology removed
- Results from areas not part of RHSC/RHC

During initial screening, laboratory GLA:RAH was also included, however as no relevant results noted, this parameter was removed from the query.

CHI numbers were replaced with new unique ID, and patient identifiers deleted. It is therefore not possible to directly link more recent cases to those form previous extracts. To ensure that the rules below could be applied, and to capture any late inclusions in the ECOSS data base, the 3 months data prior to the new months was also extracted and cases cross checked. One additional late inclusion was detected in this way.

Each case was assigned to a specialty based on the following data points included in the ECOSS reports –

1. Ward sample was taken
2. Diagnosis/clinical history recorded on lab request
3. Requesting consultant.

If it was not possible to identify a specialty from information contained in the ECOSS report, then speciality was confirmed using electronic patient records.

Two separate counts were calculated, based on methodologies described by PHE and CDC:

- Organism count: Number of positive blood cultures per calendar month. Results within 14 days of a previous positive for the **same** organism in the same patient excluded.
- Case count: Number of positive blood cultures per calendar month results within 14 days of previous positive for **any** organism in the same patient excluded (ie only one positive per patient per 14 days)

In both cases the date of result was counted as day one.

Rates were then calculated using activity data produced by NHS GGC acute service information team.

Division of organisms between “environmental” and “non-environmental” was based on advice from GGC mcirobiologists.

Non-environmental: *Citrobacter*, *Enterobacter, Klebsiella, Pantoea, Serratia.*

Environmental: All other organisms.

All gram negative positive blood cultures chart

An extraction from ICNet of blood cultures from RHSC Schiehallion, RHSC Schiehallion DCU, RHC 2A, RHC 2B & QEUH 6A, for patients under 18 years at time of BC aspiration for dates 01/11/2014 – 19/09/2019 (date of data extraction) was carried out by GGC IPCT surveillance team. Blood cultures were de-duplicated by 14 days i.e. new case on day 15 from previous isolate of the same organism in the same patient. More than one organism may have been isolated in the same blood culture specimen.

The counts were converted to rates using the occupied bed day data from NHS GGC acute services information team.

NHSGG&C Appendix: list of selected gram negative organisms

Achromobacter xylosoxidans	Morganella morganii
Acinetobacter lwofii	Pantoea agglomerans
Acinetobacter ursingii	Paracoccus sp
Brevundimonas versicularis	Pseudomonas chlororaphis
Burkholderia cepacia	Pseudomonas fluorescens
Cedecea lapagei	Pseudomonas oryzihabitans
Chryseobacterium indologenes	Pseudomonas putida
Commamonas testosterone	Pseudoxanthomonas mexicana
Cupriavidus gilardii	Ralstonia picketii
Cupriavidus pauculus	Rhizobium radiobacter
Delftia acidovorans	Serratia fonticola
Elizabehtkingia meningospetica	Shewanella puterfaciens
Enterobacter cloacae	Sphingomonas species
Klebsiella pnuemoniae	Stenotrophomonas maltophilia

Organism comparison list

Table 5 and Table 6 detail the organisms isolated in the positive blood cultures and the groupings used in this report.

Table 5: Organisms isolated from positive blood samples included in environmental groupings during the time period reviewed.[1]

NHSGGC CLABSI surveillance	NHSGGC ECOSS selected Gram-negative organisms (GGC Selected GNeg)	NHSGGC Microbiology LIMS Surveillance	HPS ECOSS Under18 bloods RHC HaemOnc
Gram Negative Environmental (GN ENV)	**Gram Negative Environmental (GN ENV)**	**Gram Negative Environmental (GN ENV)**	**Gram Negative Environmental (GN ENV)**
Achromobacter spp.	*Acinetobacter baumannii*	*Achromobacter sp*	*Achromobacter spp.*
Acinetobacter baumannii	*Acinetobacter ursingii*	*Acinetobacter baumannii*	*Acinetobacter spp.*
Acinetobacter ursingii	*Aeromonas hydrophila*	*Acinetobacter ursingii*	*Aeromonas hydrophila*
Aeromonas hydrophila	*Brevundimonas spp.*	*Aeromonas spp*	*Brevundimonas spp.*
Burkhold cepacia	*Burkholderia cepacia*	*Brev. spp.*	*Burkholderia cepacia*
Chryseomonas indologenes	*Chryseobacterium indologenes*	*Burk. cepacia group*	*Chryseobacterium indologenes*
Chryseob. spp	*Chryseobacterium spp.*	*Chryseob. spp.*	*Chryseobacterium spp.*
Cupriavidis pauculus	*Cupriavidus pauculus*	*Chryseobacterium indologenes*	*Cupriavidus pauculus*
Eliz. meningoseptica	*Delftia acidovorans*	*Chryseomonas spp.*	*Delftia acidovorans*
Elizabethkingia spp.	*Elizabethkingia meningoseptica*	*Cup. pauculus*	*Elizabethkingia meningoseptica*
Delftia acidovorans	*Elizabethkingia spp.*	*Del. acidovorans*	*Elizabethkingia miricola*
Pseudomonas spp.	*Pseudomonas spp.*	*Delftia spp.*	*Elizabethkingia spp.*
Rhiz. radiobacter	*Rhizobium radiobacter*	*Elizabethkingia. spp.*	*Pseudomonas spp.*
Roseomonas mucosa	*Sphingomonas paucimobilis*	*Herbaspirillum sp*	*Raoultella planticola*
Sphingomonas spp.	*Steno. maltophilia*	*Pseudomonas spp.*	*Rhizobium radiobacter*
Steno. maltophilia		*R. planticola*	*Roseomonas mucosa*
		R. radiobacter	*Sphingomonas paucimobilis*
		R. mucosa	*Steno. maltophilia*
		Sph. paucimobil	

		Steno. maltophilia	
Gram Negative Enteric /Environmental (GN ENT/ENV)	**Gram Negative Enteric /Environmental (GN ENT/ENV)**	**Gram Negative Enteric /Environmental (GN ENT/ENV)**	**Gram Negative Enteric /Environmental (GN ENT/ENV)**
Citrobacter spp. *Enterobacter cloacae* *Klebsiella spp.* *Pantoea spp.* *Serratia liquefaciens* *Serratia marcesens*	*Citrobacter spp.* *Enterobacter spp.* *Klebsiella spp.* *Pantoea spp.* *Serratia liquefaciens* *Serratia marcescens*	*Citrobacter spp.* *Enterobacter spp.* *Klebsiella spp.* *Pantoea spp.* *Ser. liquefac.* *Ser. marcescens*	*Citrobacter spp.* *Enterobacter spp.* *Klebsiella spp.* *Pantoea spp.* *Serratia liquefaciens* *Serratia marcescens*
Gram Positive Environmental (GP ENV)	**Gram Positive Environmental (GP ENV)**	**Gram Positive Environmental (GP ENV)**	**Gram Positive Environmental (GP ENV)**
Gordonia polyisoprenivorans	N/A	*Gordonia polyisoprenivorans*	*Gordonia bronchialis*
Acid Fast Environmental (AF ENV)	**Acid Fast Environmental (AF ENV)**	**Acid Fast Environmental (AF ENV)**	**Acid Fast Environmental (AF ENV)**
Mycobacterium chelonae	N/A	*Myc. chelonae group* *Myco fortuitum* *Mycobacterium chelonae*	*Mycobacterium chelonae* *Mycobacterium spp.*
Fungi Environmental (Fungi ENV)	**Fungi Environmental (Fungi ENV)**	**Fungi Environmental (Fungi ENV)**	**Fungi Environmental (Fungi ENV)**

1. May not include every organism of interest if no cases were found during the time period.

Table 6: Organisms isolated from positive blood samples included in non-environmental groupings during the time period reviewed.[1]

NHSGGC CLABSI surveillance	NHSGGC ECOSS selected Gram-negative organisms (GGC Selected GNeg)	NHSGGC Microbiology LIMS Surveillance	HPS ECOSS Under18 bloods RHC HaemOnc
Gram Negative Non-environmental (GN NON-ENV)	**Gram Negative Non-environmental (GN NON-ENV)**	**Gram Negative Non-environmental (GN NON-ENV)**	**Gram Negative Non-environmental (GN NON-ENV)**
Escherichia coli *Fusobacterium nucleatum* *Proteus mirabilis*	N/A	*Bact. uniformis* *Cap. sputigena* *Escherichia coli* *Fuso. nucleatum* *Haemophilus influenzae* *Mor. catarrhalis* *Moraxella nonliquefaciens* *Moraxella osloensis* *Neis. subflava* *Proteus mirabilis*	*Bacteroides uniformis* *Capnocytophaga sputigena* *Escherichia coli* *Escherichia fergusonii* *Fusobacterium nucleatum* *Haemophilus influenzae* *Moraxella spp.* *Neisseria spp.* *Ochrobactrum anthropi* *Proteus mirabilis*
Gram Positive Non-environmental (GP NON-ENV)	**Gram Positive Non-environmental (GP NON-ENV)**	**Gram Positive Non-environmental (GP NON-ENV)**	**Gram Positive Non-environmental (GP NON-ENV)**
Aerococcus viridans *Clostridium spp.* *Corynebacterium spp.* *Dermacoccus nishinomiyaens* *Diphtheroids* *Enterococcus spp.* *Gemella Sanguinis* *Gordonia polyisoprenivorans*	N/A	*Aerococcus viridans* *Alpha strep* *Bacillus spp.* *C. perfiringens* *Coag Neg Staph.* *Corynebacterium spp* *Derm. nishinomiyaens* *Diphtheroids* *Enterococcus spp.*	*Abiotrophia defectiva* *Aerococcus viridans* *Bacillus spp.* *Clostridium perfringens* *Clostridium septicum* *Corynebacterium spp.* *Dermacoccus spp.* *Enterococcus spp.* *Gemella sanguinis*

Gram +ve bacilli *Gram Pos B* *Gram Pos C* *Gran Adiac* *Granulicatella adiacens* *Kocuria rhizophilia* *Lactobacilus* *Micrococcus spp.* *Paenibacillus durus* *Propionibacterium acnes* *Rothia mucilaginosa* *Staphylococcus spp.* *STCNS* *Streptococcus spp.*		*Gemella.sanguinis* *GPC-Strep* *Gram +ve bacilli* *Gram positive cocci* *Gran. adiacens* *Kocuria rhizophilia* *Lactobacillus spp* *Micrococcus spp.* *Paenibacillus spp.* *Propionibacterium acnes* *Rothia mucilaginosa* *Staphylococcus spp.* *Streptococcus spp.*	*Granulicatella adiacens* *Kocuria spp.* *Lactobacillus spp.* *Lactococcus lactis* *Leuconostoc lactis* *Micrococcus spp.* *Paenibacillus spp.* *Propionibacterium spp.* *Rothia spp.* *Staphylococcus spp.* *Streptococcus spp.*
Acid Fast Non-environmental (AF NON-ENV)	**Acid Fast Non-environmental (AF NON-ENV)**	**Acid Fast Non-environmental (AF NON-ENV)**	**Acid Fast Non-environmental (AF NON-ENV)**
Nil	N/A	Nil	Nil
Fungi Non-environmental (Fungi NON-ENV)	**Fungi Non-environmental (Fungi NON-ENV)**	**Fungi Non-environmental (Fungi NON-ENV)**	**Fungi Non-environmental (Fungi NON-ENV)**
Candida spp. *Yeasts*	N/A	*Candida spp.*	*Candida spp.*

1. May not include every organism of interest if no cases were found during the time period.

Appendix 2 – Publication Metadata

Metadata Indicator	Description
Publication title	**Review of NHSGG&C paediatric haemato- oncology data**
Description	This management report provides information on paediatric haematology oncology related in NHS Greater Glasgow &Clyde (NHSGG&C)
Theme	Infections
Topic	Paediatric haematology oncology
Format	Management report and supplementary excel document
Data source(s)	Electronic Communication of Surveillance in Scotland (ECOSS) Total occupied bed days: Information Services Division ISD(S)1 Data provided by NHSGG&C
Date that data are acquired	ECOSS extract 07/10/2019
Release date	25 October 2019
Frequency	Ad hoc
Timeframe of data and timeliness	NA
Continuity of data	NA
Revisions statement	Case definitions have changed since previous reports (refer to methods section)
Revisions relevant to this publication	NA
Concepts and definitions	Covered in methods section.
Relevance and key uses of the statistics	NA
Accuracy	Laboratory data that has not been validation so treated with caution.
Completeness	Data not been validated
Comparability	Comparisons have been made to other Children's hospitals in Scotland however there may be differences in patient population so comparisons should be treated with caution.
Accessibility	It is the policy of HPS to make its web sites and products accessible according to **published guidelines**.
Coherence and clarity	NA
Value type and unit of measurement	Rate per 100,000 total occupied bed days (TOBDs) = (Number of cases of positive blood culture of given case definition in hospital(s) or speciality /TOBDs in hospital(s) or speciality x 100,000).
Disclosure	NA
Official Statistics designation	NA
UK Statistics Authority Assessment	NA
Last published	NA
Next published	NA
Date of first publication	NA
Help email	[redacted]
Date form completed	25/10/2019

Appendix 3 – HPS and Official Statistics

About HPS

HPS is a division of NHS National Services Scotland which works at the very heart of the health service across Scotland, delivering services critical to frontline patient care and supporting the efficient and effective operation of NHS Scotland.

HPS was established by the Scottish Government in 2005 to strengthen and coordinate health protection in Scotland. It is organised into three specialist groups with expertise provided by a multi-disciplinary workforce which includes doctors, nurses, scientists and information staff, all of whom are supported by core business and IM&T teams. The specialist groups are:

- Healthcare Associated Infections and Infection Control;
- Blood Borne Viruses and Sexually Transmitted Infections, Immunisation, and Respiratory and Vaccine Preventable Diseases;
- Gastrointestinal and Zoonoses Travel, and Environmental Public Health.

Official Statistics

Our official statistics publications are produced to a high professional standard and comply with the Code of Practice for Official Statistics. The Code of Practice is produced and monitored by the UK Statistics Authority which is independent of Government. Under the Code of Practice, the format, content and timing of statistics publications are the responsibility of professional staff working within NHS National Services Scotland.

Our statistical publications are currently classified as one of the following:

- National Statistics (ie assessed by the UK Statistics Authority as complying with the Code of Practice)
- National Statistics (ie legacy, still to be assessed by the UK Statistics Authority)
- Official Statistics (ie still to be assessed by the UK Statistics Authority)
- other (not Official Statistics)

Further information on NHS National Services Scotland's statistics, including compliance with the Code of Practice for Official Statistics, and on the UK Statistics Authority, is available on the ISD website.

Review of NHSGG&C paediatric haemato-oncology data

Health Protection Scotland

Report date
October 2019

This is management information and not official statistics

This is a Management Information publication

Published management information are non-official statistics which may be in the process of being transitioned into official statistics. They may not comply with the UK Statistics Authority's Code of Practice with regard to high data quality or high public value but there is a public interest or a specific interest by a specialist user group in accessing these statistics as there are no associated official statistics available.

Users should therefore be aware of the aspects of data quality and caveats surrounding these data, all of which are listed in this document.

Find out more about Management Information publications at:
https://www.statisticsauthority.gov.uk/wp-content/uploads/2016/06/National-Statisticians-Guidance-Management-Information-and-Official-Statistics.pdf

Contents

Introduction

Health Protection Scotland (HPS) supported NHS Greater Glasgow and Clyde (NHSGG&C) with a recent water related incident (March 2018 – September 2018) investigating and managing a contaminated water system across the Queen Elizabeth University Hospital (QEUH) and Royal Hospital for Children (RHC) with probable linked cases of bloodstream infections associated with wards 2A/2B RHC. Yorkhill Hospital (YH) relocated into the RHC in June 2015. Wards 2A/2B within RHC houses the haemato-oncology unit, also known as Schiehallion, the National Bone Marrow Transplant (BMT) Unit and the Teenage Cancer Trust (TCT). In September 2018, to allow remediation works to be undertaken in 2A/2B, patients were transferred to QEUH ward 6A and three rooms were allocated within the adult BMT of ward 4B for the paediatric BMT unit. To accommodate this move, adults from 6A were transferred to Gartnavel General. A **summary report** of the initial incident (Jan –Sept 2018) is available from Scottish Government web page.

Whilst a suspected increase in environmental Gram-negative blood cultures within ward 6A is investigated, admissions have been restricted since 1st August 2019.

The aim of this report is to review NHSGG&C paediatric haemato-oncology data and investigate the suspected increase in environmental Gram-negative blood cultures in the paediatric haemato-oncology population.

The objectives of this review are to:

- To describe the differences in the datasets currently being used to investigate cases of bacteraemia in patients cared for the in paediatric haemato-oncology wards in NHSGG&C.
- To review the environmental Gram-negative blood cultures in the paediatric haemato-oncology population.
- To identify whether there is a change in the type of reported environmental Gram-negative blood cultures in the paediatric haemato-oncology population.

Methods

The following data sets were provided for the review by NHSGG&C, further details can be found in Appendix 1 – Background information.

NHSGG&C data sets:

NHSGG&C CLABSI surveillance data

An extract was provided from the central line associated bloodstream infection (CLABSI) surveillance system for date range January 2015 –September 2019. CLABSI uses Centers for Disease Control (CDC) classification

> *'A CLABSI is a primary BSI in a patient that had a central line within the 48-hour period before the development of the BSI and is not bloodstream related to an infection at another site. However, since some BSIs are secondary to other sources other than the central line (e.g., pancreatitis, mucositis) that may not be easily recognized, the CLABSI surveillance definition may overestimate the true incidence of CRBSI'*

Paediatric haematology oncology patients were identified using theatre management system 'Opera' to obtain information on all patients who received a new central venous device at NHSGG&C and combining haematology oncology diagnosis via the Clinical Portal. This data was de-duplicated on a 7 day case definition per organism. Exclusion criteria include patients who have their central venous device inserted at another hospital even if the majority of their care was at RHC or if the patient was transferred to RHC with a CLABSI.

NHSGG&C ECOSS extract

Gram-negative extract was provided for data obtained locally from Electronic Communication of Surveillance in Scotland (ECOSS) for date range July 2013 – September 2019.

NHSGG&C Microbiology laboratory information management system (LIMS) Surveillance data

Microbiology laboratory information management system (LIMS) extract for date range June 2014 – September 2019. The dataset had been de-duplicated at species level by NHSGG&C. This is a dataset obtained through 'Telepath' the LIMS using a named consultant therefore linking cases from other hospitals/outpatients/previous admission/or coded elsewhere in the hospital which are linked to the unit through the consultant in charge of their care.

HPS dataset - ECOSS extract

A data extract from ECOSS system of all blood samples in children less than 18 years of age from 2013 to present was obtained the 7th October 2019. The following fields were used to assign the location of the samples. NHS Health Boards are coded by the location of the submitting laboratory. Additional hospital/ward data was derived from the ECOSS Unit Location field, or where incomplete free text within the medical specialty and requesting location fields were used to generate a final hospital list to be mapped against the total occupied bed days to generate hospital level rates.

For NHSGG&C hospitals, the free text within the unit location, medical specialty and requesting location fields are used to derive a location and ward within the hospital where the positive blood culture aspirated was associated, to find any specimens with a connection to wards 6A and 4B in the QEUH, ward 2A or 2B within RHC, or the equivalent within Schiehallion ward in Yorkhill hospital. In ECOSS the reporting laboratory codes for wards 6A and 4B were coded to RHC following the move to QEUH.

Positive blood cultures of the following micro-organisms were grouped. A full breakdown of the grouping is detailed in the Appendix 1:

- **Gram-negative bacteria**
- **Gram-positive bacteria**
- **Environmental bacteria group** all species of the following: *Achromobacter; Acinetobacter; Aeromonas; Brevibacillus species; Brevundimonas; Burkholderia; Cedecea; Chryseobacterium; Chryseomonas; Clavibacter; Comamonas; Cupriavidus; Delftia acidovorans; Elizabethkingia; Flavimonas; Gordonia; Pseudomonas; Pseudoxanthomonas; Psychrobacter; Ralstonia; Rhizobium; Rhodococcus; Roseomonas; Sphingomonas; Stenotrophomonas and atypical mycobacteria).*
- **Environmental including Enteric (ENT) group** - Environmental bacteria including following enteric organisms which as well as the environmental list above includes species of the following *Citrobacter; Enterobacter; Klebsiella; Pantoea; Serratia.*

Fungi (all species of the following: Candida; Rhodotorula) were excluded as it could not be established if all positive fungi blood cultures were being processed through ECOSS.

The following organisms grouped by genus, were previously isolated in water samples from ward 2A/2B: *Acinetobacter; Burkholderia; Chryseobacterium; Cupriavidus; Delftia acidovorans; Elizabethkingia; Pantoea; Pseudomonas; Rhizobium; Stenotrophomonas*.

The following organisms grouped by genus, were previously isolated in drain samples from ward 2A/2B: *Citrobacter; Cupriavidus; Delftia acidovorans; Enterobacter; Klebsiella; Pantoea; Pseudomonas; Serratia; Stenotrophomonas.*

Case definition

The trends in bacteraemia in this patient population were assessed using the HPS ECOSS data extract of positive blood cultures.

The study population includes patients less than 18 years of age cared for in the paediatric haematology oncology specialty in NHSGG&C (including new and existing patients).

A species level case definition was used in previous investigations and this was repeated for this review in order to make comparisons with the NHS GG&C datasets.

In order to account for the diversity of organisms likely to be identified if there is an environmental source and to account for polymicrobial episodes, case definitions were developed at group level. These groups are defined as an environmental bacteria group, environmental including enteric bacteria group and Gram-negative group. These groups are not mutually exclusive; therefore the trends analysis should be interpreted as such. A case definition for Gram-positive bacteraemia was also developed to provide context to the trends in the other groups.

From this population the proposed case definition of a case is defined as a patient with:

1) A positive blood culture of a single organism that has not been previously isolated from the patient's blood within the same 14 day period (i.e. 14 days from date last positive sample obtained).
2) A positive blood culture for any organism defined as environmental bacteria group (detailed above) that has not been previously isolated with same or other environmental bacteria group organism in the patient's blood within the same 14 day period.
3) A positive blood culture for an environmental including enteric bacteria group (detailed above) that has not been previously isolated with same or other environmental including enteric bacteria group organism in the patient's blood within the same 14 day period.
4) A positive blood culture where Gram-negative bacteria has been isolated in 14 day period that has not been previously isolated with same or other Gram-negative organism within the same 14 day period.
5) A positive blood culture where Gram-positive bacteria has been isolated in 14 day period that has not been previously isolated with same or other Gram-positive organism within the same 14 day period.

As per the case definition and to align with other national bacteraemia surveillance, a standard 14 day rolling deduplication was applied to the HPS ECOSS dataset. All positive blood cultures were included with the exception of post mortem blood, any quality test samples, foetal samples or non-human samples.

Denominator data

HPS use extracted data from ISD(1) provided by Information Services Division (ISD) for routine published reports. Due to unavailability of data for September 2019 data from August 2019 were used as a proxy.

Full details of ISD data collection can be obtained from **http://www.isdscotland.org/Products-and-Services/Data-Support-and-Monitoring/ISDS1/**

The activity data extract provided information on occupied bed days and bed occupancy of haematology and oncology from July 2013 to August 2019. In addition, it provided data on combined haemato-oncology day cases and outpatient appointments. The outpatient figures included patents who did not attend (DNA).

Incidence Rate

Rate per 1,000 total occupied bed days (TOBDs) = (Number of cases of positive blood culture of given case definition in hospital(s) or speciality /TOBDs in hospital(s) or speciality x 100,000). Incidence rates for the whole of RHC (including positive blood cultures and bed days of wards 6A and 4B following the move to QEUH) were compared with combined rates from the Royal Hospital for Sick Children in Lothian and the Royal Aberdeen Children's Hospital in Grampian. R was used to calculate rate ratios (RR) with corresponding exact 95% Confidence Intervals (95%CI).

SPC Charts

Hospital and specialty data were analysed using Byars method for statistical process control (SPC) U-charts using the rules detailed in Table 1. The mean, trigger/warning (+2 standard deviations) and upper control limits (+3 standard deviations) are presented. These control lines vary by month due to variations in the TOBD denominator. The mean was calculated from the data prior to the move to RHC when available (HPS and NHSGG&C Gram-negative data). Further information on SPC charts can be found at : **http://www.isdscotland.org/Health-Topics/Quality-Indicators/Statistical-Process-Control/**

Table 1: Statistical Process Control (SPC) rules.

Rule	Description	Marker
Outlier	Data point(s) exceeding the upper or lower control limit (as 3 standard deviations)	Red diamond
Trigger point	Data point(s) exceeding the upper or lower warning limit (as 2 standard deviations)	Yellow triangle
Shift	A run of 8 or more consecutive data points above the centreline	Circle drawn round points
	A run of 6 or more consecutive data points either increasing or decreasing.	N/A

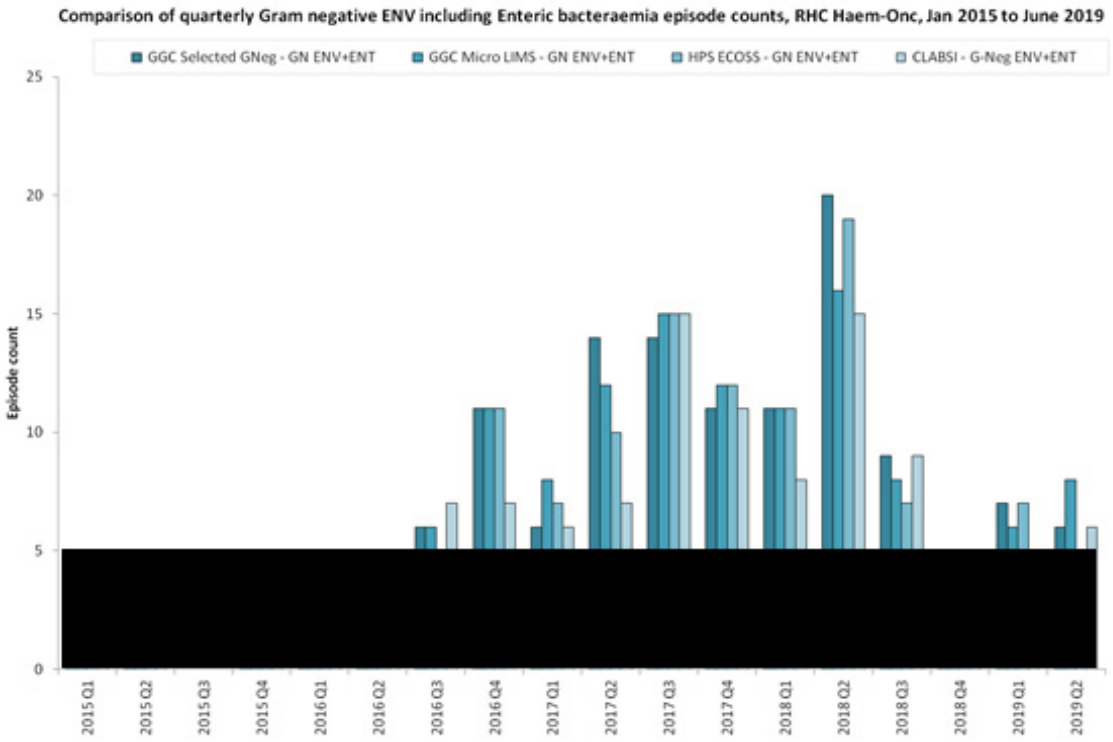
Results and Commentary

Comparison of datasets (species level)

In order to validate the datasets provided by NHSGG&C they were compared with an extract taken by HPS (ECOSS extract) a single organism at species level case definition (**1**) was used so all isolates could be compared. The datasets that were provided all contained data covering the period from January 2015 to June 2019. Figure 1 shows the differences between the datasets when selected environmental Gram-negative organism were compared. The main difference found between the datasets are detailed in Table 2 and Table 3.

It is important to note that each dataset used different case definitions and methods to identify patients who had samples taken or treatment in RHC haemato-oncology unit which accounts for most of the discrepancies identified between datasets.

Figure 1: Comparison of NHSGG&C selected Gram-negative quarterly counts of species level case definition (1) for NHSGG&C and HPS datasets from 2015 Quarter 1 to 2019 Quarter 2.



1. Source of data is Electronic Communication of Surveillance in Scotland (ECOSS), NHSGG&C central line associated bloodstream infection (CLABSI) surviellance system, and NHSGG&C laboratory information management system (LIMS).

Table 2: NHSGG&C CLABSI surveillance data and possible reasons for dataset not matching for the time period January 2015 and September 2019.

HPS episodes without corresponding NHSGG&C episode (n=118, 20.8%)	NHSGG&C episodes without corresponding HPS episode (n=56, 12.4%)
Possible contaminants (n=48, 40.7%) (only one result available for common skin contaminants coagulase-negative staphylococci, *Micrococcus spp., Propionibacterium acnes, Bacillus spp., Corynebacterium spp*.)	Location mapping 53.6% (n=30) could not be identified as belonging to the RHC haematology oncology cohort based on the details of their ECOSS result.
Differences in inclusion and exclusion criteria in CLABSI data - 48.3% (n=57) were either known pathogens or had more than one positive and were included in the other NHSGG&C datasets.	Using de-duplication of 7 rather than 14 days - 23.2% (n=13)
Using de-duplication of 7 rather than 14 days - [redacted]).	Missing in ECOSS [redacted]) of results were not in ECOSS but were included in the NHSGG&C Micro LIMS dataset.
Location errors [redacted]) were not included in any of the NHSGG&C datasets therefore it is likely that they were not part of the true RHC Haem-On cohort.	18 years of age or above excluded by HPS – [redacted])

1. Source of data is Electronic Communication of Surveillance in Scotland (ECOSS) and NHSGG&C central line associated bloodstream infection (CLABSI) surviellance system.

Table 3 NHSGG&C Microbiology LIMS surveillance data and possible reasons for dataset not matching for the time period June 2014 and September 2019.

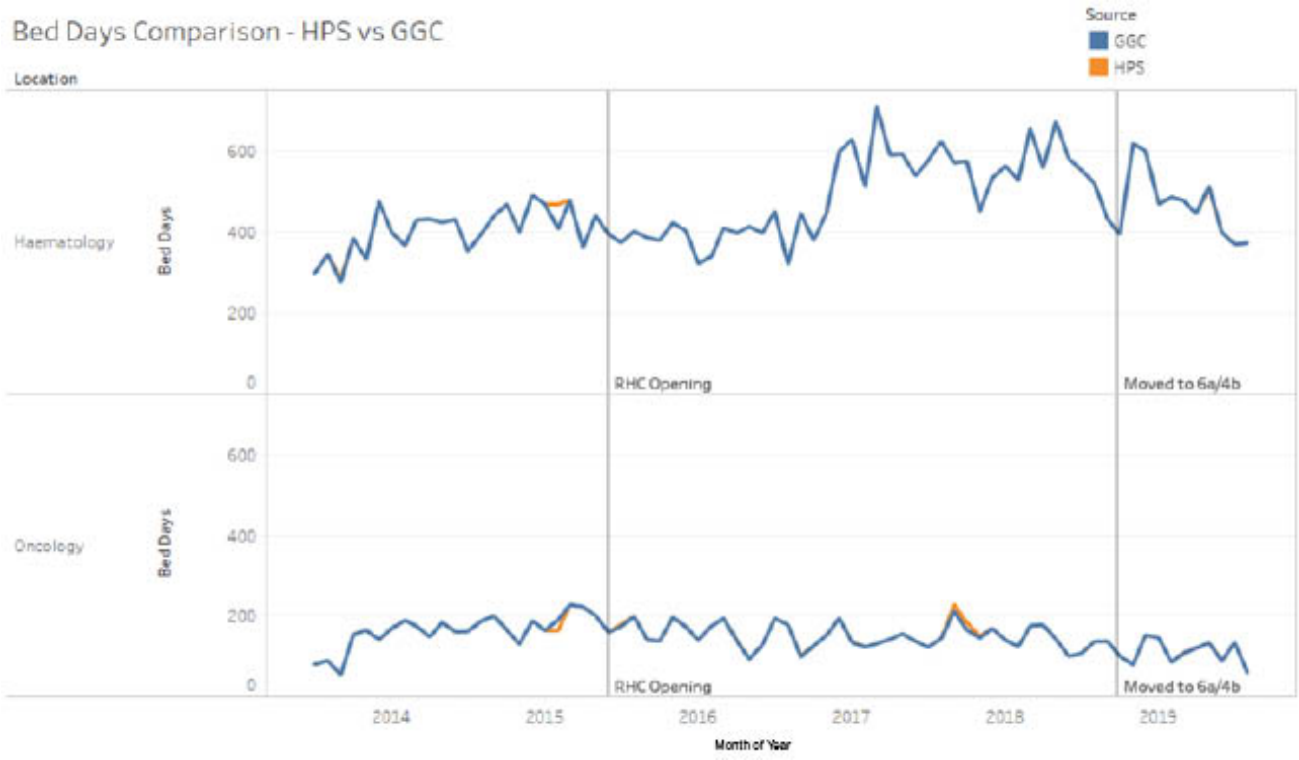
HPS episodes without corresponding NHSGG&C episode (n=42, 6.8%)	NHSGG&C episodes without corresponding HPS episode (n=85, 12.9%)
HPS episodes with corresponding results listed in NHS GGC CLABSI dataset but missing in Micro LIMS data (n=25, 59.5%)	Micro LIMS data included 24 (28.2%) episodes that should have been excluded using the 14 day species de-duplication rule.
Episodes missing from both the NHSGGC Micro LIMS and CLABSI datasets (n=15, 35.7%). [redacted] of these specimens were not collected from haem-oncology wards so were unlikely to be part of the true RHC Haem-Onc cohort and can be excluded from surveillance. [redacted] were possible contaminants with only one result available in ECOSS and can be excluded from surveillance. [redacted] were known enteric pathogens and aspirated in haem-oncology wards. [redacted] was an environmental organism which was also included in the NHSGGC selected Gram-neg dataset.	Location mapping 29.4% (n=25) could not be identified as belonging to the RHC haematology oncology cohort based on the details of their ECOSS result. Ten of these patients had their start of episode specimens taken in different hospitals across six health boards.
ECOSS result not updated with species name, these should be excluded as episodes during deduplication [redacted]	18 years of age or above excluded by HPS – [redacted]
	Non-blood culture specimens excluded by HPS – [redacted] This included four bone marrow specimens and one pus.
	Missing in ECOSS -30.6% (n=26) of results were not in ECOSS. Of these 10 were included in the NHSGG&C CLABSI dataset.

1. Source of data is Electronic Communication of Surveillance in Scotland (ECOSS) and and NHSGG&C laboratory information management system (LIMS).

Review of denominator data

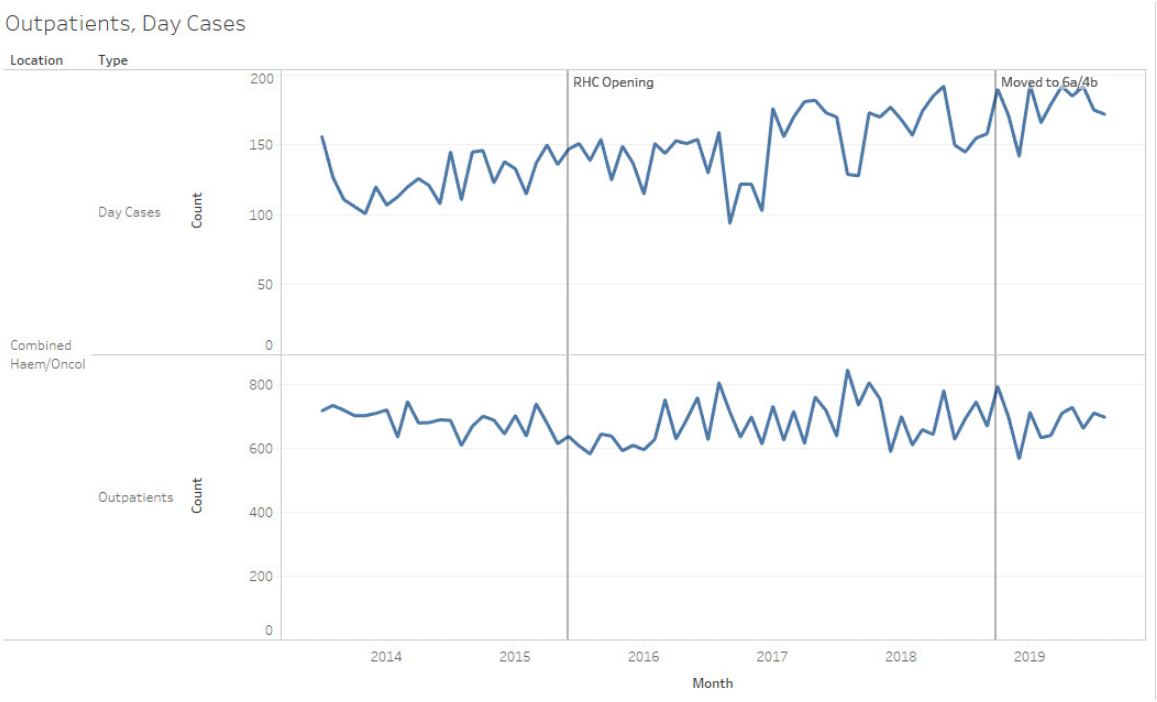
The NHSGG&C activity data was also validated by comparing it to data held by HPS provided by Information Services Division (ISD) and only minor differences were shown (Figure 2). An increase in occupied bed days' activity occurs in haematology in December 2016 which was not mirrored in the oncology figures. Activity data for day cases and outpatients including patients that did not attend (DNA) is shown in Figure 3 showing a gradual increase in day cases following the move to RHC.

Figure 2: Review of total occupied bed days by haematology and oncology specialities for the time period July 2013 to August 2019.



1. Total occupied bed days: Activity data (provided by NHSGG&C) & Information Services Division ISD(S)1 (HPS).

Figure 3: Day cases and outpatient appointments (including did not attend) of combined haematology and oncology activity from July 2013 to August 2019.



1. Activity data provided by NHSGG&C.

Case level data

From the data obtained by HPS from ECOSS there were 688 positive blood culture episodes at species level (case definition 1) for under 18 paediatric haematology oncology population in NHSGG&C linked to RHC between July 2013 and September 2019. From the 688 species level cases, 167 episodes were classed as environmental including enteric group from 97 different patients. Approximately one third (33.5%, n=56) of the species episodes reported formed part of polymicrobial environmental gram negative bacteraemia episodes.

For case definition 2, there were 70 cases of environmental organisms, and when expanding this group to include enteric organisms (case definition 3), there were 132 cases.

When deduplicating at Gram-stain level (case definitions 4 and 5), there were 390 cases of Gram-positive group organisms and 176 cases of Gram-negative group organisms.

Using the Gram-negative case definition an upward shift with a run of ten data points above the mean was observed from March to December 2017, with the upper warning limit (UWL) breached in August 2017, March 2018, May 2018 and again in September 2019 (Figure 4).

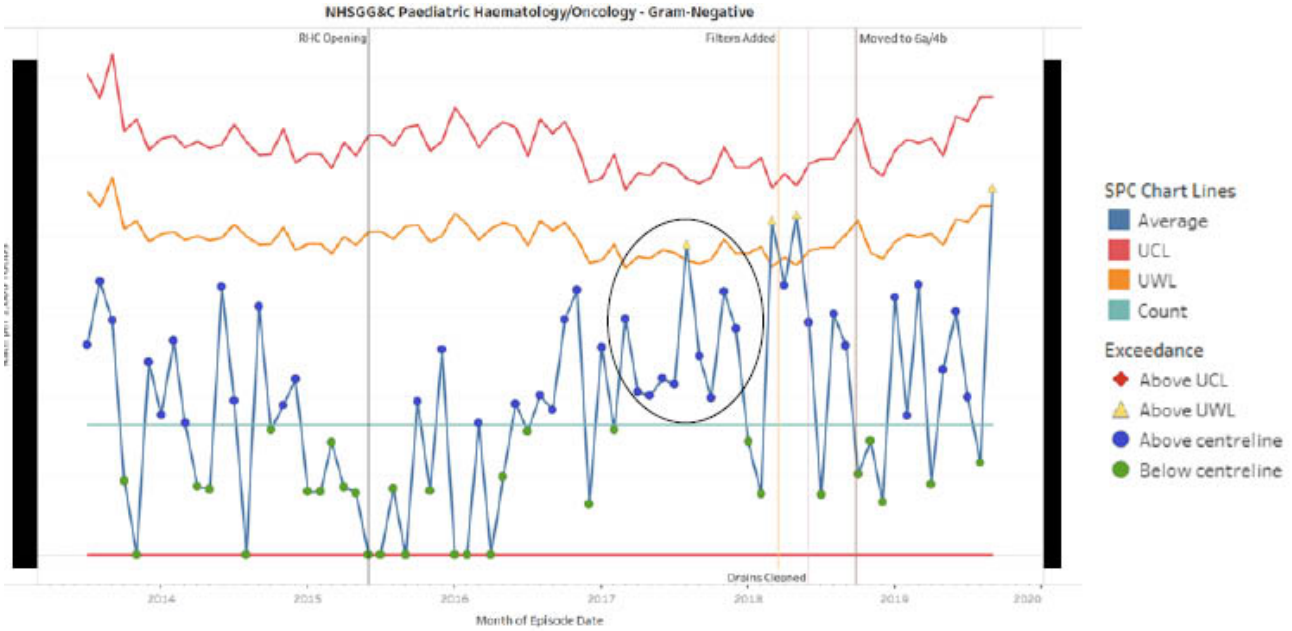
Figure 5 shows the SPC chart for the environmental group case definition. The UWL was breached in June 2018. The environmental group was extended to include selected enteric organisms such as species of *Enterobacter; Klebsiella* that were linked with drain contamination. The environmental including enteric group is described in Figure 6, showing the UWL was breached in March 2018 and March 2019.

Figure 7 describes the incidence of Gram-positive blood cultures in paediatric haematology oncology population. There was no upward shift in rates following the move to RHC however the upper control limit (UCL) was breached in January 2016, January 2017, April 2017 and June 2017. With rates above the UWL July 2016, May 2017, November 2017 and December 2017. Following the increase in activity at the RHC shown in Figure 7 with six out of twelve data points in 2017 breached a trigger limit (UWL or UCL). The rate now appears to be similar to that observed prior to the move to RHC with seven out twelve data points having a rate below the mean rate in the last year.

A summary of the SPC shifts and triggers shown in Figure 4 to Figure 7 is provided in Table 4.

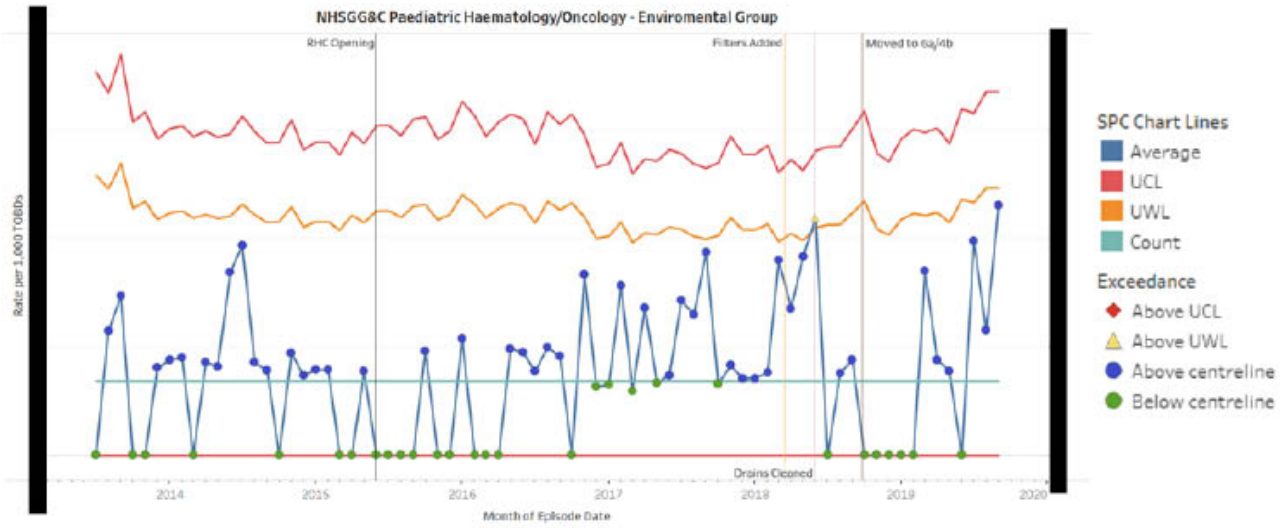
No change was observed when crude comparisons were made between the rates with the exception of the Gram-positive group ($p=0.04$) which significantly decreased when comparing the overall incidence before and after the move to RHC.

Figure 4: SPC chart using the Gram-negative case definition for HPS data from the July 2013 to September 2019.[1]



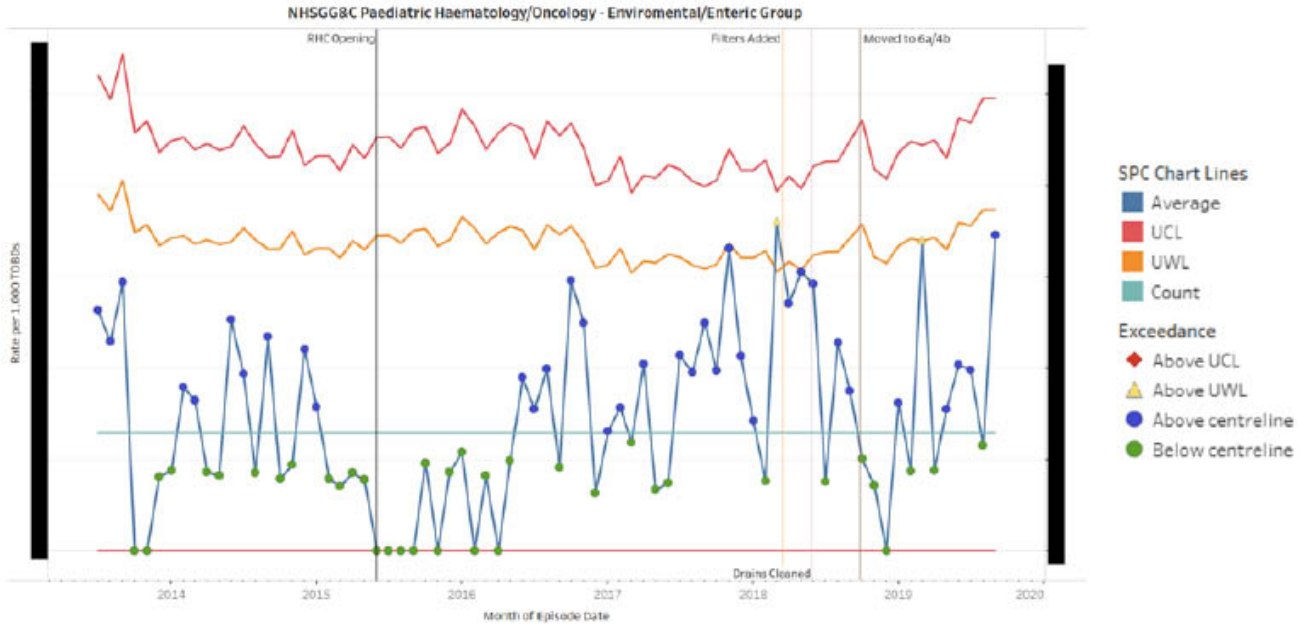
1. Source of data is Electronic Communication of Surveillance in Scotland (ECOSS) & Total occupied bed days: from activity data provided by NHSGG&C.

Figure 5: SPC chart using the environmental group case definition for HPS data from the July 2013 to September 2019.[1]



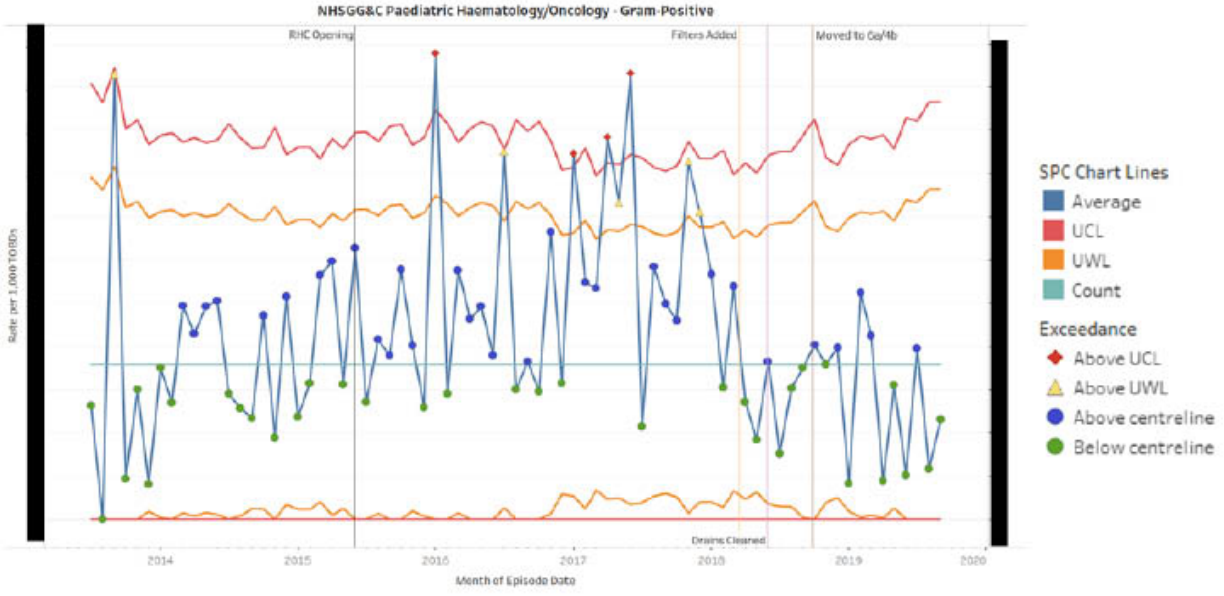
1. Source of data is Electronic Communication of Surveillance in Scotland (ECOSS) & Total occupied bed days: from activity data provided by NHSGG&C.

Figure 6: SPC chart using the environmental including enteric group case definition for HPS data from the July 2013 to September 2019.[1]



1. Source of data is Electronic Communication of Surveillance in Scotland (ECOSS) & Total occupied bed days: from activity data provided by NHSGG&C.

Figure 7: SPC chart using the Gram-positive case definition for HPS data from the July 2013 to September 2019.[1]



1. Source of data is Electronic Communication of Surveillance in Scotland (ECOSS) & Total occupied bed days: from activity data provided by NHSGG&C.

Table 4: Summary table listing SPC shifts, trigger points (UWL breach) and outliers(UCL breach) following the move to RHC using HPS data from July 2013 to September 2019.[1]

Year	Gram-positive	Gram-negative	Environmental	Enviro/Enteric
2015				
2016	Jan 2016 (UCL)			
	July 2016 (UWL)			
2017	Jan 2017 (UCL)	Upward shift (Mar 2017 – Dec 2017)		
	April 2017 (UCL)	Aug 2017 (UWL)		
	May 2017 (UWL)			
	June 2017 (UCL)			
	Nov 2017 (UWL)			
	Dec 2017 (UWL)			
2018		March 2018 (UWL)	June 2018 (UWL)	March 2018 (UWL)
		May 2018 (UWL)		
2019		Sept 2019 (UWL)		March 2019 (UWL)

1. Source of data is Electronic Communication of Surveillance in Scotland (ECOSS) & Total occupied bed days: from activity data provided by NHSGG&C.

Comparison with other health boards

When comparing the overall hospital rate of positive blood cultures since the move to RHC (June 2015 to September 2019) to the combined rate of the other two Scottish children's hospitals (Royal Aberdeen Children's Hospital (NHS Grampian) and Royal Hospital for Sick Children (NHS Lothian)), the incidence of positive blood cultures, using the case definitions 2 to 5, was higher in RHC for environmental including enteric group (RR= 1.86 95%CI 1.42-2.47, p<0.001), but lower for Gram-positive group (RR=0.76, 95%CI 0.70-0.83, p<0.001). There was no difference in the rates of Gram-negative group (RR=1.18, 95%CI 0.96-1.42, p=0.07) or environmental group (RR=1.42, 95%CI 0.94-2.16, p=0.11).

When compared over two years (October 2017 to September 2019), the rate of positive blood cultures was higher in RHC for environmental including the enteric group (RR=1.70, 95%CI 1.17-2.53, p<0.005) and Gram-negative group (RR=1.31, 95%CI 1.00-1.73, p=0.05) but lower for the Gram-positive group (RR=0.74, 95%CI 0.66-0.84, p<0.001). There was no difference in the rates of the environmental group (RR=1.36, 95%CI 0.77-2.52, p=0.39).

In the last year following the move to QEUH (October 2018 to September 2019) there was no difference in the rate for Gram-negative group (RR=1.23, 95%CI 0.85-1.80, p=0.30), environmental including the enteric group (RR=1.26, 95%CI 0.74-2.18, p=0.44) or environmental group (RR=0.93, 95%CI 0.41-2.23, p=1) however the rate was lower for the Gram-positive group (RR=0.77, 95%CI 0.64-0.93, p=0.005).

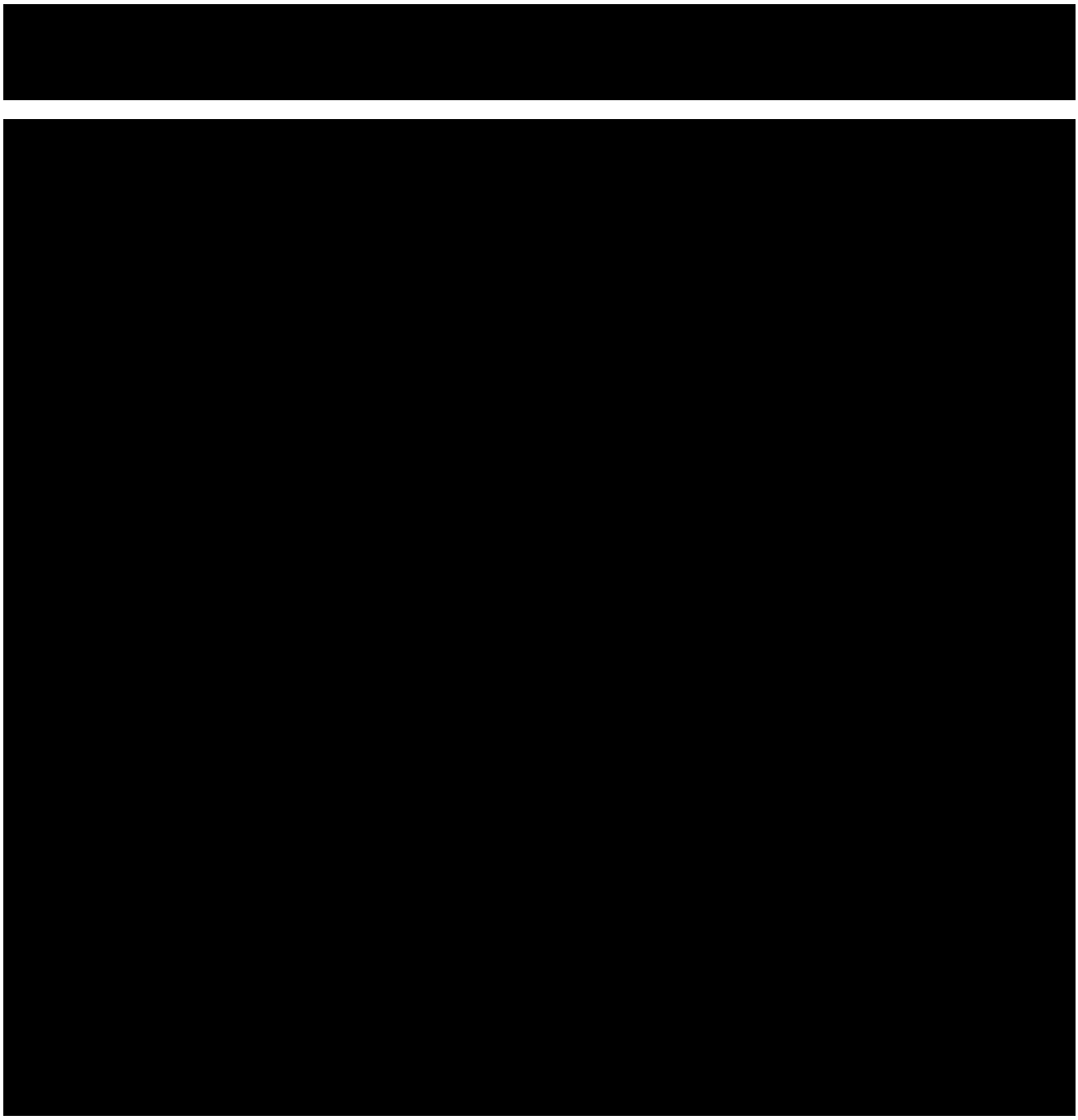
Diversity of Environmental Organisms

The diversity of organisms isolated in the haemato-oncology unit prior and post move to RHC for the environmental group and the environmental including enteric group are shown in Figure 8 and Figure 9.

[redacted]

[redacted]

[redacted]



Caveats

There are a number of limitations associated with the use of ECOSS blood culture data. Blood samples are non-validated records. The cases may include interim results, contaminants, and may include non-blood cases which are incorrectly mapped to a blood sample within either the laboratory system or within ECOSS. Location mappings within ECOSS records may also be prone to error and it may be difficult to capture all haemato-oncology patients admitted to other RHC or YH wards who subsequently had a positive blood culture. Gram-negative blood culture data may be incomplete for September 2019 and non tuberculous mycobacteria data may be incomplete from July 2019 onward as samples are still to be reported. Due to uncertainty over positive fungal blood samples coming into ECOSS they were excluded from this review.

Improvements in speciation, for example using MALDI-TOF technologies, may change the identification over time. Species level case definitions may result in a patient having more than one episode of positive blood culture in a 14 day period.

Environmental bacteria grouping include bacteria commonly found in the environment however they may also be associated with normal human microbiome and laboratory surveillance is unable to distinguish.

It is not possible to determine whether changes in episodes are confounded by changes in the patient population and their underlying medical conditions.

The rates used to compare the overall rate at RHC following the move to QEUH to the combined rate of the other two Scottish children's hospitals used an estimated denominator (Total Occupied Bed Days) for September 2018 by taking the proportion of days following the move.

In the monthly analysis of environmental bacteria positive blood cultures, the numbers are small and should be treated with caution.

The main reasons documented about discrepancies in the review of datasets were only the most likely reason and due to time constraints were not further investigated.

Summary and Recommendations

This report provides a review of datasets currently being used in NHSGG&C and HPS to support the investigation of this incident; an updated description of trends in positive blood cultures; and a description of the diversity of organisms.

One of the key objectives of this review was to assess the NHSGG&C datasets and provide assurance that the data provides an accurate reflection of the current epidemiological situation in this patient population and where differences exist, to understand reasons and assist with the interpretation. The results from this exercise suggest that the datasets currently used by NHSGG&C provide important intelligence that is aligned with the microbiological data held nationally in ECOSS. There are pros and cons to each of the datasets. The ECOSS and LIMS microbiology datasets do not provide clinical information relating to the cases, without this it is difficult to ensure that the blood cultures are true cases of clinical bacteraemia and there is limited epidemiological and clinical information to support investigation. The CLABSI dataset includes clinical information but has strict case definitions that may exclude cases of bacteraemia associated with the haemato-oncology specialty including those presenting in the first 48 hours of admission and those where the line was inserted in another unit.

Reviewing monthly SPC charts has been shown to be an appropriate method in identifying triggers and outliers when a stable period can be used to set the mean. In this review, the crude incidence rates before and after the move did not reflect the variation in incidence over time within this population. The changes in activity, in particular the occupied bed days, have highlighted the importance of considering activity when interpreting charts and where possible to use incidence rates in SPC charts. The use of grouped case definitions have allowed the data to be reviewed without reporting bias of selecting significant organisms or over reporting when multiple organisms are isolated from the one patient.

The SPC charts included in this report describe that there has been instances of variation outside what would normally be expected in this patient population, the latest was a breach of an upper warning limit for Gram-negative blood culture episodes in September 2019. The characterisation of these cases alongside understanding in the context of environmental microbiology is critical to understanding and managing risk.

The purpose of developing triggers that identify areas where the number of cases is out with what would normally be expected due to random variation, is to identify when it is appropriate to instigate a local investigation into the possible increase in cases. In order to ensure that appropriate action is taken, high sensitivity where there is a high degree of suspicion for increased number of cases is important, particularly in such a vulnerable population. For this reason, the use of microbiological laboratory data rather than the CLABSI data would provide a more sensitive measure for identifying areas for local investigation.

Triggers for areas where there is a need to monitor infectious agents with a possible environmental source that are based on groups of organisms rather than single species triggers likely provides a better measure. This is due to the complex microbiology of

environmental sources. The data presented in this report provide a starting point for supporting the development of appropriate triggers for environmental pathogens. The organisms included in the environmental category can be reviewed following the comprehensive literature reviews being undertaken by HPS for Chapter 4 of the National IPC Manual.

These analyses also indicate that approximately a third of cases of positive blood culture of environmental organisms had a polymicrobial episode. This observation provides an indication of the complexity of the interpretation of microbiology data in the absence of clinical data for this patient population. In addition, there were patients who had multiple episodes of positive blood cultures with different organisms over extended periods of time. Again, the interpretation of the data requires clinical data collected systematically to support interpretation of both unusual clinical pictures and breaches in the limits in SPC charts. The microbiological and clinical data should also be set in the environmental context including the environmental microbiology results such as water and ventilation sampling.

The data presented in this report do not provide evidence of single point of exposure and there is a need to continually monitor the risk in this patient population. There is no immunity to the organisms under investigation, therefore all patients within this cohort are at risk from developing gram negative bacterium due to their co morbidities and treatment plan. The control measure of restricting clinical services for newly diagnosed patients over existing patients should now be reconsidered.

The following recommendations should be considered:

- NHS GG&C should systematically collect clinical data on cases to describe risk in this patient population and ensure ongoing monitoring is in place.
- NHS GG&C should further characterise of cases in terms of “person” and “place” to support understanding when there are more cases than normally expected.
- NHS GG&C should consider the epidemiological characterisation of cases in the context of environmental risks and incidents e.g. water testing results, ventilation testing results.
- NHS GG&C should consider the data provided in the context of the findings from the action plan
- NHS GG&C should consider current control measures around restriction on services for newly diagnosed patients as there is no evidence from the HPS review of the data that supports the continued restriction of services.
- HPS will review the categorisation of environmental organisms following the literature reviews for Chapter 4 of the **National Infection Prevention and Control Manual**.
- HPS will further support the development of an appropriate trigger for ongoing monitoring.
- HPS should consider these findings when developing methods to support other boards in monitoring infection risk associated with environmental organisms.

Glossary

BMT	Bone Marrow Transplant
CDC	Centers for Disease Control
CLABSI	Central line associated bloodstream infection
CI	Confidence intervals
DNA	Did not attend
ECOSS	Electronic Communication of Surveillance in Scotland
ENT	Enteric
HPS	Health Protection Scotland
ISD	Information Services Division
LIMS	Laboratory information management system
NHSGG&C	NHS Greater Glasgow and Clyde
QEUH	Queen Elizabeth University Hospital
RR	Rate ratios
RHC	Royal Hospital for Children
SPC	Statistical Process Control
TOBD	Total occupied bed days
UCL	Upper control limit
UWL	Upper warning limit
YH	Yorkhill Hospital

List of Tables

List of Figures

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Further Information

Further Information can be found on the HPS website.

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Appendices

Appendix 1 – Background information

NHS GG&C supplied methods statement for Royal Hospital for Children Blood Stream infections for HPS review.

CLABSI

CLABSI data is prepared according to the following protocol, agreed by the RHC CLABSI Quality Improvement Group:

The QI group refer to CLABSI as defined according to the CDC classification as:

> *'A CLABSI is a primary BSI in a patient that had a central line within the 48-hour period before the development of the BSI and is not bloodstream related to an infection at another site. However, since some BSIs are secondary to other sources other than the central line (e.g., pancreatitis, mucositis) that may not be easily recognized, the CLABSI surveillance definition may overestimate the true incidence of CRBSI'*

The data includes all patients within the haemato-oncology cohort, so inclusive of those cared for at home by the outreach nurses, those attending day care and those who are inpatients in ward 2A including Bone Marrow Transplant, and teenage cancer patients.

CLABSI Data Collection Process:

1) ALL patients receiving a new central venous device at Yorkhill/Glasgow Royal Hospital for Children between January 2015 and July 2019 were collated (using Opera data to look at every operation done in every theatre every day in the Children's Hospital)

2) Out of this group, only the haematology/oncology patients were kept (searching for and confirming a diagnosis via Clinical Portal)

3) The total line day data was obtained by counting the number of days each line was in situ

4) Each patient was analysed monthly or twice monthly looking at positive microbiology culture results from either a central line or a peripheral venous sample whilst a central line was in situ (via Clinical Portal)

5) Any positive microbiology result with a concurrent illness (IE chest infection or urinary tract infection) was excluded (again via Clinical Portal and the electronic notes)

6) If a culture positive result occurred repeatedly in the 7 days following the first positive culture and the organism was the same, this was excluded (IE a patient with a Staph Aureus infection on 5/9/18 and a subsequent culture positive Staph Aureus on 7/9/18 was only counted as ONE infection); a second Staph Aureus infection on 13/9/18 would be counted as TWO infections in total as one would presume that a week of treatment should have effectively treated the first organism.

7) If, however, a second culture positive result occurred in the 7 days following the first positive culture and the organism was different, this was included (IE a patient with a Staph Aureus infection on 5/9/18 and a subsequent culture positive pseudomonas infection on 7/9/18 was counted as TWO infections in total).

8) Patients receiving their Hickman/Broviac Line, Port, or Haemodialysis line in a unit other than the Royal Hospital for Children in Glasgow were excluded. This point was discussed at the first CLABSI QI meeting and it was felt that these (few) patients that had lines inserted elsewhere but were treated in Glasgow could not be analyzed in the same fashion as those receiving the majority of their care (from line insertion to treatment to line removal) here in Glasgow.

9) Patients shared care in local district general hospitals who presented locally initially with a CLABSI and were subsequently transferred to Glasgow did not have that single line infection counted for similar reasons (we would be looking at the management of care in the district general hospital and thus would not be able to analyze them in the same methodology).

To produce the total CLABSI/Gram negative CLABSI chart as shown in the presentation, each line was checked to assign he organism to either gram positive, gram negative or fungus. The same denominator (line days) was used.

Where there were multiple organisms in a single line, the first named organism was used for classification. One organism was not classified, as it can exist as gram positive, gram negative or gram neutral.

CLABSI funnel plot

The funnel plot was produced using the PHE fingertips funnel plot for rates tool. The data used was the gram negative counts, and line day denominator used in the other CLABSI charts. The plot was produced using the instructions included in the tool. As there is no long term stable average, and in recognition of the quality improvement project, the central line was set to the aim of 1 per 1000 line days.

Epicurves

The ECOSS system was queried to obtain data on positive blood cultures for selected gram negative organisms reported from the GLA:SGH or GLA:GRI laboratories, age <16. The initial extract (during the water/drains incident 2018) was for date of report from July 2013 to June 2018. Further extracts were made periodically. The list of gram negatives was provided by the NHS GGC lead Infection Control Doctor, and is contained in the appendix to this document. This list is based on organisms identified during the water/drains incident. Following further discussion since the initial extract, *Citrobacter* and Aeromonas were added

to that list. To increase sensitivity, data were pulled from ECOSS on basis of genus, rather than species.

Following extraction, the following exclusions were applied:

- Results from neonatal, maternity and pathology removed
- Results from areas not part of RHSC/RHC

During initial screening, laboratory GLA:RAH was also included, however as no relevant results noted, this parameter was removed from the query.

CHI numbers were replaced with new unique ID, and patient identifiers deleted. It is therefore not possible to directly link more recent cases to those form previous extracts. To ensure that the rules below could be applied, and to capture any late inclusions in the ECOSS data base, the 3 months data prior to the new months was also extracted and cases cross checked. One additional late inclusion was detected in this way.

Each case was assigned to a specialty based on the following data points included in the ECOSS reports –

1. Ward sample was taken
2. Diagnosis/clinical history recorded on lab request
3. Requesting consultant.

If it was not possible to identify a specialty from information contained in the ECOSS report, then speciality was confirmed using electronic patient records.

Two separate counts were calculated, based on methodologies described by PHE and CDC:

- Organism count: Number of positive blood cultures per calendar month. Results within 14 days of a previous positive for the **same** organism in the same patient excluded.
- Case count: Number of positive blood cultures per calendar month results within 14 days of previous positive for **any** organism in the same patient excluded (ie only one positive per patient per 14 days)

In both cases the date of result was counted as day one.

Rates were then calculated using activity data produced by NHS GGC acute service information team.

Division of organisms between “environmental” and “non-environmental” was based on advice from GGC mcirobiologists.

Non-environmental: *Citrobacter*, *Enterobacter, Klebsiella, Pantoea, Serratia.*

Environmental: All other organisms.

All gram negative positive blood cultures chart

An extraction from ICNet of blood cultures from RHSC Schiehallion, RHSC Schiehallion DCU, RHC 2A, RHC 2B & QEUH 6A, for patients under 18 years at time of BC aspiration for dates 01/11/2014 – 19/09/2019 (date of data extraction) was carried out by GGC IPCT surveillance team. Blood cultures were de-duplicated by 14 days i.e. new case on day 15 from previous isolate of the same organism in the same patient. More than one organism may have been isolated in the same blood culture specimen.

The counts were converted to rates using the occupied bed day data from NHS GGC acute services information team.

NHSGG&C Appendix: list of selected gram negative organisms

Achromobacter xylosoxidans	Morganella morganii
Acinetobacter lwofii	Pantoea agglomerans
Acinetobacter ursingii	Paracoccus sp
Brevundimonas versicularis	Pseudomonas chlororaphis
Burkholderia cepacia	Pseudomonas fluorescens
Cedecea lapagei	Pseudomonas oryzihabitans
Chryseobacterium indologenes	Pseudomonas putida
Commamonas testosterone	Pseudoxanthomonas mexicana
Cupriavidus gilardii	Ralstonia picketii
Cupriavidus pauculus	Rhizobium radiobacter
Delftia acidovorans	Serratia fonticola
Elizabehtkingia meningospetica	Shewanella puterfaciens
Enterobacter cloacae	Sphingomonas species
Klebsiella pnuemoniae	Stenotrophomonas maltophilia

Organism comparison list

Table 5 and Table 6 detail the organisms isolated in the positive blood cultures and the groupings used in this report.

Table 5: Organisms isolated from positive blood samples included in environmental groupings during the time period reviewed.[1]

NHSGGC CLABSI surveillance	NHSGGC ECOSS selected Gram-negative organisms (GGC Selected GNeg)	NHSGGC Microbiology LIMS Surveillance	HPS ECOSS Under18 bloods RHC HaemOnc
Gram Negative Environmental (GN ENV)	**Gram Negative Environmental (GN ENV)**	**Gram Negative Environmental (GN ENV)**	**Gram Negative Environmental (GN ENV)**
Achromobacter spp.	*Acinetobacter baumannii*	*Achromobacter sp*	*Achromobacter spp.*
Acinetobacter baumannii	*Acinetobacter ursingii*	*Acinetobacter baumannii*	*Acinetobacter spp.*
Acinetobacter ursingii	*Aeromonas hydrophila*	*Acinetobacter ursingii*	*Aeromonas hydrophila*
Aeromonas hydrophila	*Brevundimonas spp.*	*Aeromonas spp*	*Brevundimonas spp.*
Burkhold cepacia	*Burkholderia cepacia*	*Brev. spp.*	*Burkholderia cepacia*
Chryseomonas indologenes	*Chryseobacterium indologenes*	*Burk. cepacia group*	*Chryseobacterium indologenes*
Chryseob. spp	*Chryseobacterium spp.*	*Chryseob. spp.*	*Chryseobacterium spp.*
Cupriavidis pauculus	*Cupriavidus pauculus*	*Chryseobacterium indologenes*	*Cupriavidus pauculus*
Eliz. meningoseptica	*Delftia acidovorans*	*Chryseomonas spp.*	*Delftia acidovorans*
Elizabethkingia spp.	*Elizabethkingia meningoseptica*	*Cup. pauculus*	*Elizabethkingia meningoseptica*
Delftia acidovorans	*Elizabethkingia spp.*	*Del. acidovorans*	*Elizabethkingia miricola*
Pseudomonas spp.	*Pseudomonas spp.*	*Delftia spp.*	*Elizabethkingia spp.*
Rhiz. radiobacter	*Rhizobium radiobacter*	*Elizabethkingia. spp.*	*Pseudomonas spp.*
Roseomonas mucosa	*Sphingomonas paucimobilis*	*Herbaspirillum sp*	*Raoultella planticola*
Sphingomonas spp.	*Steno. maltophilia*	*Pseudomonas spp.*	*Rhizobium radiobacter*
Steno. maltophilia		*R. planticola*	*Roseomonas mucosa*
		R. radiobacter	*Sphingomonas paucimobilis*
		R. mucosa	*Steno. maltophilia*
		Sph. paucimobil	

		Steno. maltophilia	
Gram Negative Enteric /Environmental (GN ENT/ENV)	**Gram Negative Enteric /Environmental (GN ENT/ENV)**	**Gram Negative Enteric /Environmental (GN ENT/ENV)**	**Gram Negative Enteric /Environmental (GN ENT/ENV)**
Citrobacter spp. *Enterobacter cloacae* *Klebsiella spp.* *Pantoea spp.* *Serratia liquefaciens* *Serratia marcesens*	*Citrobacter spp.* *Enterobacter spp.* *Klebsiella spp.* *Pantoea spp.* *Serratia liquefaciens* *Serratia marcescens*	*Citrobacter spp.* *Enterobacter spp.* *Klebsiella spp.* *Pantoea spp.* *Ser. liquefac.* *Ser. marcescens*	*Citrobacter spp.* *Enterobacter spp.* *Klebsiella spp.* *Pantoea spp.* *Serratia liquefaciens* *Serratia marcescens*
Gram Positive Environmental (GP ENV)	**Gram Positive Environmental (GP ENV)**	**Gram Positive Environmental (GP ENV)**	**Gram Positive Environmental (GP ENV)**
Gordonia polyisoprenivorans	N/A	*Gordonia polyisoprenivorans*	*Gordonia bronchialis*
Acid Fast Environmental (AF ENV)	**Acid Fast Environmental (AF ENV)**	**Acid Fast Environmental (AF ENV)**	**Acid Fast Environmental (AF ENV)**
Mycobacterium chelonae	N/A	*Myc. chelonae group* *Myco fortuitum* *Mycobacterium chelonae*	*Mycobacterium chelonae* *Mycobacterium spp.*
Fungi Environmental (Fungi ENV)	**Fungi Environmental (Fungi ENV)**	**Fungi Environmental (Fungi ENV)**	**Fungi Environmental (Fungi ENV)**

1. May not include every organism of interest if no cases were found during the time period.

Table 6: Organisms isolated from positive blood samples included in non-environmental groupings during the time period reviewed.[1]

NHSGGC CLABSI surveillance	NHSGGC ECOSS selected Gram-negative organisms (GGC Selected GNeg)	NHSGGC Microbiology LIMS Surveillance	HPS ECOSS Under18 bloods RHC HaemOnc
Gram Negative Non-environmental (GN NON-ENV)	**Gram Negative Non-environmental (GN NON-ENV)**	**Gram Negative Non-environmental (GN NON-ENV)**	**Gram Negative Non-environmental (GN NON-ENV)**
Escherichia coli *Fusobacterium nucleatum* *Proteus mirabilis*	N/A	*Bact. uniformis* *Cap. sputigena* *Escherichia coli* *Fuso. nucleatum* *Haemophilus influenzae* *Mor. catarrhalis* *Moraxella nonliquefaciens* *Moraxella osloensis* *Neis. subflava* *Proteus mirabilis*	*Bacteroides uniformis* *Capnocytophaga sputigena* *Escherichia coli* *Escherichia fergusonii* *Fusobacterium nucleatum* *Haemophilus influenzae* *Moraxella spp.* *Neisseria spp.* *Ochrobactrum anthropi* *Proteus mirabilis*
Gram Positive Non-environmental (GP NON-ENV)	**Gram Positive Non-environmental (GP NON-ENV)**	**Gram Positive Non-environmental (GP NON-ENV)**	**Gram Positive Non-environmental (GP NON-ENV)**
Aerococcus viridans *Clostridium spp.* *Corynebacterium spp.* *Dermacoccus nishinomiyaens* *Diphtheroids* *Enterococcus spp.* *Gemella Sanguinis* *Gordonia polyisoprenivorans*	N/A	*Aerococcus viridans* *Alpha strep* *Bacillus spp.* *C. perfiringens* *Coag Neg Staph.* *Corynebacterium spp* *Derm. nishinomiyaens* *Diphtheroids* *Enterococcus spp.*	*Abiotrophia defectiva* *Aerococcus viridans* *Bacillus spp.* *Clostridium perfringens* *Clostridium septicum* *Corynebacterium spp.* *Dermacoccus spp.* *Enterococcus spp.* *Gemella sanguinis*

Gram +ve bacilli *Gram Pos B* *Gram Pos C* *Gran Adiac* *Granulicatella adiacens* *Kocuria rhizophilia* *Lactobacilus* *Micrococcus spp.* *Paenibacillus durus* *Propionibacterium acnes* *Rothia mucilaginosa* *Staphylococcus spp.* *STCNS* *Streptococcus spp.*		*Gemella.sanguinis* *GPC-Strep* *Gram +ve bacilli* *Gram positive cocci* *Gran. adiacens* *Kocuria rhizophilia* *Lactobacillus spp* *Micrococcus spp.* *Paenibacillus spp.* *Propionibacterium acnes* *Rothia mucilaginosa* *Staphylococcus spp.* *Streptococcus spp.*	*Granulicatella adiacens* *Kocuria spp.* *Lactobacillus spp.* *Lactococcus lactis* *Leuconostoc lactis* *Micrococcus spp.* *Paenibacillus spp.* *Propionibacterium spp.* *Rothia spp.* *Staphylococcus spp.* *Streptococcus spp.*
Acid Fast Non-environmental (AF NON-ENV)	**Acid Fast Non-environmental (AF NON-ENV)**	**Acid Fast Non-environmental (AF NON-ENV)**	**Acid Fast Non-environmental (AF NON-ENV)**
Nil	N/A	Nil	Nil
Fungi Non-environmental (Fungi NON-ENV)	**Fungi Non-environmental (Fungi NON-ENV)**	**Fungi Non-environmental (Fungi NON-ENV)**	**Fungi Non-environmental (Fungi NON-ENV)**
Candida spp. *Yeasts*	N/A	*Candida spp.*	*Candida spp.*

1. May not include every organism of interest if no cases were found during the time period.

Appendix 2 – Publication Metadata

Metadata Indicator	Description
Publication title	**Review of NHSGG&C paediatric haemato- oncology data**
Description	This management report provides information on paediatric haematology oncology related in NHS Greater Glasgow &Clyde (NHSGG&C)
Theme	Infections
Topic	Paediatric haematology oncology
Format	Management report and supplementary excel document
Data source(s)	Electronic Communication of Surveillance in Scotland (ECOSS) Total occupied bed days: Information Services Division ISD(S)1 Data provided by NHSGG&C
Date that data are acquired	ECOSS extract 07/10/2019
Release date	25 October 2019
Frequency	Ad hoc
Timeframe of data and timeliness	NA
Continuity of data	NA
Revisions statement	Case definitions have changed since previous reports (refer to methods section)
Revisions relevant to this publication	NA
Concepts and definitions	Covered in methods section.
Relevance and key uses of the statistics	NA
Accuracy	Laboratory data that has not been validation so treated with caution.
Completeness	Data not been validated
Comparability	Comparisons have been made to other Children's hospitals in Scotland however there may be differences in patient population so comparisons should be treated with caution.
Accessibility	It is the policy of HPS to make its web sites and products accessible according to **published guidelines**.
Coherence and clarity	NA
Value type and unit of measurement	Rate per 100,000 total occupied bed days (TOBDs) = (Number of cases of positive blood culture of given case definition in hospital(s) or speciality /TOBDs in hospital(s) or speciality x 100,000).
Disclosure	NA
Official Statistics designation	NA
UK Statistics Authority Assessment	NA
Last published	NA
Next published	NA
Date of first publication	NA
Help email	[redacted]
Date form completed	25/10/2019

Appendix 3 – HPS and Official Statistics

About HPS

HPS is a division of NHS National Services Scotland which works at the very heart of the health service across Scotland, delivering services critical to frontline patient care and supporting the efficient and effective operation of NHS Scotland.

HPS was established by the Scottish Government in 2005 to strengthen and coordinate health protection in Scotland. It is organised into three specialist groups with expertise provided by a multi-disciplinary workforce which includes doctors, nurses, scientists and information staff, all of whom are supported by core business and IM&T teams. The specialist groups are:

- Healthcare Associated Infections and Infection Control;
- Blood Borne Viruses and Sexually Transmitted Infections, Immunisation, and Respiratory and Vaccine Preventable Diseases;
- Gastrointestinal and Zoonoses Travel, and Environmental Public Health.

Official Statistics

Our official statistics publications are produced to a high professional standard and comply with the Code of Practice for Official Statistics. The Code of Practice is produced and monitored by the UK Statistics Authority which is independent of Government. Under the Code of Practice, the format, content and timing of statistics publications are the responsibility of professional staff working within NHS National Services Scotland.

Our statistical publications are currently classified as one of the following:

- National Statistics (ie assessed by the UK Statistics Authority as complying with the Code of Practice)
- National Statistics (ie legacy, still to be assessed by the UK Statistics Authority)
- Official Statistics (ie still to be assessed by the UK Statistics Authority)
- other (not Official Statistics)

Further information on NHS National Services Scotland’s statistics, including compliance with the Code of Practice for Official Statistics, and on the UK Statistics Authority, is available on the ISD website.

NHSScotland's Approach to Microbiological Water Testing

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Version 6.0

Version history

Version	Date	Summary of changes
1.0	01/02/2021	Draft for internal review
2.0	18/05/2021	Second draft for internal review
3.0	31/03/2022	Final draft for review
4.0	16/06/2022	Report finalised for formatting and sign off
5.0	17/06/2022	Final report
6.0	18/07/2022	Final Formatting

Contents

1 Introduction

Healthcare facilities are reliant upon water for the provision of clinical care, to maintain hygiene, and to ensure a comfortable and safe environment for patients, staff and visitors. However, water distribution systems can act as reservoirs for opportunistic pathogens in healthcare facilities. Waterborne pathogens do not normally infect healthy individuals, but can cause colonisation or infection in healthcare settings where patients are immunocompromised through treatment, disease, medications, devices or breaches in the skin. Over the years there have been a number of water-associated outbreaks and incidents across the United Kingdom. Healthcare facilities must provide an assurance that water is of a safe microbiological quality as effective management of water distribution systems is crucial to reducing the risk of infection in patients[1].

The commission by Scottish Government to gather intelligence around current practice for healthcare water management was initially made in 2019 however in early 2020 the work was suspended to redirect resource to support the national response to the SARS-CoV-2 pandemic. During this time the group within HPS became ARHAI Scotland.

2 Background

In February 2019 Health Protection Scotland (HPS) published a report on behalf of the Scottish Government 'Summary of Incident and Findings of NHS Greater Glasgow and Clyde: Queen Elizabeth University Hospital/Royal Hospital for Children water contamination incident and recommendations for NHSScotland'[2]. This report contained a number of recommendations relating to the prevention and management of water related incidents in healthcare settings.

Currently wider routine microbiological water testing is not mandated within NHSScotland, however it is recommended for *Pseudomonas aeruginosa* and Legionella[3] (as per the HPS Addendum – Guidance for high risk units to minimise the risk of *Pseudomonas aeruginosa* infection from water) and to ensure compliance with the Health and Safety Executive Approved Code of Practice and Guidance: Legionnaire's Disease. The Control of Legionella Bacteria in Water Systems[4]. NHS Boards have a responsibility to ensure that compliance is ongoing and monitored.

High risk units are defined as care areas where high risk in-patients are treated and include:

- Neonatal units (levels 1, 2 and 3), adult and paediatric intensive care units (ICUs)
- Bone marrow and stem cell transplant units
- Haematology-Oncology units
- Units where organ support is required, such as renal or respiratory units
- Units where patients have extensive skin breaches e.g. Burns units

There are healthcare settings that may also deliver care to high-risk patient groups but are not necessarily considered high-risk units. Extremes of age (i.e. neonates and the elderly), patients with burns and/or wounds, immunocompromised and immunosuppressed patients (e.g. AIDS, cancer or transplant patients) and patients who receive renal dialysis are more vulnerable to infections associated with water systems. Clinical judgement is required to assess individual patient risk and a local NHS Board risk assessment should be undertaken to identify any additional healthcare settings where patients may be extremely vulnerable to infection. This risk assessment should take into account any available epidemiologic data from both local and national surveillance or monitoring systems and any previous incidents or outbreaks in individual care settings.

The NHSScotland estate has developed over the years with a wide variation of old and new builds and a number of hybrid buildings where refurbishments or new builds have been carried out to existing facilities. Water systems management remains a key priority throughout. However, there is no nationally agreed standard within NHSScotland for water sampling. One of the aims of this report is to establish the current practices in water sampling and monitoring across all Scottish Health Boards.

3 Aims

The aims of the survey are to:

- Establish current approach to water testing in healthcare settings across NHSScotland;
- Examine current surveillance and reporting of potentially linked water-related healthcare associated infection (HAI) cases;
- Explore the use of mesh flow regulators/straighteners across NHSScotland;
- Provide a report to Scottish Government Chief Nursing Officer Directorate detailing the findings of the survey of the current approach to water testing across all Health Boards and recommendations for consideration.

4 Methods

In May 2019 the Healthcare Associated Infection (HAI) Executive Leads were provided with a link to an electronic survey to obtain information on each Health Board's current position regarding routine water testing, water testing as part of an investigation of potentially water-associated incidents/outbreaks, and the use of mesh flow regulators/straighteners. (See Appendix 1).

The question set was developed by HPS in conjunction with Health Facilities Scotland (HFS) as technical experts to ensure the questions met the recommendations from the 2018 HPS report.

A four-week consultation period was provided for completion of the survey. During this period there was a request that the survey question set was also sent out via e-mail to allow the HAI Executive Leads to review and forward to the appropriate colleagues for completion. As a result, some Health Board responses were completed by Estates and Facilities representatives.

Following completion of the survey further clarification of responses was sought from the Boards via telephone and e-mail. All completed responses were manually entered onto a Microsoft Excel spreadsheet by an Information Officer at HPS.

5 Results

This is the first water testing survey carried out across NHSScotland and provides a snapshot of water testing carried out across clinical areas in NHSScotland during the reporting period May - October 2019. Survey responses were received from all 14 territorial NHS Boards and 2 special NHS Boards.

5.1 National Perspective: Routine Testing for Legionella and *Pseudomonas aeruginosa*

From the responses received:

- 88% (n=14) of Health Boards carry out routine water testing
- 12% (n=2) of Health Boards only carry out testing in response to suspected or confirmed healthcare outbreaks/incidents. These boards have no high risk units.

This demonstrates that all Health Boards surveyed have capacity and facilities, either internally or externally, to conduct water testing as no Boards provided a nil response.

5.1.1 National Perspective: Additional Testing

A number of NHS Boards reported additional water testing for organisms over and above the current requirements for Legionella and *Pseudomonas aeruginosa* were being undertaken.

Of the 14 responses received:

- 79% (n=11) of NHS Boards are carrying out testing for a variety of additional organisms.

5.2 Healthcare Specialities and Organisms Tested for

Current guidance advises that routine microbiological testing for total viable counts (TVCs) is not indicated unless there are issues identified with taste or odour. However, a number of NHS Boards monitor TVCs, as they can act as an 'early warning' indicator of potential problems. The detection of TVCs does not automatically indicate the presence of an organism such as Legionella or *Pseudomonas aeruginosa* but may be an overall indicator of water quality.

5.2.1 National Perspective

TABLE 1: NHS BOARDS: Areas Water Testing and Organisms Tested For

NHS Board	Testing: High Risk Areas[1]	Testing: Other Locations	Organisms
Greater Glasgow and Clyde	**All areas**	**Wards (low risk)** **Maternity** **Spinal Injuries Unit** **Institute of Neurological Sciences wards**	**Legionella** **Pseudomonas** ***E. coli*** **Coliforms** **Fungi**
Board 1	All areas	Swimming Pool Spa	Legionella Pseudomonas TVCs *E. coli* Coliforms
Board 2	All areas	Wards (low risk) Maternity Paediatrics Imaging Combined Assessment Unit Palliative Care Laboratories Doctors Residencies	Legionella Pseudomonas `
Board 3	All areas	All areas	Legionella TVCs (Endoscopy only)
Board 5	All areas	Wards (low risk) Outpatients Department Child Respite Dental Centres	Legionella
Board 6	N/A	Laboratories Donor Suites/Centres Clinical Apheresis	Pseudomonas TVCs *E. coli* Coliforms
Board 7	All areas		Legionella

NHS Board	Testing: High Risk Areas[1]	Testing: Other Locations	Organisms
Board 8	All areas	All areas (hospitals) Community Hospitals Mental Health Hospital	Legionella Pseudomonas TVCs *E. coli* Coliforms
Board 9	Renal Units	Clinical Decisions Unit (CDU) Robotic Surgery Local Decontamination Unit (LDU) Endoscopy LDU Dental School LDU Hydrotherapy pool	Legionella TVCs
Board 10	Not testing routinely		
Board 11	All areas	Wards (low risk) Endoscopy Washer Disinfectors Pharmacy Aseptic Suite Maternity Hydrotherapy Pools Ice Machines Renal Plant Room Water Mains Tanks	Legionella Pseudomonas TVCs
Board 12	Renal Unit	CDU Washer Disinfectors Endoscopy Kitchens Domestic Services Rooms (DSR) Mains	Pseudomonas TVCs
Board 13	All areas	Wards (low risk) Mental Health Hospital Community Hospitals	Legionella TVCs *E. coli* Coliforms
Board 14	Not testing routinely		
Board 15	All areas	All areas	Legionella Pseudomonas *E. coli*

NHS Board	Testing: High Risk Areas[1]	Testing: Other Locations	Organisms
Board 16	All areas	Wards (low risk) Emergency Department X-Ray Diabetic Clinic Day Surgery Unit Oncology Day Unit Endoscopy Plant Room Catering Hydrotherapy Pools Cold Water Storage Tanks Rapid Access Community Hospitals Health Centres	Legionella Pseudomonas TVCs

1. High risk areas include: Neonatal units (levels 1, 2 and 3), adult and paediatric intensive care units (ICUs); Bone marrow and stem cell transplant units; Haematology/Oncology units; Units where organ support is required, such as renal or respiratory units and Units where patients have extensive skin breaches e.g. Burns units

5.3 Frequency of Water Sampling and Testing

The main objectives of water testing are to provide an assurance that the current water is of a safe microbiological quality or to investigate potential problems and take the appropriate actions to minimise the growth and spread of water associated organisms. Each Health Board provided information on how frequently they obtained samples for testing across their healthcare specialties as listed in Table 2.

5.3.1 National Perspective

TABLE 2: NHS BOARDS: Frequency of water sampling and testing

Whilst the survey sought information regarding the frequency of testing, facilities tested, pathogens and acceptable limits; the format of the survey meant that the information was collected in separate sections, independent of one another. Therefore, it was difficult to ascertain for example, during six monthly testing which particular microbiological tests were performed

NHS Board	Monthly	Quarterly	Six Monthly	Annually	Other
Greater Glasgow and Clyde	✓	✓	✓	×	
Board 1	✓	✓	✓	✓	
Board 2	×	×	✓	✓	
Board 3	×	×	✓	×	Legionella only
Board 5	×	✓	×	✓	
Board 6	×	×	✓	×	
Board 7	×	✓	×	×	
Board 8	×	✓	✓	✓	PFI areas more frequently for their own governance
Board 9	×	×	✓	×	
Board 10	Not testing routinely				
Board 11	✓	×	✓	✓	
Board 12	✓	✓	✓	✓	Renal - weekly
Board 13	✓	✓	×	×	
Board 14	Not testing routinely				
Board 15	× *	× *	× *	× *	*Frequency of testing varied dependent on site risk

NHS Board	Monthly	Quarterly	Six Monthly	Annually	Other
Board 16	×	✓	✓	×	Hydrotherapy pool - weekly

5.4 Acceptable Limits

Health Boards provided information on their thresholds for acceptable microbiological limits when carrying out water testing. During data analysis it was identified that each individual Board had their own limits and process, therefore it was not possible to compare acceptable limits across NHSScotland. Of the responses received it was identified that Health Boards were testing and reviewing acceptable limits in accordance with the following guidance: Health Facilities Scotland SHTM 04-01[1]; HPS Pseudomonas Guidance[3] and the Renal Association Guidelines[5].

However, responses were not received from every Board and are only in reference to particular organisms.

5.5 Laboratory Analysis

Due to resource constraints, the majority of NHS Boards reported that they outsourced their water sample testing to independent laboratory services. Of the 16 Health Boards surveyed, only 13% (n=2) conduct in-house testing, both of the sites being within central Glasgow.

94% (n=15) of the laboratories used by Boards are accredited by the United Kingdom Accreditation Service (UKAS), which assess against internationally agreed standards, organisations that provide certification, testing, inspection and calibration services. However, UKAS accreditation only covers laboratory aspects, and does not assess the sampling process undertaken within NHS Boards.

Since the original survey was carried out the 1 non-UKAS accredited laboratory reported was no longer being used for clinical services.

5.6 Water Sampling

5.6.1 Responsibilities

All microbiological water sampling should be undertaken by staff who are trained in the appropriate technique for obtaining water samples and for TVC samples in accordance with SHTM 04-01 (C)[3]. Each Board has identified and trained responsible person(s) for obtaining samples. Of the 16 responses received:

- 31% (n=5) employ in-house staff to obtain samples;
- 38% (n=6) outsource their sampling to external contractors;
- 31% (n=5) use a combination of both in-house and external contractors.

5.6.2 Methodology

Standard Operating Procedures (SOPs) for obtaining water samples aim to ensure that the process is completed in a consistent and efficient manner, therefore reducing the risk of error. Of the 16 boards, 50% (n=8) have a local SOP in place for water sampling. The remaining 50% carry out water sampling in accordance with the following:

- External contractor's SOP/method statement;
- Microbiology of Drinking Water Guidance (2010) (Environment Agency, archived 2018)[6];
- Legionella Code of Practice (2008)[4].

5.7 Surveillance and Reporting

5.7.1 Results: Routine Water Testing

As previously outlined, 14 NHS Boards carry out routine water testing. The results from routine testing are sent to a variety of disciplines and specialities for clinical interpretation, analysis and escalation if deemed necessary. From the responses received:

- 100% (n=14) of Health Boards send their routine water testing results to Estates and Facilities personnel. This includes; Head of Estates and Facilities, Estates Managers,

Contracts Managers, Maintenance Managers, Estates Officers, Senior Water Engineers and Responsible/Authorised Person(s) for water;

- 57% (n=8) of routine water testing results are sent to Infection Prevention and Control Teams (IPCTs). This includes, Infection Control Doctors/Consultant Microbiologists, Infection Control Managers and Infection Control Nurses;

- 29% (n=4) of routine water testing results are sent to other stakeholders, which include, Technical Service Managers, Public Health Consultant, members of the Water Safety Group (WSG), Private Finance Initiative (PFI) personnel and the clinical area concerned.

5.7.2 Clinical Interpretation: Water Testing in Response to Incidents/Outbreaks

Whilst it is recognised that there is currently no national guidance to assist with results interpretation, as part of the investigation of a potential water-associated outbreak/incident, results of water testing require to be interpreted to allow for the appropriate escalation and remedial actions. From the responses received:

- 50% (n=8) of Boards have Estates and Facilities personnel interpret their incident water testing results. This includes; Head of Estates and Facilities, Estates Managers, Maintenance Managers, Estates Officers, Building Officers, Senior Water Engineers and Responsible/Authorised Person(s) for water;

- 94% (n=15) of Boards have members of the IPCT interpret their incident water testing results. This includes Infection Control Doctors/Consultant Microbiologists and Infection Control Managers;

- 19% (n=3) of Boards have their incident water testing results interpreted by Public Health Consultants;

- 6% (n=1) of Boards have another stakeholder interpret their incident water testing results, which includes: members of the Water and Air Quality Committee.

5.7.3 Escalation Process

Following the identification of positive water testing results it is important that these are appropriately managed and escalated for further action if necessary. From the 16 NHS Board responses received:

- 88% (n=14) have an escalation process in place following positive water testing results
- 12% (n=2) do not have an escalation process in place following positive water testing results

Of the 14 responses received from NHS Boards, each had their own local process /method of escalation. The responses included:

- E-mailing results to IPCT and/or Estates for review
- Reviewing results at Water Safety Group (WSG)
- Exception reports escalated to management
- Taking outlets out of use (if appropriate) and re-testing
- Holding a Problem Assessment Group (PAG) or Incident Management Team meeting (IMT) to assess the incident

5.8 Incidents, Outbreaks and Data Exceedance

Chapter 3 of the National Infection Prevention and Control Manual – Healthcare Infection Incidents, Outbreaks and Data Exceedance[7] aims to support the early recognition of potential infection incidents and to guide local IPCTs and Health Protection Teams (HPTs) in the incident management process within NHSScotland.

See Chapter 3 for definitions of incidents, outbreaks and data exceedance. Chapter 4 remains currently under development will cover the healthcare built environment and will support Chapter 3 for incidents, outbreaks and data exceedance associated with the healthcare built environment.

5.8.1 HIIAT Assessment and Reporting

An early response to an actual or a potential healthcare incident, outbreak or data exceedance is crucial.

The Healthcare Infection Incident Assessment Tool[8] (HIIAT) should be used by IPCTs or HPTs to assess every healthcare infection incident (including decontamination incidents or near misses) in any healthcare setting within NHSScotland. The HIIAT assesses the impact of a healthcare incident/outbreak on patients, services and public health and should be utilised to assess the initial impact and monitor any ongoing impact.

The National Water Survey asked Boards: 'Would you carry out a HIIAT assessment when you have identified water contamination (e.g. increased total viable counts, microbiological growth) within a clinical area?'

From the 16 responses received:

- 44% (n=7) would carry out a HIIAT assessment only if there is a potentially linked clinical case
- 38% (n=6) would always carry out a HIIAT assessment
- 18% (n=3) provided an alternative rationale.

Of those that responded regarding completion of a HIIAT with an alternative rationale their responses included:

> "A HIIAT assessment is only done in the context of a multidisciplinary Problem Assessment Group (PAG), convened to look at a specific problem that has not been resolved by following our Standard Operating Procedures (SOPs). Increased TVCs or growth of organisms in tap water (since we do not expect tap water is to be sterile) initially just trigger following an SOP to resample, then if persistent high counts to flush, if necessary followed by thermal then chemical disinfection. The microbiologist and Authorising Engineer (water) approve these actions and review the results"
>
> "Elevated TVCs would not normally instigate a HIIAT assessment but would be reviewed locally depending on the increase from baseline and the associated clinical area risk".

It is recognised that the HIIAT assessment tool requires to be reviewed and updated to ensure applicability for incidents and outbreaks related to the healthcare built environment and is on the ARHAI Scotland work plan for 2022/23.

5.9 Mesh Flow Regulators/Straighteners

As part of the incident review within NHS Greater Glasgow and Clyde at the Queen Elizabeth University Hospital and the Royal Hospital for Children, the presence of flow regulators was identified. The National Water Survey asked Boards if they had these in use within any hospitals and if they were present, was a decontamination protocol in place.

Presence

- 69% (n=11) of Health Boards have flow regulators in use within hospitals.

Decontamination Protocol

- 18% (n=2) of Health Boards have a decontamination protocol in place;
- 73% (n=8) of Health Boards do not have a decontamination protocol in place;
- 9% (n=1) of Health Boards reported having a programme of 3-monthly replacement in place of a decontamination protocol.

5.10 Water Safety Group

As detailed in SHTM 04-01[1] and CEL 08 (2013)[9], it is a legislative requirement that NHS Boards ensure that there are robust systems in place and documented evidence of safe water management systems, which includes having a Water Safety Group (WSG) who are responsible for developing and maintaining a Water Safety Plan (WSP). Water safety plans provide a risk management approach to the microbiological safety of water and establish good practice in local water distribution and supply.

Across NHSScotland:

- 94% (n=15) of Health Boards have a Water Safety Group;
- 6% (n=1) of Health Boards do not currently have a Water Safety Group (at the time of survey) but there are plans in place to establish this.

6 Discussion

A summary of the themes identified as a result of this survey are outlined below.

6.1 Infrastructure

As outlined in CEL 48 (2008)[10], all new-build hospitals and healthcare facilities that provide in-patient accommodation should ensure that patients are nursed within single rooms, unless there are clinical reasons for multi-bedded rooms to be available. This mandate also takes into consideration major refurbishments of existing healthcare facilities; to ensure they also seek to offer 100% single room accommodation. However, if this is not possible then 50% single room provision is the absolute minimum agreed standard. SHFN 30[11] indicates that wash hand basins should be present in all toilet and en-suite facilities. Therefore, each facility built since 2008 will have a significantly higher proportion of water outlets which consequently will mean additional resource is require maintenance, cleaning, monitoring and testing. In addition, the availability and use of alcohol based hand rub has increased dramatically, with hands more frequently being decontaminated by ABHR and not hand washing therefore the use of wash hand basins has significantly reduced,

Infrequently used water outlets pose a risk, with the potential for water stagnation and the development of biofilm. Under-utilisation of these outlets encourages colonisation of the water system with microorganisms and it may be necessary to remove them. However, the consideration to remove infrequently used outlets should be risk assessed. It is also important that clinical teams are aware of the risk and liaise with Estates to ensure that infrequently used outlets are promptly identified.

Ease of access to systems allows for the implementation of control measures. Water outlet flushing is a preventative control measure carried out to reduce the risk of water-associated outbreaks and incidents.

The presence of clinical hand wash basins may also encourage inappropriate practices/behaviours by patients, healthcare staff and visitors and have been linked to HAI outbreaks[12]. Disposal of food/drinks, nutrients or other contaminated materials in clinical wash hand basins and the preparation of intravenous solutions within splash zones of water outlets increase the risk of contamination. Inappropriate usage of these outlets also carries a risk of waterborne transmission. Placement of extraneous items on sink surfaces or washing of items of patient care equipment also increases the risk of contamination.

6.2 Testing Approach

Throughout NHSScotland Boards reported different approaches to testing in terms of specialties, frequency of testing, organisms tested for and acceptable limits. The rationale for this could be due to availability of resources, financial constraints, history of incidents, outbreaks or data exceedance or clinical preference. However, this was not explored as part of the survey.

Each Board outlined variances in their approach, therefore analysis was not possible to compare results nationally. Some Boards conducted an extensive variety of tests, demonstrating continual and consistent monitoring of their water quality. This was in contrast to other Boards that only implemented further testing in the context of incident and outbreak investigation.

The differences in approach throughout NHSScotland demonstrates the potential requirement for a considered and measured testing methodology that can be implemented across all healthcare settings. This will allow for a comparison of the results, and identification of risks and concerns at a national level.

6.3 Laboratory Services

Currently 87% of NHS Boards outsource water testing to independent laboratory services. There is a significant cost associated with external contractors, and across Scotland in-house water testing only takes place within central Glasgow at two NHS premises which are UKAS accredited. UKAS accredit laboratories to the testing standard of ISO 17025 and in addition to this accreditation they have a schedule of accredited tests which they must be deemed competent to perform.

Due to 11 NHS Boards having reported carrying out testing of other organisms in addition to Legionella and *P. aeruginosa,* the provision of laboratory services and UKAS accredited testing schedules is something that should be explored across Scotland. NHSScotland Assure may consider undertaking a review of laboratory services across NHSScotland.

6.4 Incident and Outbreak Reporting

Surveillance of incidents and outbreaks allows for the detection of emerging threats or clinical risks and provides a focus for national guidance and resource. As outlined in the Scottish

Government letter (2017)[13], HIIAT assessment and reporting is mandatory within NHSScotland. The survey results demonstrate that the application of the HIIAT in relation to water-associated incidents and outbreaks is variable.

It is possible that NHS Boards do not associate the completion of a HIIAT assessment as part of routine incident and outbreak management, but only in the wider context of commencement of a Problem Assessment Group (PAG) or Incident Management Team (IMT) meeting. Boards may not deem a HIIAT assessment necessary if the issues identified are promptly rectified and control measures are put in place. It is also considered that NHS boards do not associate completion of HIIAT assessment with environmental incidents including water incidents. Therefore, if managed at a local level, Boards may not feel escalation reporting is appropriate or required. However, if the incident meets the definitions within Chapter 3 of the NIPCM[7], the HIIAT must be applied and reported accordingly. General feedback from IPCTs is that HIIAT in its current format is not easily applicable to environmental incidents.

The HIIAT may be seen as subjective, but if definitions are applied consistently and in accordance with the NIPCM Chapter 3, they are objective and should therefore be applied and assessed in the same manner by each Board. However, it is recognised that the HIIAT assessment tool requires to be reviewed and updated to ensure applicability for incidents and outbreaks related to the healthcare built environment.

Although it can be expected that there may be some natural variation across NHSScotland it is important to consider the potential impact on the overall validity of national infection incident reporting. ARHAI Scotland should ensure that the definitions are clear, concise and applied consistently throughout NHSScotland to allow for the accurate identification of trends or clinical risks.

6.5 Presence of Flow Regulators

The design and construction of wash hand basins, showers and taps in hospitals are agreed in accordance with the Scottish Health Technical Memorandum (SHTM) 04-01 at the point of design, which previously included the use of flow regulators. In 2015 SHTM 04-01[14] was revised and no longer supports the use of flow regulators in clinical wash hand basins. This is due to the high-surface to volume ratio and location within taps, which may present a larger surface area for colonisation and growth of microorganisms.

A biofilm is a collection of one or more types of microorganism, including bacteria, fungi and protists, that stick together forming a sludge, and can become embedded on a surface[15].

Biofilm formation in flow regulators has been identified in a previously published outbreak and was also identified during the 2018 water contamination incident investigation within NHS Greater Glasgow and Clyde[16]. During this investigation all flow regulators were microbiologically tested and 100% of them had the presence of biofilm detected, with 50% showing high levels of contamination.

Manufacturers of flow regulators recommend regular removal for cleaning/decontamination. However, they do not offer more specific guidance on the frequency or method of decontamination. Flow regulators are complex pieces of equipment with multiple components and can create an ideal environment for the development of biofilms.

7 Limitations

There are a number of limitations to note:

1. The survey was extensive and in a format that was reported as difficult to complete.
2. Some of the survey data received provided limited detail e.g. some data fields were incomplete.
3. Interpretation of the survey varied between NHS Boards and clarification was sought from a number of Boards prior to the data analysis process.
4. Whilst the survey sought information regarding the frequency of testing, facilities tested, pathogens and acceptable limits; the format of the survey meant that the information was collected in separate sections, independent of one another. Therefore, it was difficult to ascertain for example, during six monthly testing which particular microbiological tests were performed.
5. This survey provides a snapshot of water testing across NHSScotland at a specific point in time. Further testing may have been commenced by NHS Boards following completion of the survey.
6. The analysis and development of this report was significantly delayed due to the SAR-CoV-2 pandemic and therefore the information provided by NHS Boards may now be out of date.

This report should be used as an information resource relevant to guidance and practice during the survey period and the results and recommendations interpreted with caution. Future

surveys should consider the limitations listed above, in particular the survey design, and consider alternative data collection processes.

8 Conclusions

Undertaking this survey has allowed an understanding of the then current approach to microbiological water testing across NHSScotland. The number of water outlets that are present in healthcare facilities has steadily increased since 2008, alongside an increase in the complexity of procedures/treatments and at risk patient population emphasising that water systems management remains a key priority and a potential threat to the NHSScotland estate. NHSScotland should continue to ensure compliance with national guidance in relation to the built environment and champion innovation and research within this area.

As more water-associated incidents and outbreaks are reported nationally, it is important that current practice and new evidence is continuously reviewed. In the future further consideration may be given to widening the profile of water testing, to identify novel gram-negative organisms. However, it is important that IPCTs have clear guidance on how to interpret and manage these results.

NHS Scotland Assure covers the full lifecycle of a build, from strategic assessment, building operations and ongoing maintenance, to decommissioning bringing together HFS, ARHAI Scotland and developing new services to enhance safety for all service users. Any further commissions for assessment of water management should be considered through NHS Scotland Assure.

9 Recommendations

The following recommendations have been grouped for local and national consideration. As part of the response to Scottish Government commissions, some of these recommendations may already have been considered and enacted.

9.1 NHS Boards

- Consider, as part of a phased maintenance programme, the removal of mesh flow regulators/straighteners from all outlets. Where it is not reasonably practicable to remove

mesh flow regulators/straighteners a local decontamination protocol should be in place in line with manufacturers instructions and monitored by the facilities team.

- Ensure local surveillance systems are in place for early identification of any waterborne or potentially waterborne incidents, outbreaks or data exceedance.
- Ensure waterborne incidents, outbreaks or data exceedance are reported to ARHAI Scotland through the existing established incident and outbreak process.
- Ensure that interpretation of results at a local level follows a multidisciplinary approach and related risk assessments are undertaken and documented.

9.2 NHS Assure: ARHAI Scotland/Health Facilities Scotland

- ARHAI Scotland to share report with an anonymised summary of board responses with others boards once Scottish Government has reviewed the complete report.
- ARHAI Scotland will develop an evidence based water review with recommendations and policy application for chapter 4 NIPCM.
- ARHAI Scotland/HFS will consider developing a national standard operating procedure agreed between NHSScotland Boards and laboratory services regarding review and escalation of water test results to ensure a standardised approach.
- ARHAI Scotland/HFS will liaise closely with compliance (NHS Assure) and develop guidance on results interpretation.
- ARHAI Scotland/HFS will liaise closely with compliance (NHS Assure) and develop guidance on environmental (water) sampling.
- ARHAI Scotland will develop Chapter 4 within the NIPCM, which will provide evidence-based IPC guidance based on clinical interpretation of technical guidance, available scientific literature and expert opinion for IPC and clinical staff and will include water systems management.
- ARHAI Scotland/HFS will develop a toolkit within Chapter 4 that details role, remit and governance of Board Water Safety Groups.

- ARHAI Scotland will develop outbreak and incident reporting tools relevant to clinical HAI incidents with a potential/confirmed link to the built environment.

- ARHAI Scotland will provide HIIAT and HIIORT training to IPCTs and HPTs to ensure that the HIIAT is applied consistently and outbreaks, incidents and data exceedances are reported in accordance with Chapter 3 of the NIPCM.

- NHS Scotland Assure, should consider repeating the survey (or similar) in financial year 2023/24, taking into consideration the limitations above and any significant changes to the NHSScotland estate. This should include a review of the current question set and survey format and laboratory and testing methods and capacity.

- NHS Scotland Assure will develop a toolkit relating to commissioning, design and operational maintenance of water systems with clearly defined responsibilities

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Appendix 1 HPS National Water Survey; Current Approach to Water Testing

The Health Protection Scotland (HPS) report 'Summary of Incident and Findings of NHS Greater Glasgow and Clyde: Queen Elizabeth University Hospital/Royal Hospital for Children water contamination incident and recommendations for NHSScotland' was published on behalf of the Scottish Government earlier this year. The report contained a number of recommendations relating to the prevention and management of water related incidents in healthcare settings. These included the following:

HPS (supported by HFS):

- review NHSScotland's current approach to water testing in healthcare settings;
- review NHSScotland's current surveillance and reporting of potentially linked water-related healthcare-associated infection (HAI) cases;
- review the use of flow regulators across NHS Scotland and identify any associated risks.

As part of the ongoing work required to meet these recommendations, HPS have developed the following survey which aims to collect information regarding NHSScotland's current approach to water testing.

We would appreciate if you would answer the questions as thoroughly as possible.

All NHSScotland Boards are required to complete this survey by Thursday 20th June 2019.

If you have any questions or require any assistance please contact XXXX, Healthcare Scientist on 0141 300 1175 or **NSS.HPSInfectionControl@nhs.net**

1. Name:

Designation:

Board:

2. Does your Board currently undertake any **routine** water testing?
   - ☐ Yes....Go to question 4
   - ☐ No..... Go to question 9

3. If yes, was this initiated as a result of a previous incident/outbreak?
   - ☐ Yes
   - ☐ No

4. How often are samples taken for routine water sampling? (Check any that apply)
   - ☐ Routine – monthly
   - ☐ Routine – quarterly
   - ☐ Routine – six monthly
   - ☐ Routine – yearly
   - ☐ Routine – other (please state)

5. In which healthcare settings and clinical specialties do you conduct routine water testing? (e.g. NICU, ICU, general wards...). Note: Outlets include taps of clinical hand wash sinks, taps of patient hand wash sinks, shower faucets, bath taps, taps from utility sinks (such as dirty utilities, DSR), kitchen taps, other water outlets.

If you have more than 20 entries please email additional information to:NSS.HPSInfectionControl@nhs.net

	Name of the facility e.g. hospital	List all units/departments for this hospital	Frequency of testing e.g. monthly, six monthly,	Outlets tested (e.g. Taps of clinical hand wash sinks, taps of patient hand wash sinks, shower faucets, bath taps, taps from utility sinks (such as dirty utilities, DSR), kitchen taps, other water outlets (please state)	Proportion of outlets tested (e.g. 5 hand patient hand wash sinks out of 25)
1					
2					
3					
4					

6. In your Board, which microbiological water tests do you request to be performed as part of **routine** water testing by your chosen laboratory? (e.g. *Pseudomonas aeruginosa,* Legionella...)

7. What has your Board agreed are the acceptable limit(s) for the microbiological water tests performed as part of **routine** water testing?

If you have more than 20 results please email the additional results to NSS.HPSInfectionControl@nhs.net

	Pathogen tested for	Acceptable limit
1		
2		
3		

8. In your Board, where are water samples sent for testing of water samples taken during routine testing and/or samples taken during investigation of potentially water-associated incidents /outbreaks?
(please provide the full laboratory contact details)

9. Do you know if your chosen test laboratory is accredited with any official body? i.e. UKAS.

☐ No

☐ Yes

10. If yes, please provide details.

11. Do you know which specific water tests (if any) your chosen test laboratory is accredited for?

☐ No

☐ Yes

12. If yes, please specify:

13. In your Board, who is the person(s) responsible for collecting water samples for testing? Please list all persons (designations/positions only, individual names not required)

14. Has the person(s) taking the water samples had training in the procedure?

- ☐ No
- ☐ Yes

15. If yes, please specify the name of the training, who provided the training and how often this training is undertaken.

16. Does your Board have a Standard Operating Procedure(s) (SOP) for water sampling?

- ☐ No
- ☐ Yes

17. If yes please attach these or send to **NSS.HPSInfectionControl@nhs.net**

18. If your Board does not have a SOP(s) please describe your testing protocol in the box below, including volume of water obtained per sample, how the water sample is collected etc.

Describe:

19. Has your Board agreed the situations where water samples would be sent for typing?

☐ No

☐ Yes

20. If yes, please specify:

21. In your Board, who receives water test results from samples taken during routine testing? Please list all recipients: (designations/positions only, individual names not required)

If your Board does not currently conduct routine water sampling, please write N/A

22. In your Board, who receives water test results from samples taken during investigation of potentially water-associated incidents/outbreaks?

Please list all recipients: (designations/positions only, individual names not required)

23. In your Board, who is responsible for interpretation of water test results from samples taken during **routine** testing?

Please list all persons: (designations/positions only, individual names not required) If your Board does not currently conduct routine water sampling, please write N/A

24. In your Board, who is responsible for interpretation of water test results from samples taken during investigation of potentially water-associated incidents/outbreaks?

Please list all persons: (designations/positions only, individual names not required)

25. In your Board, is there an agreed process for escalation of test results?

- ☐ No
- ☐ Yes

26. If yes, please attach process documentation or describe in the box below.

27. Or upload process documentation here:

28. Does your Board have an agreed protocol for when microbiological results are not satisfactory?

- ☐ No
- ☐ Yes

29. If yes, please attach protocol or describe in the box below:

30. Or upload protocol here:

31. Does your Board have an agreed protocol for the recording of water testing results, including how long they are kept for?

- ☐ No
- ☐ Yes

32. If yes, please attached protocol or describe in the text box below.

33. Or attach protocol here:

34. Does your Board have a Water Safety Group?

- ☐ No
- ☐ Yes

35. If yes, please attach the agreed terms of reference for this local group or describe in the text box below how often this group meets, membership (job titles), governance and reporting structures, and standing agenda items

36. Or upload the agreed terms of reference for the WSG here:

37. Are there mesh flow regulators/straighteners in use in any hospitals within your Board?

- ☐ No
- ☐ Yes

38. Does your Board have a decontamination protocol for mesh flow regulators/straighteners?

- ☐ No
- ☐ Yes

39. If yes, please describe process below or attach protocol

40. Attach the protocol for decontamination here:

41. What trigger(s) would you consider to be an indication that a case of infection is potentially linked to the water system and would warrant water testing?

42. Would you carry out a HIIAT assessment when you have identified water contamination (increased total viable counts (TVCs), microbiological growth) within a clinical area?

- ☐ Yes, always
- ☐ Yes, only if there is a potentially linked clinical case
- ☐ No, never
- ☐ Other: please state

SCOTTISH HOSPITALS INQUIRY

Bundle of Documents for the Oral Hearing Commencing 12 June 2023 in relation to the Queen Elizabeth University Hospital and the Royal Hospital for Children, Glasgow

Bundle 7 - Written Reports prepared by Health Protection Scotland (HPS), Health Facilities Scotland (HFS) and Antimicrobial Resistance and Healthcare Associated Infection (ARHAI)

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