HEALTH PROTECTION SURVEILLANCE CENTRE

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Guidelines for the Prevention and Control of Infection from Water Systems in Healthcare Facilities

Prepared by the Prevention and Control of
Infection from Water Systems in Healthcare Facilities Sub-Committee
of the HPSC Scientific Advisory Committee, 2015

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Abbreviations

ACU	Augmented Care Unit
AFB	Acid fast bacilli
AHR	Alcohol-based handrub
BMS	Building management system
BPR	Biocidal product regulation
BSRIA	Building Services Research and Information Association
CARA	Chemical agent risk assessment
CDU	Central Decontamination Unit
CEO	Chief Executive Officer
CFU	Colony Forming Units
CIBSE	Chartered Institution of Building Services Engineers
ClO_2	Chlorine dioxide
CPAP	Continuous positive airway pressure
CRE	Carbapenem resistant Enterobacteriaceae
CSF	Cerebrospinal fluid
DAFM	Department of Agriculture, Food and the Marine
DBP	Disinfection by-products
DIC	Dissolved inorganic carbon
DOC	Dissolved organic carbon
DWIRP	Drinking water incident response plan
EARS-Net	European Antimicrobial Resistance Surveillance Network
ECA	Electrochemically activated water
EDTA	Ethylenediaminetetraacetic acid
EMC	Environmental monitoring committee
EPDM	Ethylene propylene diene monomer
ESBL	Extended spectrum beta-lactamase
EU	European Union
EWD	Endoscope Washer Disinfector
HBN	Health Building Notes
HCAI	Healthcare associated infection
HIQA	Health Information and Quality Authority
HSA	Health and Safety Authority
HSE	Health Service Executive
HSE-HPSC	HSE-Health Protection Surveillance Centre
HTM	Health Technical Memorandum
ICU	Intensive Care Unit
IPC	Infection prevention and control
IW	Irish Water
IWMS	Intelligent Water Management System
KPC	Klebsiella pneumoniae carbapenemase
LA	Local authority
LSI	Langelier Saturation Index
MDR	Multi-drug resistant
MOH	Medical Officer of Health
NTM	Non-tuberculous mycobacteria
OCT	Outbreak Control Team
OELV	Occupational exposure limit values
PCS	Pesticide control service
PHLS	Public Health Laboratory Service
pHs	Saturation pH
PPE	Personal protective equipment
PWTAG	Pool Water Treatment Advisory Group
SAC	Scientific Advisory Committee
SI	Statutory Instruments
Spp	Species
THM	Trihalomethanes
TMV	Thermostatic mixing valve
TOC	Total organic carbon
UK	United Kingdom
US	United States of America
UV	Ultraviolet
VFM	Value for money
WHO	World Health Organization
WRAS	Water Regulations Advisory Scheme
WSG	Water safety group
WSP	Water safety plan

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Corrigendum

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Table 5.6. Testing Options and Interpretation of Results for Endoscopy Final Rinse

The final row in this table had incorrect data. The corrected table is available in this version of the document.

Background

In 2012, the Scientific Advisory Committee (SAC) of the Health Protection Surveillance Centre (HPSC) proposed that a sub-committee be established to produce national guidelines on the prevention and control of infection associated with water systems in healthcare facilities. This was in response to an outbreak of *Pseudomonas aeruginosa* that affected a number of neonatal units in Northern Ireland between November 2011 and January 2012 and previous *P. aeruginosa* outbreaks reported in England and Wales which affected patients in augmented care units and were associated with colonisation of taps. Nominations were requested from various professional groups. Membership is listed previously.

The sub-committee initially met in December 2012 and agreed the terms of reference. The sub-committee conducted a detailed review of the relevant legislation, scientific literature, international guidance and national surveillance data. A draft document was available for public consultation on the HPSC website and was also sent to a range of professional organisations in January 2014 (Appendix 6). The final document was approved by the SAC of the HPSC in October 2014.

Please note that the sub-committee did not review recent scientific literature regarding Legionella species and advises that this document be read and the key recommendations implemented in conjunction with the National Guidelines for the Control of Legionellosis in Ireland, 2009.

Terms of Reference

The purpose of this guidance is to provide advice on the following:

1. The environmental (water) controls required in all healthcare facilities to prevent health-care associated infection from water sources
2. The need for risk assessment to be in place in augmented care units to prevent infection from water sources
3. A quality managed water system to be implemented in healthcare facilities to prevent infection from water sources including bottled water
4. Advice on routine sampling and testing of water systems in healthcare facilities
5. Surveillance and actions required in healthcare facilities if healthcare-associated infection from water sources is suspected

Foreword

This document represents the expert opinion of the HPSC SAC sub-committee on the prevention and control of infection associated with water systems in healthcare facilities, following a review of relevant legislation, scientific literature and an extensive consultation process. Key recommendations requiring action are highlighted at the beginning of this document and individually at the beginning of each of the five chapters. Personnel with responsibility for implementation of each recommendation are identified, where possible. It is acknowledged that the infrastructure and water systems in some healthcare facilities may be sub-optimal. It is also acknowledged that some aspects of the recommendations may be challenging to implement. Nonetheless, the recommendations represent current best practice. Where there are difficulties with full implementation, these should be highlighted locally and to the Health Service Executive (if a HSE-funded institution), so that measures are taken to ensure implementation.

Dr Susan Knowles
Chairman, Prevention and control of infection associated with water systems in healthcare facilities sub-committee

KEY RECOMMENDATIONS

Introduction

- Healthcare providers should be aware that hospital water systems have frequently been identified as a source of nosocomial infection especially among those who are immunocompromised and high dependency patients in critical care units. Steps should be taken to minimise the risk.
- Clinical infection and outbreaks caused by legionellosis, *Pseudomonas aeruginosa* infection (invasive) and Cryptosporidiosis are statutorily notifiable in Ireland under the Infectious Diseases (Amendment) Regulations 2011 (SI No. 452 of 2011) (September 2011). Cases and outbreaks should be notified to the Medical Officer of Health in the relevant Department of Public Health.
- This guidance should be used in conjunction with the National Guidelines for the Control of Legionellosis in Ireland, 2009 available at http://www.hpsc.ie/A-Z/Respiratory/Legionellosis/Guidance/

Irish Legislation and Key National Standards

- Each healthcare institution is responsible for the quality of water once it enters its building(s) (CEO, HSE (HBS) Estates Department, maintenance/engineering department/facilities management)
- Employers, including those with responsibility for managing healthcare facilities, have a duty to ensure employees' and other persons' safety, health and welfare at work as far as is reasonably practicable. (CEO of hospital, Manager of hospital)
- Employers are required to carry out a risk assessment for the workplace which should identify any hazards present in the workplace, assess the risks arising from such hazards and identify the steps to be taken to eradicate or minimise these risks (CEO, HSE (HBS) Estates Department)
- Employers must prepare a safety statement that is based on risk assessments. The statement should clearly identify people in the workforce who are responsible for health and safety issues. Employees should be given access to this statement and employers should review it on a regular basis. (CEO, HSE (HBS) Estates Department)

Engineering Controls

- All facilities should have a water safety plan, incorporating a risk assessment
- Water safety plans and risk assessments should be kept up-to-date.
- Water safety plans and risk assessments should include up-to-date schematics of the water distribution system.
- Risk assessments should consider
  - Contamination of distal parts of the water system, in particular water outlets
  - Biofilm contamination of water systems
  - Underused outlets such as sinks, showers or toilets
  - Water distribution system components, such as flexible hoses, thermostatic mixing valves (TMVs), aerators and flow straighteners
  - The need for additional secondary disinfection
- Correct temperatures must be maintained throughout the water distribution system.
  - Keep hot water hot and cold water cold
  - Hot water should leave the calorifier above 60°C
  - Hot water should not return to the calorifier below 50°C
  - Circulate hot water in the system flow at 55°C
  - Cold water should be stored and distributed below 20°C
- Pressure and flow throughout the distribution system must be maintained and monitored.
- Cleaning regimens must be maintained to reduce biofilm and scale build-up
- Intelligent water management systems and automated flushing regimens should be considered where appropriate.
- Materials, fixtures and fittings that support biofilm and micro-organism growth and colonisation should be avoided wherever possible.
- This chapter should be read in conjunction with the 2009 National Guidelines for the Control of Legionellosis in Ireland and the key regulations, standards, codes of practice and guidance listed in Appendix 2.

Infection Prevention & Control

- The healthcare facility manager must ensure that the recommendations in this guidance document are implemented in their institution.
- Prevention and control of water related healthcare associated infection (HCAI) requires a multidisciplinary approach and must be monitored by the environmental monitoring committee or equivalent.
- Clinical areas where patients may be at increased risk of waterborne infection must be identified within each healthcare facility by the environmental monitoring committee or equivalent.
- Healthcare providers should be aware of the potential risk of HCAI from water sources and water outlets. In order to mitigate many of the infectious risks associated with water, all healthcare workers must adhere to the HIQA National Standards for the Prevention and Control of Healthcare Associated Infections (2009) and the National Guidelines for the Control of Legionellosis in Ireland (2009).
- A culture of adherence to hand hygiene should be embedded in all healthcare institutions. The healthcare facility manager must ensure that staff have access to appropriate hand hygiene facilities and that regular hand hygiene audits are performed, reported and actioned.
- The healthcare facility manager must ensure that clinical hand wash sinks should be dedicated for the purposes of hand washing only and that alternative sinks and sluices are available for other purposes.
- Household/cleaning staff must clean clinical hand wash sinks in a manner that minimises the risk of contamination of the tap from organisms in the basin trap.
- The augmented care unit manager must ensure that water outlets in augmented care units that are not used frequently each day are flushed on a daily basis.
- The Infection prevention and control team must monitor clinical isolates of *Pseudomonas aeruginosa* from augmented care units and all clinical isolates of *Legionella* species as alert organisms.
- The Infection prevention and control team must have an active surveillance programme in place in each healthcare facility to detect alert organisms, clusters of infection, outbreaks, unexpected antimicrobial resistance mechanisms and unexpected infections.
- If an outbreak is suspected, an outbreak control team (OCT) with multi-disciplinary representation should be established by the healthcare facility manager.

NEONATAL UNITS

- Infants born at extreme prematurity (less than 28 weeks gestation) may have fragile skin which may breakdown easily during the early days of life; these infants are usually placed in a humidified incubator. Clinical staff must use sterile water or saline for washing non-intact or fragile skin, including during nappy change.
- Clinical staff may use tap water for bathing other high risk infants with intact skin, who do not require placement in a humidified incubator, provided there are no current clinical incidents suggesting water system contamination. However, if surveillance of infection identifies an outbreak or increased incidence of infection with water-borne organisms, clinical staff should use sterile water for bathing high risk infants (such as <1500g weight, central vascular catheter, endotracheal intubation or other invasive device) until an infection control investigation and water testing concludes that tap water is safe for bathing.
- Clinical staff should use tap water for washing neonates with normal healthy skin without invasive devices.
- The neonatal unit manager must ensure that when an incubator is being humidified, a sterile water reservoir and sterile water must be used. The reservoir and water must be changed daily. A re-usable reservoir must be cleaned and sterilised between uses in a central decontamination unit.
- The ward manager must ensure that frozen breast milk must never be defrosted by placing the container in tap water, unless the tap water has been boiled first. Breast or formula milk must never be warmed by placing the container in tap water, unless the tap water has been boiled first.

Microbiological Parameters

- The microbiological examination of water from the healthcare facility environment is necessary both in the routine monitoring of decontamination procedures and in the investigation of contamination incidents and outbreaks of healthcare associated infection.
- Sampling should be undertaken by staff trained in the appropriate technique for taking water samples including the use of aseptic technique to minimise extraneous contamination.
- Pre-flush and post-flush water samples may be indicated depending on the nature of the outbreak and/or the purpose of the sampling. If contamination is detected, compare the pre- and post-flush bacterial counts. A substantially higher bacterial count in the pre-flush sample, compared with the post-flush, should direct remedial measures towards the tap and associated pipework and fittings near to that outlet. A higher bacterial count in the post-flush sample than in the pre-flush sample suggests stagnation in the water system and inadequate flushing. A similar bacterial count in pre-flush and post-flush samples indicates that attention should focus on the whole water supply, storage and distribution system.
- All laboratories carrying out environmental water testing should be accredited for the methods used and participate in appropriate external proficiency schemes.
- Laboratory testing requirements for different water samples and interpretation of results must be in accordance with international standards.

Chapter 1: Introduction

Key Recommendations

- Healthcare providers should be aware that hospital water systems have frequently been identified as a source of nosocomial infection especially among those who are immunocompromised and high dependency patients in critical care units. Steps should be taken to minimise the risk.
- Clinical infection and outbreaks caused by legionellosis, *Pseudomonas aeruginosa* infection (invasive) and Cryptosporidiosis are statutorily notifiable in Ireland under the Infectious Diseases (Amendment) Regulations 2011 (SI No. 452 of 2011) (September 2011). Cases and outbreaks should be notified to the Medical Officer of Health in the relevant Department of Public Health.
- This guidance should be used in conjunction with the National Guidelines for the Control of Legionellosis in Ireland, 2009 available at http://www.hpsc.ie/A-Z/Respiratory/Legionellosis/Guidance/

1.1 Background

Hospital water systems have frequently been identified as a source of nosocomial infection especially among those who are immunocompromised and high dependency patients in critical care units.[1-3] Moist environments and aqueous solutions in healthcare facilities have the potential to serve as reservoirs for waterborne microorganisms. Under favourable environmental circumstances (e.g. warm temperature and the presence of a source of nutrition), many bacterial and some protozoal microorganisms can either proliferate, or remain for long periods in highly stable, yet infectious, forms.

The modes of transmission of waterborne infections include:

- Direct contact with water e.g. that required for hydrotherapy
- Ingestion of water e.g. through consuming contaminated ice
- Indirect-contact transmission e.g. from an improperly reprocessed medical device
- Inhalation of aerosols dispersed from water sources
- Aspiration of contaminated water[4]

The first three modes of transmission are commonly associated with infections caused by Gram-negative bacteria and non-tuberculous mycobacteria (NTM). Aerosols generated from water sources contaminated with *Legionella* species (spp) often serve as the vehicle for introducing Legionellae to the respiratory tract while aspiration is less commonly implicated.[4]

Awareness of *Legionella* spp amongst healthcare workers is generally fairly high. However, there is less awareness of the other opportunistic pathogens listed below, which may be found in hospital and healthcare facility water systems. Many of these microorganisms also harbour antimicrobial resistance determinants.[1, 2]

1.2 Waterborne Infection in Healthcare Facilities

The most commonly occurring microorganisms in healthcare facility water systems which may result in clinical illness include:

- *Legionella spp*
- *Pseudomonas aeruginosa*

Other less commonly encountered microorganisms in this setting include:

- Other *Pseudomonas* spp
- *Acinetobacter* spp
- Other non-fermentative Gram negative bacteria including: *Burkholderia* spp, *Stenotrophomonas* spp, *Sphingomonas* spp, *Novosphingobium* spp, *Ralstonia* spp
- Enterobacteriaceae e.g. *Enterobacter* spp, *Serratia* spp
- Non-tuberculous Mycobacteria
- *Cryptosporidium* spp

Clinical infection caused by the following microorganisms is statutorily notifiable in Ireland under the Infectious Diseases (Amendment) Regulations 2011 (SI No. 452 of 2011) (September 2011)[i]

Legionellosis

Pseudomonas aeruginosa infection (invasive)

Cryptosporidiosis

Under the Infectious Diseases regulations, laboratory and clinical notification of these three microorganisms, as defined above, is mandatory. Cases should be notified to the Medical Officer of Health (MOH) in the relevant Department of Public Health.

In addition, under the Infectious Diseases (Amendment) (No 3) Regulations 2003 (SI No. 707 of 2003)[ii] medical practitioners and laboratories are required to notify the MOH of any unusual clusters or changing patterns of any illness and individual cases which may be of public health concern. Since 2004, four nosocomial outbreaks of *P. aeruginosa* (not attributable to water) and two of legionellosis (waterborne) have been reported to HSE-Health Protection Surveillance Centre (HSE-HPSC). (Personal communication with HSE-HPSC)

Information on *Pseudomonas aeruginosa* and *Acinetobacter* spp is also collected through the European Antimicrobial Resistance Surveillance Network (EARS-Net) which collects routinely generated antimicrobial susceptibility testing data on invasive infections caused by eight important bacterial pathogens using the EARS-Net case definition. This is a voluntary notification scheme.

Exposure to waterborne microorganisms in health-care facilities can occur when bathing, showering or washing hands, during contact with contaminated fixtures e.g. washbasins and taps and via medical equipment e.g. nebulisers rinsed with water.[1, 2] Waterborne microorganisms can originate from biofilms, sludge and sediments in supply water, water storage tanks and water distribution network pipes and associated equipment including valves, pumps, particulate filters, water softening resins and carbon filter matrices.[5] Even in well maintained water systems, the quality of the water can deteriorate rapidly due to the formation of biofilm by bacteria in the water supply.[5] Taps may be contaminated with biofilm containing opportunistic pathogens especially *P. aeruginosa* and numerous cases of cross-infection from hospital taps have been reported.[1-3]

1.2.1 Gram-negative bacteria

Clinically important, opportunistic organisms which may be present in tap water include:

- *Pseudomonas aeruginosa*
- Other *Pseudomonas* spp
- *Acinetobacter* spp
- Enterobacteriaceae
- *Burkholderia* spp
- *Stenotrophomonas* spp
- *Ralstonia* spp
- *Sphingomonas* spp

[i] These regulations can be viewed on the Irish Government website at www.irishstatutebook.ie
[ii] These regulations can be viewed on the Irish Government website at www.irishstatutebook.ie

The Gram-negative bacteria outlined above when present in water distribution systems can all cause healthcare-associated infections. Immunocompromised patients are at greatest risk of developing infection from these bacteria. Clinical conditions associated with these bacterial agents range from colonisation of the respiratory and urinary tracts to deep, disseminated infections that can result in pneumonia and bloodstream infection. Colonisation by any of these microorganisms often precedes the development of infection.

The use of tap water in medical care presents a potential risk for exposure e.g. in direct patient care, as a diluent for solutions, as a water source for medical instruments and equipment, and during the final stages of instrument disinfection. Colonised patients also can serve as a source of contamination.[4]

In addition to *Legionella* spp, *P. aeruginosa* and other *Pseudomonas* spp are among the most clinically relevant Gram-negative healthcare associated pathogens identified from water. These and other less common Gram-negative non-fermentative bacteria such as *Stenotrophomonas* spp, *Burkholderia* spp, *Sphingomonas* spp and *Ralstonia* spp, have minimal nutritional requirements i.e. some of these microorganisms can grow in distilled water and can tolerate a variety of physical conditions. These attributes are critical to the success of these microorganisms as healthcare–associated pathogens. Measures to prevent the spread of these microorganisms and other waterborne Gram-negative bacteria include implementation of standard and transmission based precautions with strict adherence to hand hygiene, and the appropriate use of personal protective equipment (PPE) as well as eliminating potentially contaminated environmental reservoirs.[4]

Pseudomonas aeruginosa

Pseudomonas aeruginosa may be associated with a broad range of infections in humans including folliculitis, septic arthritis (especially of smaller joints), otitis externa, keratitis, wound infection, urosepsis, pneumonia and bacteraemia.[6] It is an important cause of infection in vulnerable individuals including those with burns or neutropenia or receiving intensive care. In these groups morbidity and mortality rates attributed to *P. aeruginosa* infection can be high.[7] Management of these infections is challenging as *P. aeruginosa* is inherently resistant to many antimicrobials and treatment is becoming more difficult due to the emergence and spread of resistance to the few antimicrobial agents that remain as therapeutic options. A notable recent development is the acquisition of carbapenemases by some strains of *P. aeruginosa* resulting in limited therapeutic options for infection caused by multi-drug resistant strains.[8] In the context of these challenges, strategies must be identified to prevent the acquisition of *P. aeruginosa* by hospitalised patients.[9]

Data on *P. aeruginosa* bacteraemia in Ireland are obtained via the mandatory reporting system EARS-Net. EARS-Net data consists only of invasive clinical isolates (blood culture and cerebrospinal fluid only). The HSE-HPSC receives enhanced data on *P. aeruginosa* from 21 of 39 laboratories nationally which accounts for approximately 40% of all bacteraemia notified in 2014. Reporting of enhanced data is voluntary. Data on whether contaminated water systems were the primary source of *P. aeruginosa* infections are not collected in Ireland. Consequently, it is difficult to quantify the contribution of contaminated water systems to the occurrence of *P. aeruginosa* bacteraemia.

In 2014, there were 182 cases (rate: 4.0 per 100,000 population) of invasive *P. aeruginosa* infection reported in Ireland. Males were 1.5 times more likely than females to have an invasive *P. aeruginosa* infection reported (Table 1.1). Between 2011 and 2014 the highest rate of infection occurred in those aged 70 years and older (Figure 1.1). Four cases were reported in 2014, in those aged under one year of age, of whom two were aged less than one month and two were aged between 1 and 3 months (Table 1.1). The frequency of invasive *P. aeruginosa* infection increased with age with the majority of infections occurring in adults over 60 years (Table 1.1). It is not known if any of these infections were attributable to water contamination as exposure data are not collected by EARS-Net. To date four outbreaks of *Pseudomonas* spp. (two of which were specifically *P. aeruginosa*) have been reported to HSE-HPSC, two in 2013 and two in 2014; none was attributable to water (Personal communication with HSE-HPSC).

Table 1.1 *Pseudomonas aeruginosa* Bacteraemia in Ireland, 2014

Age Group	ROI Pop	Total No. of cases	Overall rate
0-9	677,099	8	1.2
<1 year	72,410	4	5.5
<3 months		4	
<1 month		2	
10-19	585,510	1	0.2
20-29	658,353	4	0.6
30-39	758,206	3	0.4
40-49	635,997	13	2
50-59	518,908	23	4.4
60-69	392,424	43	11
70+	361,755	87	24
Unk		0	
Total	**4,588,252**	**182**	**4**
M/F ratio	**1.5**		

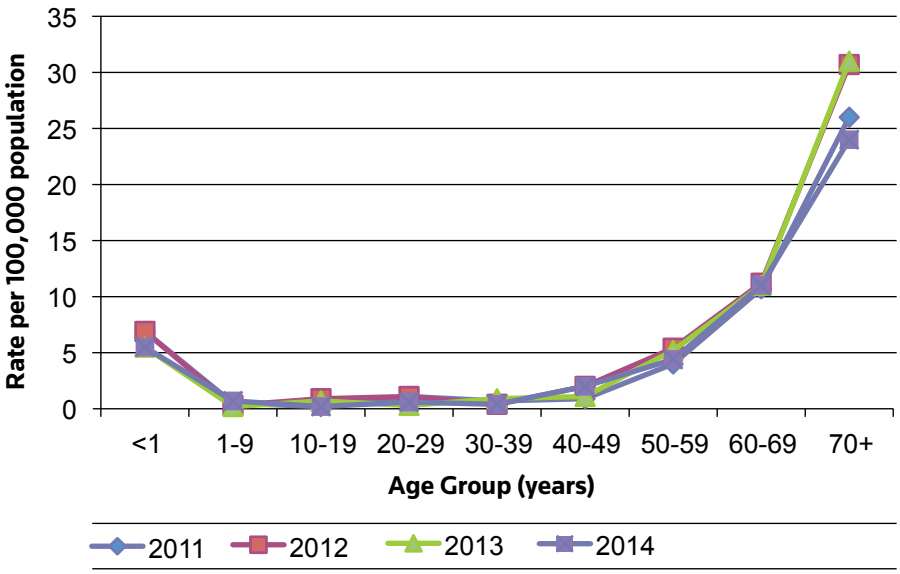

Figure 1.1. Rates of *Pseudomonas aeruginosa* Bacteraemia in Ireland by age, 2009-2014

However, outbreaks of *P. aeruginosa* have occurred in other jurisdictions including outbreaks in four neonatal units in Northern Ireland in 2011-12.[10] The first outbreak which occurred in the Western Health and Social Care Trust involved three infants and resulted in two deaths. The second outbreak occurred in the Belfast Health and Social Care Trust and also involved three infants, all of whom died indicating the severe morbidity and mortality associated with this organism in vulnerable groups. Investigation determined that babies in two other neonatal units were colonised with *P. aeruginosa* on their skin. An independent review was commissioned by the United Kingdom (UK) Regulation and Quality Improvement Authority to investigate the outbreaks. Water from sinks/taps in all of these neonatal units was found to be colonised with *P. aeruginosa*. Outbreaks have also been described in burns units associated with contaminated tubing used for irrigation of patient wounds/lesions and in intensive care units associated with bottled water.[11, 12] In addition, an outbreak of pan-resistant *P. aeruginosa* in an intensive care unit (ICU) of a cancer centre in Bratislava resulted in the death of 5 of 6 patients with *P. aeruginosa* bacteraemia.[13]

The ability of *P. aeruginosa* to form biofilms is important for the ability of the bacterium to persist in environmental niches such as pipes and taps.[14] When growing as a complex mass of cells encased in an exopolysaccharide matrix attached to a surface, *P. aeruginosa* cells can be significantly more resistant to biocides than when they are in a planktonic (free-living) state.[15]

Environmental sites most likely to harbour the bacteria are water-related e.g. taps, showers or where moisture/humidity is high e.g. respiratory therapy equipment.

Several properties of *P. aeruginosa* favour persistence in the hospital environment including:

- Inherent resistance to several disinfectants e.g. biguanides and quaternary ammonium compounds
- Ability to form biofilm on a range of inanimate surfaces also contributes to disinfectant resistance as well as impeding physical removal[16]

The true importance of *P. aeruginosa* in the hospital environment remains a controversial issue. However, there is accumulating evidence to suggest that the environment can play an important role in the epidemiology of healthcare acquired infection caused by *P. aeruginosa*.[8]

Strategies to prevent infection from *P. aeruginosa* and to reduce the likelihood of antimicrobial resistance should include prioritisation and implementation of robust (i) antimicrobial stewardship and (ii) infection prevention and control programmes. Measures to prevent spread include consistent application of appropriate standard and transmission based precautions including hand hygiene and appropriate use of PPE, as well as elimination of potentially contaminated environmental reservoirs.

Acinetobacter spp

Since 2013, *Acinetobacter* spp. is included in the list of EARS-Net organisms reported in Ireland. However, it is not mandatory to notify this organism and it only pertains to *Acinetobacter* spp isolated from blood or cerebrospinal fluid (CSF) as per the EARS-Net case definition. To date, HPSC has been notified of one outbreak due to multi-drug resistant *Acinetobacter* in an acute hospital in Ireland. (Personal communication with HSE-HPSC)

Acinetobacter spp is responsible for healthcare–associated episodes of colonisation, bloodstream infection, pneumonia, and urinary tract infection among medically compromised patients, especially those in ICUs and burn therapy units. Infections caused by *Acinetobacter* spp represent a significant clinical problem. Studies have reported mortality rates associated with *Acinetobacter* bacteraemia of 17–52%, and rates as high as 71% have been reported for pneumonia caused by infection with either *Acinetobacter* spp or *Pseudomonas* spp.

Due to the nature of medical equipment (e.g. ventilators) and the moisture associated with this equipment in intensive care areas, patients and healthcare workers contribute significantly to the environmental contamination of surfaces and equipment with *Acinetobacter* spp. In addition, hand carriage and hand transfer are also associated with healthcare–associated transmission of *Acinetobacter* spp.

Acinetobacter spp have been isolated from the hands of 4–33% of healthcare workers and transfer of an epidemic strain of *Acinetobacter* from patients' skin to healthcare workers' hands has been demonstrated experimentally. *Acinetobacter* infections and outbreaks have also been attributed to medical equipment and materials e.g. ventilators, cool mist humidifiers, vaporisers, and mist tents that may have contact with water of uncertain quality e.g. rinsing a ventilator circuit in tap water.[17, 18]

Acinetobacter spp have also been detected on dry environmental surfaces e.g. bed rails, counters, sinks, bed cupboards, bedding, floors, telephones, and medical record charts in the vicinity of colonised or infected patients. Such contamination is especially problematic for surfaces that are frequently touched. In two studies, the survival periods of *Acinetobacter baumannii* and *Acinetobacter calcoaceticus* on dry surfaces approximated that for *S. aureus* e.g. 26–27 days.[17, 18]

A. baumannii frequently develops antibiotic resistance via diverse mechanisms, leading to the emergence of multidrug-resistant (MDR) strains. Hospital outbreaks of carbapenem-resistant MDR *A. baumannii* have been increasingly reported in ICU settings.[19, 20] Environmental reservoirs of outbreak clones of MDR *Acinetobacter baumannii* which have been identified by epidemiological investigation include sinks and taps in intensive care units[20] and the sink trap within a patient room located in the ICU.[19] The authors considered it likely that the sink tray represented contamination of the entire horizontal drainage system. Running water in the sink in this situation raises aerosols from the drainage system and may cause contamination of the surrounding environment including the hands of healthcare workers.

Because *Acinetobacter* spp may come from numerous sources at any given time, laboratory investigation of healthcare-associated *Acinetobacter* infections should, where possible, involve techniques to determine biotype, antibiogram, plasmid profile, and genomic fingerprinting to accurately identify sources and modes of transmission of the organism(s).[21]

Other Non-fermentative Gram Negative Bacteria

Rare but clinically important opportunistic pathogens which may be present in tap water and have been associated with nosocomial outbreaks include *Burkholderia cepacia, Stenotrophomonas maltophilia, Ralstonia picketti* and *Sphingomonas paucimobilis.* Immunocompromised patients are at greatest risk of developing infection with these organisms.

Some of these non-fermenters have minimal nutritional requirements and can tolerate a variety of physical conditions and are therefore well adapted to survival in water systems and in associated biofilm. *Stenotrophomonas maltophilia, Ralstonia picketti* and *Sphingomonas paucimobilis* have all been implicated in outbreaks and nosocomial infections linked to contamination of distilled water used in the healthcare setting.[4]

Infections and outbreaks attributed to this group of bacteria have also been reported involving medical equipment and materials such as ventilators, nebulisers and dialysis machines, especially in the intensive care setting.[4]

Enterobacteriaceae

Enterobacteriaceae are a family of gram-negative bacilli that commonly reside in the gastrointestinal tract and include organisms such as *Escherichia coli*, *Klebsiella spp*, *Enterobacter spp* and *Serratia spp.* These organisms frequently cause bacterial infections in hospital patients including intra-abdominal sepsis, urinary tract, skin, soft tissue, respiratory and blood stream infection. They are frequent colonisers of hospital patients, particularly in augmented care settings. They may acquire extended-spectrum beta-lactamases (ESBL) and carbapenemases resulting in MDR organisms such as carbapenem resistant Enterobacteriaceae (CRE).

Outbreaks caused by multidrug resistant Enterobacteriaceae are a growing problem of great concern worldwide. Such outbreaks occur most frequently (but not exclusively) in augmented care units and may be associated with significant mortality.

Reservoirs in patient or healthcare worker populations and the environment represent the principal modes of spread in nosocomial outbreaks. Consistent strict adherence to hand hygiene and other standard precautions is essential for the prevention of transmission and thus prevention of HCAIs. Reservoirs on moist surfaces, especially in sink drains, have been reported as the possible source of transmission to patients of Enterobacteriaceae, particularly *Klebsiella spp.*[22, 23] Contamination of the hands of healthcare workers due to back splash during hand washing in a contaminated sink and sink drain is increasingly recognised as a possible mode of transmission to patients, particularly in the ICU setting.

Klebsiella spp

Klebsiella oxytoca is primarily a healthcare associated pathogen acquired from environmental sources. It may be more likely than other Enterobacteriaceae to be associated with environmental reservoirs in hospitals. Outbreaks in ICUs have been reported in recent years which indicate that sinks should be considered potential reservoirs when clusters of infection caused by *Klebsiella oxytoca* are investigated.[22, 23]

Klebsiella pneumoniae: In many countries the emergence of CREs such as *Klebsiella pneumonie* carbapenemase (KPC) have resulted in hospital outbreaks. The genetic resistance determinant has been identified on plasmids allowing rapid dissemination of hyperepidemic clones. This has been a major factor in the spread of antimicrobial resistance.

The epidemiology of outbreaks due to CRE may be complex and evolving. Even when the main reservoir is colonised patients and cross transmission is the principal means of spread, alternative reservoirs should be suspected if strictly applied traditional control measures are not efficacious. In these circumstances, a wet environmental reservoir (mainly the drain, sink trap and horizontal drainage system of a sink) should be considered.

KPC-producing bacteria were detected in as many as 21% of environmental locations in screening samples from sink drains during the investigation of one hospital outbreak in an intensive care unit.[24]

1.2.2 Legionellosis

For more extensive details on the prevention and control of legionellosis, see National Guidelines for the Control of Legionellosis in Ireland, 2009

Legionella species are Gram-negative bacteria that live as intracellular parasites of a variety of species of amoebae, protozoa and slime moulds in aquatic environments. Infection with *Legionella* bacteria can cause two distinct clinical syndromes, grouped together under the name Legionellosis. The first is Pontiac fever, a self-limiting influenza-like illness. The second is Legionnaires' disease which is a severe and potentially fatal form of pneumonia. The case fatality rate is about 12%, rising to about 30% in nosocomial cases.[25]

To date, at least 50 *Legionella* species and 70 serotypes have been described.[26] At least 20 species are associated with causing disease in humans.[26] *L. pneumophila* serogroup 1 is the cause of 70-90% of cases of Legionnaires' disease where the aetiological agent has been isolated. One of these subtypes, the Pontiac subtype, is responsible for 85% of cases due to *L. pneumophila* serogroup 1.[27] Other species identified as causing pneumonia in humans include *L. micdadei, L. bozemanii, L. dumoffii*, and *L. longbeachae*.[26]

Legionellosis is usually acquired through the respiratory tract, by inhalation of aerosols contaminated with *Legionella* bacteria. Aspiration of water contaminated with *Legionella* has also been described as a route of transmission. This may occur predominantly in persons with swallowing disorders or in conjunction with nasogastric feeding.[28]

Sources or potential sources of *Legionella* bacteria:

- Water systems incorporating a cooling tower
- Water systems incorporating an evaporative condenser
- Hot and cold water systems
- Spa pools
- Natural thermal springs and their distribution systems
- Respiratory and other therapy equipment
- Humidifiers
- Dental chair unit waterlines
- Fountains/sprinklers
- Water-cooled machine tools
- Vehicle washes
- Potting compost/soil in warmer climates
- Other plants and systems containing water which is likely to exceed 20°C, or have an electrical component that can transfer heat and cause localised heating, and which may release a spray or aerosol (i.e. a spray of droplets and/or droplet nuclei) during operation or when being maintained.

The infectious dose for *Legionella* bacteria in humans is unknown.

Those at higher risk for Legionnaires' disease include:

- Those aged greater than 40 years [25]
- Males
- Smokers
- Those with excessive alcohol intake
- Immunocompromised organ transplant patients, patients with HIV/AIDS, and those receiving systemic steroids
- Patients with chronic underlying disease such as diabetes mellitus, congestive heart failure, chronic obstructive pulmonary disease and chronic liver failure.

In several hospital outbreaks, patients have been infected through exposure to contaminated aerosols generated by cooling towers, showers, faucets, respiratory therapy equipment, and room-air humidifiers.[29-31]

Factors that enhance colonisation and amplification of Legionellae in man-made water environments include:

- Temperatures of 25°C–42°C
- Water stagnation
- Scale and sediment
- The presence of certain free-living aquatic amoebae that can support intracellular growth of Legionellae. The bacteria multiply within single-cell protozoa in the environment and within alveolar macrophages in humans.

The number of cases of Legionnaires' disease reported to the HSE- HPSC 2004-2014 is shown in Table 1. 2.

Table 1.2 Legionnaires' disease cases per million population in Ireland, 2004-2014

Age group (Years	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Total	4	8	12	15	11	7	11	7	15	14	8
CIR	0.9	1.9	2.8	3.5	2.6	1.5	2.4	1.5	3.3	3.1	1.7

During this period 2004-2014, six cases of nosocomial Legionnaires' disease and one case of nosocomial Pontiac fever were notified to HSE-HPSC (Figure 1.2). Of the cases of Legionnaires' disease, two were associated with acute hospitals and four with other healthcare facilities. (Personal communication with HSE-HPSC).

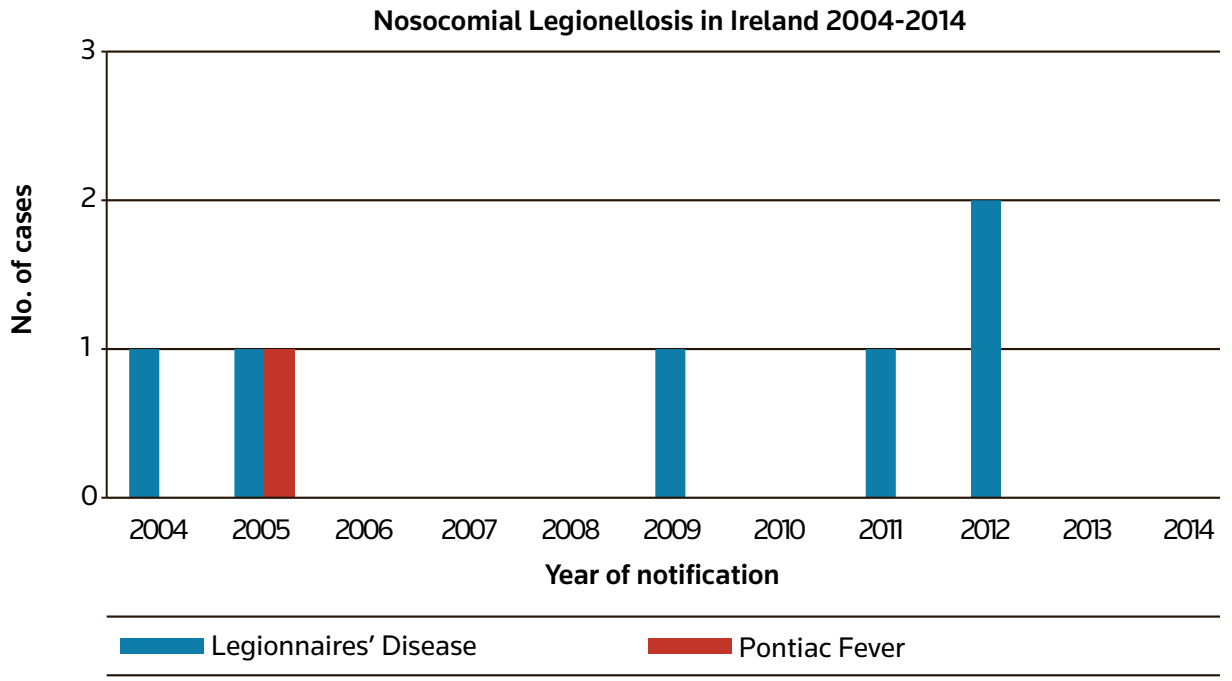

Figure 1.2. Cases of Nosocomial Legionellosis in Ireland, 2004-2014

1.2.3 Infections and Pseudo-Infections Due to Non-Tuberculous Mycobacteria

Non-tuberculous Mycobacteria (NTM) are acid-fast bacilli (AFB) commonly found in potable water. These organisms are not statutorily notifiable in Ireland; hence no routine surveillance data are available. However, it has been reported that the incidence of NTM infection is increasing in other countries; in the United States of America (US) and Canada, for example, the incidence rose from 1.5 to 9 cases per 100,000 between 1997 and 2003. Many NTM are of low virulence, and some measure of host impairment is necessary to enhance clinical disease. Infections occur in immunodeficient (e.g. HIV/AIDS patients) and immunosuppressed (e.g. cancer and transplant patients) patients and in non-immunosuppressed persons with risk factors for mycobacterial infection which include exposure to dust or smoke and underlying lung disease. The major manifestation of NTM in the immunocompetent host is pulmonary disease, whereas disseminated disease is found in patients with immunosuppression.[32]

NTM may be spread via all modes of transmission associated with water. In addition to healthcare–associated outbreaks of clinical disease, NTM can colonise patients in health-care facilities through consumption of contaminated water or ice, or through inhalation of aerosols. NTM have been recovered from a variety of environmental sources with which humans have come into contact, especially drinking water. Endoscopy rinse-water is a source of infection and can cause opportunistic infection. Consequently, this end-water should be tested for NTM.[33-36]

The resistance of mycobacteria to chlorine is species specific. Consequently, it is difficult to establish standard chlorine concentrations and times to reduce or eliminate waterborne mycobacteria. It is therefore important to consider the level of chlorine resistance of the mycobacterial species responsible for contamination when establishing chlorination conditions for disinfection. NTM are 100-330 times more resistant to chlorine than *E. coli*.[37-38]

1.2.4 Cryptosporidiosis

Cryptosporidium species is a protozoan parasite that causes self-limiting gastroenteritis in normal hosts but can cause severe, life-threatening disease in immunocompromised patients. First recognised as a human pathogen in 1976, *C. parvum* can be present in raw and treated waters after faecal contamination from either human or animal sources.[4] The health risks associated with drinking potable water contaminated with minimal numbers of *C. parvum* oocysts are unknown. It remains to be determined if immunosuppressed persons are more susceptible to lower doses of oocysts than are immunocompetent persons.

Since the 1980s, approximately 20 outbreaks of cryptosporidiosis have been reported in health care facilities.[39] Two cryptosporidiosis outbreaks that were reported to HSE-HPSC between 2004 and 2012 were in hospital settings. One was reported as being due to person-to-person spread and one was suspected to be waterborne. (Personal communication with HSE-HPSC)

For guidance see the Report of Waterborne Cryptosporidiosis Subcommittee (2004) of the HPSC Scientific Advisory Committee at http://www.hpsc.ie/A-Z/Gastroenteric/Cryptosporidiosis/Publications/.

Summary

In summary, the principal microorganisms that are of concern as a source of infection from water systems in healthcare facilities are *Legionella* spp and *Pseudomonas* spp, in particular *Pseudomonas aeruginosa.* Following recommended infection prevention and control practices for these microorganisms will also limit the potential for illness to occur in healthcare facilities due to the less commonly encountered microorganisms mentioned above.

The main focus of this guidance is the prevention and control of infection risks in healthcare facilities and includes the following chapters:

- Irish legislation and key national standards
- Engineering controls
- Infection prevention and control, including in augmented care units and management of an outbreak
- Microbiological parameters

Chapter 2: Irish Legislation and Key National Standards

- Each healthcare institution is responsible for the quality of water once it enters its building(s). (CEO, HSE (HBS) Estates Department, maintenance/engineering department/facilities management)
- Employers, including those with responsibility for managing healthcare facilities, have a duty to ensure employees' and other persons' safety, health and welfare at work as far as is reasonably practicable. (CEO of hospital, Manager of hospital)
- Employers are required to carry out a risk assessment for the workplace which should identify any hazards present in the workplace, assess the risks arising from such hazards and identify the steps to be taken to eradicate or minimise these risks. (CEO, HSE (HBS) Estates Department)
- Employers must prepare a safety statement that is based on risk assessments. The statement should clearly identify people in the workforce who are responsible for health and safety issues. Employees should be given access to this statement and employers should review it on a regular basis. (CEO, HSE (HBS) Estates Department)

Introduction

Each healthcare institution is responsible for the quality of water once it enters its building(s). Poorly maintained water systems are among the top ten emerging biological risks.[40] There are several pieces of legislation enacted in Ireland that impact on infection risks associated with microorganisms present in hospital and other healthcare facility water networks and associated fixtures and fittings. Some of this legislation results from European Union (EU) Directives being transcribed into Irish law. Individual Statutory Instruments (SIs) are available at http://www.irishstatutebook.ie/. The term "patient" or "patients" is not specifically mentioned in most of the relevant legislation. Nonetheless, this legislation ensures that patients are not exposed to risks to their safety, health or welfare in hospitals and other healthcare institutions. A summary of Irish legislation and key national standards, code of practice and guidelines, with links, are provided in Appendix 1.

2.1 Health and Safety Legislation

The health and safety of all people in the workplace including healthcare facilities is regulated by law in Ireland and covers all employers, employees, patients, visitors, contractors and all others who visit healthcare facilities. Employers, including those with responsibility for managing healthcare facilities, have a duty to ensure employees' and other persons' safety, health and welfare at work as far as is reasonably practicable. Irish health and safety legislation provides for substantial fines and penalties for breaches of the legislation.

To prevent workplace injuries and ill health employers are specifically required to:

- Provide and maintain a safe workplace environment with safe infrastructure that uses safe plant and equipment. It follows that the necessary financial and other resources to achieve these objectives must be provided.
- Prevent/minimise potential risks from use of any article or substance and from exposure to physical (including biological agents such as potentially infectious microorganisms) or chemical agents, noise and vibration
- Provide appropriate instruction and training to employees on health and safety and risk minimisation
- Provide appropriate and adequate protective clothing and equipment to employees
- Appoint a competent person(s) as the organisation's Safety Officer. In large healthcare facilities this function may be managed by several people or groups of people (e.g. Infection Prevention and Control Committee, Facilities Management and Environmental Monitoring Committee)
- Employers are required to carry out a risk assessment for the workplace which should identify any hazards present in the workplace, assess the risks arising from such hazards and identify the steps to be taken to eradicate or minimise these risks
- Employers must prepare a safety statement that is based on risk assessments. The statement should clearly identify people in the workforce who are responsible for health and safety issues. Employees should be given access to this statement and employers should review it on a regular basis.

Employees have a responsibility to take reasonable care to protect the health and safety of themselves and of other people in the workplace, to engage and comply with the organisation's health and safety protocols, and to alert management concerning any defects in the place of work or equipment that might be a danger to health and safety. Protective clothing and equipment should be provided free of charge to employees.

Comprehensive details of Irish health and safety legislation are provided by the Health and Safety Authority (HSA) (www.hsa.ie). The following is a summary of this legislation.

Safety, Health and Welfare at Work Act 2005 (No. 10 of 2005)[41]

(http://www.irishstatutebook.ie/2005/en/act/pub/0010/)

Schedule 3: This schedule provides an outline of the general principles of prevention to be followed in complying with section 8 of the legislation.

Part 2, Chapter 1, Section 8: General Duties of Employers. This includes the general duties of employers to employees.

Part 2, Chapter 1, Section 12: General Duties of Employers. This includes the general duties of employers to ensure that persons other than their employees at the place of work (e.g. patients in hospitals or other healthcare facilities) are not exposed to risks to their safety, health or welfare.

Part 2, Chapter 3, Section 16: General Duties of Other Persons. This includes the general duties of designers, manufacturers, importers and suppliers of articles and substances for use at work in order to ensure, as far as is reasonably practicable, the elimination or minimisation of any risks to safety or health to which the design or article may give rise.

Part 3, Protective and Preventive Measures, Section 19: Hazard identification and risk assessment. This section outlines the responsibilities of and the requirement for employers (and where applicable persons who have control to any extent of a place of work) to carry out a written risk assessment of the risks to the safety, health and welfare at work of his or her employees, including the safety, health and welfare of any single employee or group or groups of employees who may be exposed to any unusual or other risks under the relevant statutory provisions.

Safety, Health and Welfare at Work (General Application) Regulations 2007 (SI No. 299 of 2007)[42]

(http://www.irishstatutebook.ie/2007/en/si/0299.html)

Chapter 2- Use of Work Equipment, Regulation 29: An employer shall ensure that the necessary measures are taken so that employees have at their disposal adequate information and, where appropriate, written instructions on the work equipment containing at least adequate safety and health information concerning:

(i) The conditions of use of work equipment
(ii) Foreseeable abnormal situations
(iii) The conclusions to be drawn from experience, where appropriate, in using such work equipment, and employees are made aware of safety and health risks relevant to them associated with work equipment (e.g. potential infectious risks associated with exposure to water and water outlets and associated fixtures and fittings) located at or near their workstation or to any changes relating to that work equipment, even if they do not use the equipment.

Chapter 2- Inspection of Work Equipment, Regulation 30: An employer shall ensure that, in the case of work equipment which is exposed to conditions causing deterioration that may be liable to result in a danger to safety or health, periodic inspections and where appropriate, testing is carried out. Special inspections are carried out when exceptional circumstances arise which are liable to make the work equipment unsafe, including modification of work, accidents, natural phenomena or prolonged inactivity, and deterioration is detected and remedied in good time.

Inspections are carried out by a competent person and are appropriate to the nature, location and use of the work equipment, and five years from the date of inspection access to these records is made available to users of the work equipment upon request. The results of inspections carried out are recorded and maintained for five years.

Chapter 2- Maintenance, Regulation 31: An employer shall ensure that work equipment is maintained in such a way as to reduce risks to users of the work equipment and to other persons at work and that a maintenance log is kept up to date.

Safety, Health and Welfare at Work (Biological Agents) Regulations, 2013 (SI No. 572 of 2013)[43]

(http://www.irishstatutebook.ie/2013/en/si/0572.html)
Biological agents or microorganisms are ubiquitous in nature, including many work environments. They include bacteria, viruses, fungi (yeasts and moulds), amoebae and protozoa and other parasites. Most of these agents are harmless, while others may have potential to cause disease. It is often difficult to appreciate the risks presented by microorganisms in the workplace. Workers and patients in healthcare facilities may be harmed by being infected by a microorganism, by being exposed to substances produced by microorganisms such as toxins and enzymes or by being exposed to microbial by-products such as bacterial endotoxins and allergens.

The Safety, Health and Welfare at Work (Biological Agents) Regulations 2013 sets down the minimum requirements for the protection of workers from the health risks associated with biological agents in the workplace. The regulations must be applied to any activity where workers are actually or potentially exposed to biological agents as a result of their work. This SI revokes the Safety, Health and Welfare at Work (Biological Agents) Regulations 1994 (SI No. 146 of 1994) and the Safety, Health and Welfare at Work (Amendment) Regulations 1998 (SI No. 248 of 1998).

Regulation 5: It shall be the duty of every employer to prevent the exposure of employees to a biological agent at a place of work where the results of the risk assessment under Regulation 7 (see below) reveal a risk to employees' health and safety. It shall be the duty of every employer to ensure that the level of exposure of employees is reduced to as low a level as necessary in order to protect adequately the health and safety of the employees concerned, where it is not technically possible to prevent exposure.

Regulation 7: It shall be the duty of every employer to assess any risk to the health and safety of employees resulting from any activity at that employer's place of work likely to involve a risk of exposure of any employee to a biological agent and for that purpose to determine the nature, degree and duration of any employee's exposure to a biological agent and to lay down the measures to be taken to ensure the safety and health of such employees. It shall be the duty of every employer to keep the risk assessment in written form. It shall be the duty of every employer when carrying out the risk assessment in the case of activities involving exposure to several groups of a biological agent, on the basis of the danger presented by all hazardous biological agents present. It shall be the duty of every employer to review the risk assessment regularly and in any event whenever there is a change in conditions at the place of work which may affect any employee's exposure to a biological agent, and as appropriate, amend the risk assessment.

It shall be the duty of every employer to conduct the risk assessment on the basis of all available information, including - (i) the classification of a biological agent which is or may be a hazard to human health referred to in Part 1, 2 of the Regulations, (ii) information on diseases which may be contracted as a result of the work of the employees, (iii) potential allergenic or toxigenic effects as a result of the work of the employees and (iv) knowledge of a disease from which an employee is found to be suffering and which has a direct connection with his work.

Biological Agents are classified in the Safety, Health and Welfare at Work (Biological Agents) Regulations, 2013 into four risk groups – groups 1, 2, 3 and 4. Under the classification system, Group 1 agents are the least hazardous whilst Group 4 are the most hazardous. Some of the microbial species found in water systems in buildings that may be of concern for human health are categorised as Group 2 biological agents, examples of which include *Pseudomonas aeruginosa*, *Legionella pneumophilia* and *Legionella* species. A "Group 2 biological agent", is one that can cause human disease and might be a hazard to employees, although it is unlikely to spread to the community and in respect of which there is usually effective prophylaxis or treatment available.

Safety, Health and Welfare at Work (Chemical Agents) Regulations, 2001 (SI No. 619 of 2001)[44]
(http://www.irishstatutebook.ie/2001/en/si/0619.html)
Chemical agents, disinfectants and biocides are used routinely for cleaning and disinfection to minimise risks from infectious agents in hospitals and healthcare facilities. Employers are required to consider the requirements of these regulations to ensure that their employees (and non-employees such as patients) are not at risk from exposure to chemicals (e.g. disinfectant and cleaning agents) while at work and/or performing a work-related activity in which chemical agents are being used.

A hazardous substance is something that has the potential to cause harm. A chemical agent can be considered hazardous not only because of what it contains (e.g. constituent or chemical ingredient(s)) but also because of the form or way in which it is used at the workplace (i.e. the concentration), how and where it is stored, if used with other chemicals in a mixture, the temperature and environment for use, disposal and storage, etc.

These regulations place duties on employers, employees and other users of workplaces. Regulation 4 outlines the requirements necessary for employers to perform an adequate Chemical Agent Risk Assessment (CARA) on any hazardous chemical agent (e.g. disinfectants and cleaning agents) present and used at the workplace. When assessing the risk from exposure to chemicals it is important to know the chemical in question, to adopt a step-by-step approach to identifying all the possible means of exposure, and to understand the effects that factors such as duration and frequency of exposure can have on the risk of harm being caused. A safety data sheet should be obtained from the manufacturer or supplier of each chemical to enable CARAs to be completed effectively.

The Health and Safety Authority, with the consent of the Minister for Labour Affairs, and following public consultation, published a Code of Practice entitled "2011 Code of Practice for the Safety, Health and Welfare at Work (Chemical Agents) Regulations 2001 (SI No. 619 of 2001)" in accordance with section 60 of the Safety, Health and Welfare at Work Act 2005 (No. 10 of 2005).[45] This Code of Practice provides practical guidance as to the observance of Regulations 4 (1) (e), 4 (5) (d), 6 (1) (c), and 10 (3) of the Safety, Health and Welfare at Work (Chemicals Agents) Regulations 2001, in relation to occupational exposure limit values (OELVs) for a number of chemical agents as listed in Schedule 1 to the Code, having regard to the provisions of the Safety, Health and Welfare at Work Act 2005. This Code of Practice came into effect on 27 August 2007, and from that date it replaces the "2002 Code of Practice for the Safety, Health and Welfare at Work (Chemicals Agents) Regulations 2001 (SI No. 619 of 2001))".

Consideration should be given to the availability of a universal chemical antidote in all healthcare facilities (e.g. the hypertonic, polyvalent, amphoteric compound Diphoterine) that can neutralise many hazardous chemicals. Nonetheless, the availability of such a chemical antidote does not negate the requirement to undertake a CARA for each hazardous chemical agent used.

2.2 The Quality of Water for Human Consumption

The quality of water intended for human consumption within the European Union is regulated by Council Directive 98/83/EC.[46] This was originally transcribed into Irish law under the European Communities (Drinking Water) (No. 2) Regulations 2007. (SI No. 278 of 2007).[47] These regulations were updated in 2014 under the European Union (Drinking Water) Regulations 2014 (SI No. 122 of 2014)[48] to reflect the provisions of Section 7 of the Water Services (No.2) Act 2013 which provide that certain water services functions, which were the responsibility of the water services authorities, are transferred to Irish Water. The 2014 Regulations (i.e.SI No. 122 of 2014) duly revoke the 2007 regulations (i.e.SI No. 278 of 2007).The Directive is intended to protect human health by establishing specific chemical, microbiological, sampling frequency, methods of analysis and other requirements that must be met by drinking water within the European Union. The Directive applies to all water intended for human consumption apart from natural mineral waters and waters that are medicinal products (within the meaning of Council Directive 2001/83/EC of 6 November 2001 on the Community code relating to medicinal products for human use). Member countries are required to regularly monitor the quality of water intended for human consumption by using analysis

protocols specified in the directive, or equivalent methods. Member countries are also required to regularly publish drinking water quality reports.

The EU Directive and the Irish Regulations (SI No. 122 of 2014) specify the main microbiological parameters for water for human consumption in colony forming units (CFU) i.e.0 cfu/100 ml coliform bacteria and *Escherichia coli* and 0 cfu/100 ml enterococci, and no upper limit on other bacterial species, including aerobic heterotrophic bacteria. In addition to the above, the EU Directive does limit the levels of *Pseudomonas aeruginosa* in water offered for sale in bottles or containers to 0 cfu/250 ml and caps the aerobic heterotrophic plate count at 100 cfu /ml.

Irish Water is responsible for monitoring public water supplies, with the parametric values specified in Part 1 of the Schedule of the 2014 Regulations. Each local authority shall monitor compliance of water intended for human consumption supplied in its functional area by any other supplier, with the parametric values specified in Part 1 of the Schedule. The Environmental Protection Agency is responsible for verifying compliance of water intended for human consumption supplied by Irish Water, or any person acting jointly with it or on its behalf, with the parametric values specified in Part 1 of the Schedule.

The European Communities (Drinking Water) (No.2) Regulations, 2014 (SI 122 of 2014) place specific obligations on owners of public buildings (which include healthcare facilities). Regulation 6(2) places a legal obligation on owners of public buildings to "maintain the domestic distribution system in such condition that it does not cause, contribute to or give rise to a risk of non compliance with a parametric value specified in Table A or B of Part 1 of the Schedule or in Table C where there is a risk to public health". Furthermore, where a failure occurs in a public water supply and it has been investigated and found to be caused by the distribution system of that public building Irish Water or the relevant local authority has a duty to ensure that action is taken by the owner of the public building. Irish Water or the relevant local authority may issue legally binding directions to ensure that this action is taken.

Water which is intended for human consumption that is placed on the market for sale in either bottles or containers must be free from any microorganism and parasite, and from any substances which, in numbers or concentrations, constitute a potential danger to human health, and must meet the minimum requirements set out in the Schedule to SI No. 225 of 2007 and SI No. 686 of 2007.[49, 50]

2.3 Infectious Diseases Regulations

A number of specified waterborne infectious agents are regulated under the Infectious Diseases Regulations (SI No. 390 of 1981) as amended by the Infectious Diseases (Amendment) Regulations 1985 (SI No. 268 of 1985), Infectious Diseases (Amendment) Regulations 1988 (SI No. 288 of 1988), Infectious Diseases (Amendment) Regulations 1996 (SI No. 384 of 1996), Infectious Diseases (Amendment) Regulations 2003 (SI No. 707 of 2003), Infectious Diseases (Amendment) Regulations 2007 (SI No. 559 of 2007) and Infectious Diseases (Amendment) Regulations 2011 (SI No. 452 of 2011).[51-57]

Legionellosis and *Pseudomonas aeruginosa* invasive infections are covered by these regulations. Legionellosis is a statutorily notifiable disease in Ireland as defined by the Infectious Disease Regulations 1981 (SI No. 390 of 1981). Under the Infectious Diseases (Amendment) (No. 3) Regulations 2003 (SI No. 707 of 2003), which came into effect on 1 January 2004, laboratory and clinical notification of legionellosis is mandatory. Invasive *Pseudomonas aeruginosa* infection is also a statutorily notifiable disease in Ireland as defined by the Infectious Disease Regulations 1981 (SI No. 390 of 1981) under the Infectious Diseases (Amendment) Regulations 2011 (SI No. 452 of 2011).

In addition, under the Infectious Diseases (Amendment) (No 3) Regulations 2003 (SI No. 707 of 2003)[iii] medical practitioners and laboratories are required to notify the MOH of any unusual clusters or changing patterns of any illness and individual cases which may be of public health concern.

Article 11 of the 1981 regulations states: "On becoming aware, whether from a notification or intimation under these regulations or otherwise, of a case or a suspected case of infectious disease or a probable source of infection with such disease, a medical officer of health, or a health officer on the advice of a medical officer of health shall make such enquiries and take such steps as are necessary or desirable for investigating the nature and source of such infection, for preventing the spread of such infection, and for removing conditions favourable to such infection".

[iii] These regulations can be viewed on the Irish Government website at www.irishstatutebook.ie

2.4 Key National Standards

Under section 8 (1)(b) of the Health Act 2007 the Health Information and Quality Authority (HIQA) has the function of setting standards on the safety and quality of health and social care services provided by the HSE or a service provider in accordance with the Health Acts 1947 to 2007, Child Care Acts 1991 and 2001, the Children Act 2001 and nursing home services as defined in section 2 of the Health (Nursing Homes) Act 1990. Under section 8 (1)(c) of the Health Act 2007, the Authority has the function to monitor compliance with standards and to advise the Minister for Health and the HSE accordingly.

The Health Information and Quality Authority (HIQA) National Standards for the Prevention and Control of Healthcare Associated Infections, 2009 (http://www.hiqa.ie/standards/health/healthcare-associated-infections) are the national standards for use across the Irish health and social care system.[58] A guide to HIQA's programme of monitoring service providers' compliance with the National Standards has also recently been published (see the above link). These standards are consistent with current evidence and best practice both nationally and internationally. The objective of these standards is to provide a framework for health and social care providers to prevent or minimise the occurrence of healthcare-associated infections in order to maximise the safety and quality of care delivered to all service users in Ireland. These standards are designed to promote an environment that maximises safety, quality and accountability in health and social care services. They engender a culture of responsibility and accountability among all staff involved in the management and delivery of health and social care services in relation to minimising healthcare-associated infections (HCAIs).

In particular the National Standards are intended to:

- *Create a person-centred approach to the prevention and control of HCAIs*
- *Promote a multidisciplinary and team-based approach within all health and social care services to the prevention and control of HCAIs*
- *Provide an impetus for the attainment of evidence-based best practice in the prevention and control of HCAIs*
- *Drive continuous quality improvement through effective management and regular performance monitoring and evaluation of services.*

National Standards for Safer Better Healthcare (2012) (http://www.hiqa.ie/publications/national-standards-safer-better-healthcare) were also published by HIQA.[59] They are aimed at protecting patients and they provide a strategic approach to improving safety, quality and reliability in the health services. They will form the basis for future licensing of all healthcare facilities in Ireland. The standards promote responsibility and accountability for the quality and safety of services provided or funded by the Health Service Executive (HSE).

2.5 Governance Structures

2.5.1 Healthcare Facility Manager/Person with Corporate Responsibility

The healthcare facility manager has overall responsibility for ensuring that the recommendations in this guidance document are implemented in their institution.

Healthcare facility managers must ensure that healthcare institutions adhere to relevant national guidance including National Guidelines for the Control of Legionellosis in Ireland (2009) and National Standards for the Prevention and Control of Healthcare Associated Infections (2009).

2.5.2 Environment Monitoring Committee

An environmental monitoring committee (EMC) or equivalent committee must be in place in each healthcare facility. The EMC is a multi-disciplinary committee which is responsible for, *inter alia,* the programme to prevent and control water-associated healthcare associated infection. The EMC should be chaired by the healthcare facility manager or a representative from the senior management team of the institution.

- An EMC should be in place in all acute hospitals and all HSE long-stay institutions/healthcare facilities e.g. mental health and physical disability facilities.
- The composition of the EMC may vary from one healthcare facility to another but in general, membership should include the following:

- General Manager/Hospital Manager/CEO
- Clinical Microbiologist
- Director of Nursing
- Infection Prevention and Control Specialist
- Clinical Risk Manager
- Health and Safety Officer
- Environmental Services Officer
- Site Maintenance Manager
- Technical Services / Facilities Engineer
- Director of Public Health or designate
- Principal Environmental Health Officer
- HSE (HBS) Estates Department

- The EMC will advise the general manager/person with corporate responsibility for the premises/system on the development of policies and procedures for the control of *Legionella* in the healthcare premises
- The EMC should provide advice on the formulation of the plans for the implementation of these policies and procedures and make recommendations as appropriate
- The EMC should, in conjunction with managers throughout the healthcare premises, ensure that all relevant staff fully appreciate the actual and potential risks of water associated healthcare infections
- The EMC will advise that technical responsibility for the prevention and control of water associated infections in the healthcare facility/system should be given to a competent person who will be accountable to the general manager/hospital manager/Chief Executive Officer (CEO)
- The EMC should regularly review (not less frequently than annually) the healthcare premises' performance for the control of water associated healthcare infections against its plans and present a report on the review to the general manager
- The EMC will advise managers in writing annually of at-risk locations for waterborne infections including *Legionella* (See National Guidelines for the Control of Legionellosis in Ireland (2009) see Chapter 1, Section 1.3) and the need to carry out bi-annual sampling for *Legionella* spp, using appropriate literature as guidance (National Guidelines for the Control of Legionellosis in Ireland (2009) see Chapter 6 on sampling).(60)
- Implementation of the advice given by the EMC is the responsibility of the manager with corporate responsibility for the healthcare facility/institution.

Additional information on the EMC and the specific roles and responsibilities is contained in the National Guidelines on the Control of Legionellosis in Ireland 2009 see Chapter 8, Section 8.1.1 pages 68-71.[60]

2.6 Biocidal products

Biocidal products that are used to protect humans, materials or articles against harmful or potentially harmful microorganisms through the action of active substances contained in the biocidal product are regulated by the EU Biocidal Products Regulation (BPR, (EU) 528/2012 as amended),[61] applicable from the 1st September 2013. This regulation concerns the making available on the market and use of biocidal products and has been transposed into Irish law under SI No. 427 of 2013 (as amended) (http://www.irishstatutebook.ie/pdf/2013/en.si.2013.0427.pdf).[62]

Most biocidal products are composed of a number of different components. Choice of the correct product should take into account its proposed use and targets, suitability and safety according to its design purpose, compatibility with other chemicals in use and compliance with the requirements of the Biocides Regulation.[63] All biocidal products require an authorisation before they can be placed on the market, and the active substances contained in each biocidal product must also have been previously approved. Such approval of active substances takes place at European Union level and the subsequent authorisation of the biocidal products at Member State level.

Therefore all biocides to be placed on the market in Ireland must firstly be notified to the competent authority, which for the purposes of these Regulations is the Pesticide Control Service of the Department of Agriculture, Food and the

Marine (DAFM). Only biocidal products that are notified to DAFM may be legally placed on the Irish market (http://www.pcs.agriculture.gov.ie/biocides.htm). Notified products are issued with a PCS number which should be displayed on the product and corresponding literature. Registers of notified and authorised products are published and updated on a regular basis.

Biocidal products are classified into 22 biocidal product-types in Annex V to the BPR, grouped in four main areas. Some of the Main Group products and Product Types (PTs) of relevance to the prevention of infection from water systems in healthcare facilities are outlined as follows:

Main Group 1 products consist of disinfectants but exclude cleaning products that are not intended to have a biocidal effect (e.g. washing liquids).

Main Group 1 PT2 products include disinfectants and algicides not intended for direct application to humans or animals. These include products used for disinfection of air, water not used for human or animal consumption, chemical toilets, wastewater, hospital waste and soil, as well as products used as algicides for treatment of swimming pools, aquaria and other waters.

Main Group 1 PT 5 products include products used for the disinfection of drinking water for both humans and animals.

Main Group 2 products consist of products to prevent microbial and algal development. Main Group 2 PT 11 products include products used for the preservation of water or other liquids used within cooling and processing systems for the control of biofilms and harmful or potentially harmful microorganisms. Products used for the disinfection of drinking water or of water for swimming pools are not included in this product-type.

Main Group 4 PT 21 products include products used to control the growth and settlement of fouling organisms (microorganisms and higher forms of plant or animal species) on vessels, aquaculture equipment or other structures used in water.

Chapter 3: Engineering Controls

KEY RECOMMENDATIONS

- All facilities should have a water safety plan, incorporating a risk assessment
- Water safety plans and risk assessments should be kept up-to-date.
- Water safety plans and risk assessments should include up-to-date schematics of the water distribution system.
- Risk assessments should consider:
  - Contamination of distal parts of the water system, in particular water outlets
  - Biofilm contamination of water systems
  - Underused outlets such as sinks, showers or toilets
  - Water distribution system components, such as flexible hoses, thermostatic mixing valves (TMVs), aerators and flow straighteners
  - The need for additional secondary disinfection
- Correct temperatures must be maintained throughout the water distribution system.
  - Keep hot water hot and cold water cold
  - Hot water should leave the calorifier above 60°C
  - Hot water should not return to the calorifier below 50°C
  - Circulate hot water in the system flow at 55°C
  - Cold water should be stored and distributed below 20°C
- Pressure and flow throughout the distribution system must be maintained and monitored.
- Cleaning regimens must be maintained to reduce biofilm and scale build-up
- Intelligent water management systems and automated flushing regimens should be considered where appropriate.
- Materials, fixtures and fittings that support biofilm and micro-organism growth and colonisation should be avoided wherever possible.
- This chapter should be read in conjunction with the 2009 National Guidelines for the Control of Legionellosis in Ireland and the key regulations, standards, codes of practice and guidance listed in Appendix 2.

PRACTICAL GUIDANCE

- The strategy of "engineering out" the problem remains paramount in managing waterborne infections.
- Water safety must be an integral part of all stages of a building's life cycle.
- Risk assessments must consider the different microorganism behaviours, at-risk populations, exposure routes, transmission potentials, and the age of the building and water distribution system.
- Underused outlets such as sinks, showers or toilets result in reduced water flow and stagnation. A risk assessment may indicate a need to remove underused outlets in certain high risk areas.
- Water distribution system components, such as flexible hoses, thermostatic mixing valves (TMVs), aerators and flow straighteners are associated with a high risk of contamination. A risk assessment will determine whether or not they are required.
- A knowledge of source water characteristics, including chemical composition, is important
- Those involved in the commissioning of a building must be competent in order to minimise the risk of contaminating a water distribution system during the commissioning stage.

Introduction

Many of the controls used to minimise *Legionella* contamination have an impact on *Pseudomonas* species and apply equally to the control of other waterborne organisms. However, some additional precautions and considerations are required. Microorganisms such as non-tuberculosis mycobacterial species and amoeba-associated bacteria exhibit enhanced resistance to disinfection. In addition Gram negative aerobic heterotrophic bacterial species tend to colonise distal regions of the water distribution system near water outlets, faucets and other fittings such as shower heads. It is estimated that 90% of *Pseudomonas* water system contamination is confined to the distal two metres of the water system.[64] *Pseudomonas aeruginosa* is not commonly found in drinking water. Contamination is thought to relate more to its ability to colonise biofilms in plumbing fixtures.[65]

This chapter aims to expand and update advice on the engineering control of waterborne microorganisms to reflect the broad range of microorganisms that colonise water distribution systems, the differing routes of transmission, patient risk groups, and microorganism behaviour. This chapter should be read in conjunction with the key regulations, standards, codes of practice and guidance listed in Appendix 2.

It must be acknowledged that many healthcare facilities in Ireland are old buildings with complex water systems. Many have had several additions and extensions added over years increasing the complexity of the water distribution system and consequently the overall risk. Risk management must consider costs associated with retrofitting and ongoing maintenance, practicalities of possible solutions, and the acceptable levels of risk. When balancing risks it is important that water preservation and water charges do not take precedence over safe water. The importance of "engineering out the problem" and of completing and maintaining a risk assessment of water systems remain paramount.

3.1 Water Safety and a Building's Life Cycle

Water safety must be an integral part of healthcare facility conception, design, building and commissioning. Water safety must be considered from the very outset of the planning process and through the entire life cycle of the building, including demolition.

The healthcare facility's EMC and the Infection Prevention and Control (IPC) team should be consulted at key stages of capital projects and of ongoing system maintenance works.[66, 67] For these teams to effectively participate in the planning process for both new-build and refurbishment projects, it is essential for them to understand and be involved in the process from its inception to completion and commissioning. Failure to adequately assess risks at the appropriate time can lead to expensive redesign later and expose the patient and healthcare worker to infection hazards.

Water safety should be considered during each stage of the planning, design and construction, renovation, alteration or refurbishment of a healthcare facility. (Table 3.1)

Table 3.1: Stages of capital projects during which water safety must be considered

• Business case preparation
• Project funding
• Concept/feasibility study
• Design stage
• Contracting
• Project monitoring/construction
• Pre-handover inspections ("snagging")
• Commissioning
• Post-project evaluation

Water safety is the responsibility of many disciplines. From building conception to the day-to-day running of a facility there are many health care staff with areas of responsibility to ensure safe water including:

- Specification
- Project brief and planning
- Design
- Contractors
- Suppliers and service providers
- Maintenance
- Treatment, monitoring, cleaning, disinfection and control
- Policy development and up-dating.

It is critical that healthcare facilities have written policies that outline and assign roles and responsibilities for water safety at all stages of a building's life cycle. Chapter 8 of the HPSC National Guidelines for the Control of Legionellosis in Ireland 2009 provides further detail on the roles and responsibilities of health care workers. See http://www.hpsc.ie/A-Z/Respiratory/Legionellosis/Guidance/

Personnel with overall responsibility for managing projects and maintenance works must be aware of the key appropriate guidance, legislation, and standards (see Appendix 2) and consult with the EMC, the IPC teams and HSE (HBS) Estates Department at the appropriate time to achieve the right project outcomes.

At a minimum, systems must be installed in accordance with Irish building regulations. In addition, Irish healthcare engineering specifications utilise the UK Department of Health's Health Building Notes (HBNs) and Health Technical Memoranda (HTMs). As these are healthcare specific guidance documents their requirements are incorporated into construction and maintenance contracts. These documents generally take precedence, where specified, over Irish building regulations as they recommend higher standards that are necessary for healthcare environments.

3.2 Commissioning and Handover of Buildings

Contamination of a water distribution system can occur during commissioning, prior to handover of a building. The contractor responsible for commissioning must be competent and knowledgeable of the risks of contaminating a water distribution system and must be familiar with the relevant standards and guidance to prevent and minimise contamination.

Every effort should be made to ensure that new water systems and equipment are supplied free of biofilm. Water distribution systems should be cleaned and disinfected just prior to handover. Buildings should then be occupied and put into use immediately. Where buildings are not put into use immediately a flushing regime must be implemented. A disinfection regime may also be required.

When a new building is completed or acquired, a water hygiene logbook (Table 3.2) should be created prior to occupation. The logbook should contain a risk assessment of the system which includes new as-built layout and schematic drawings of the hot and cold water systems to indicate where the sources of both hot and cold water are located and the outlets that they serve. All new outlets should be clearly identified as drinking, non-drinking or hot water and all pipework not carrying potable water should be labelled.

Table 3.2: Critical components of a water hygiene logbook at handover of a building

• Risk assessment of the system
• New as-built and as-fitted layout & schematic drawings
• All relevant information on system performance
• Operation & maintenance manuals
• Full manufacturing details of all components
• Initial commissioning and testing records
• Disinfection and test certificates
• Water treatment parameters, operating modes & settings
• Full details of maintenance requirements

Further guidance is available in Chapters 16 and 18 of UK HTM 04-01 Part A 2006[68], Chartered Institution of Building Services Engineers (CIBSE) Commissioning Code W: Water Distribution Systems 2010[69], and from the Building Services Research and Information Association (BSRIA).[70]

3.3 Water Safety Plan and Risk Assessment of Water Distribution Systems

A risk assessment of the water distribution system in a healthcare facility is a legislative requirement, as discussed in Chapter 2. A water safety plan (WSP) approach, incorporating a risk assessment, is outlined in the World Health Organization (WHO) document Water Safety in Buildings, 2011.[71] The recently published UK HTM 04-01 Addendum: *Pseudomonas aeruginosa* – advice for augmented care units, also recommends that a Water Safety Group (WSG) commissions and develops a WSP which includes a risk assessment.[64] Irish national guidelines for the control of legionellosis recommend that EMCs should be established to provide advice to statutory duty holders on the development and implementation of policies and procedures. The key steps of a WSP, including a risk assessment, are outlined in Table 3.3.

Table 3.3: Key steps of a Water Safety Plan for a Healthcare Facility

• Establish an Environmental Monitoring Committee
• Document and describe the entire water distribution system including schematic diagrams
• Carry out a hazard analysis and risk characterisation, assessing likelihood and impact
• Assess the risks pertaining to all water, water systems, water uses, routes of exposure and patient risk groups
• Assess incoming source water quality and composition
• Identify and evaluate existing control measures
• Identify and implement additional control measures
• Carry out scalding risk assessments
• Enter ongoing risks onto the facility's risk register and manage appropriately
• Monitor and audit control measures
• Ensure maintenance is carried out in line with current recommendations
• Maintain an up-to-date hygiene logbook
• Develop written policies and procedures
• Develop a contingency plan for major disruptions to the incoming water supply
• Establish a communication plan
• Provide staff training and ensure competency
• Carry out the necessary validation, verification, and audit processes

A WSP is a dynamic working document. It is important that it is not seen as a one-off exercise. It must be kept up-to-date. Many factors in the day-to-day running of a facility can affect the risk of water system contamination such as:

- Planned/unplanned works or maintenance on the water system
- Building renovation or refurbishment
- Closure and re-opening of the facility or parts of it (planned or unplanned)
- Change of use of the building or part of it
- Disruptions to the water supply to the facility.

The WSP should be reviewed on an annual basis and when there are alterations, repairs, changes of use, building works, or critical incidents.

Sites where there are mixed uses such as buildings for direct healthcare provision and buildings for administration are often supplied by the same mains water supply. However water system use within both will be substantially different

and can negatively impact in either direction. This must be addressed during the development of a WSP and there must be clear responsibility for the safety of water on the site.

The key factors that influence risk and which should be incorporated in a healthcare facility's WSP and assessed as part of the risk assessment are illustrated in Figure 3.1.

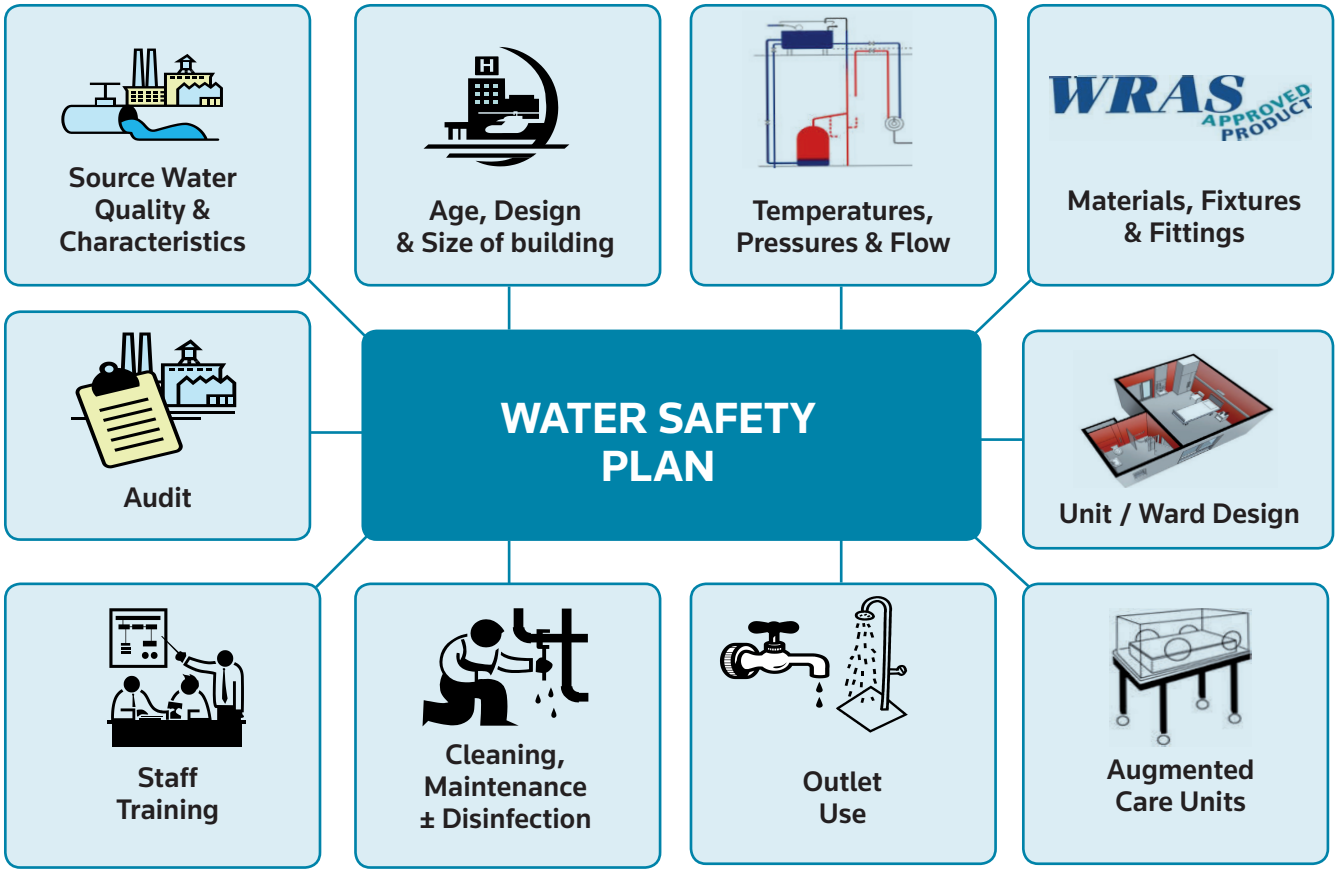

Figure 3.1: Key risks and aspects of waterborne infection prevention and control that should be assessed as part of a healthcare facility's water safety plan

Details on the risk assessment component of a WSP are available in the National Guidelines for the Control of Legionellosis in Ireland, 2009.[60] However, there should be an increased emphasis on other waterborne organisms such as *Pseudomonas*, other exposure routes and other high-risk populations such as patients in Augmented Care Units (ACUs). Risks associated with distal parts of the distribution system and biofilm contamination must be considered. Those with responsibility for carrying out the risk assessment as part of the WSP should be competent and independent of the designer, contractor or maintenance provider.

The HSE has developed further guidance on carrying out risk assessments, including using a risk matrix and developing risk registers.[72, 73]

3.4 Incoming Source Water Quality and Composition

The incoming source water quality and composition must be considered by healthcare facilities when undertaking a risk assessment of the water distribution system. Those responsible for a facility's water safety should note that failures in water quality do occur. Owners of commercial or public premises are obliged to maintain the quality of water in their distribution system.

Table 3.4 lists the characteristics of the incoming water supply that healthcare facilities should consider. A risk assessment will indicate what additional testing, monitoring or treatment may be required.

Table 3.4: Characteristics of the incoming water supply

• Vulnerability or reliability of the supply
• Source characteristics i.e. ground or surface water
• Water pressure and quantity
• Temperature
• pH and alkalinity
• Hardness
• Total organic carbon (TOC) and dissolved organic carbon (DOC)
• Trihalomethanes (THMs)
• Nitrates
• Turbidity
• Chlorine residuals

Healthcare facilities should, wherever possible, be supplied by water from the public mains supply only. Although not recommended, if a healthcare facility is supplied by a private well or other private source, this water supply is classed as a privately regulated supply. Dual supplies (i.e. where water is from both public and private sources) are also not recommended. However, if a facility has a dual supply, this is also a privately regulated supply. Privately regulated supplies must be notified to the Local Authority (LA) and the water must meet the quality standards as laid out in SI No. 122, European Union (Drinking Water) Regulations, 2014.[48] Private water supplies must be properly protected and treated. Continuous disinfection (for example with ultraviolet (UV) treatment) as opposed to sporadic disinfection is recommended. Treatment systems must be regularly maintained. In addition, wells must be physically protected from contamination, for example, from surface water run-off, animal or human effluent, fertilizer, pesticides, or other chemicals. Where a dual supply exists the public supply should take precedence and the private source should only be used as back-up. Before commissioning or recommissioning a back-up supply, it should be subject to flushing and testing, to ensure potability. A non-return valve must be fitted to the private supply connection to the building in order to eliminate back siphoning from the private to the public supply.

Protection of metal service pipes against the potential corrosivity of water

The corrosivity of water with respect to metal pipes (e.g. lead – plumbosolvency and copper - cuprosolvency) is a complex issue related to several factors, many of which interact, including:

- pH
- Alkalinity
- Hardness
- Dissolved Inorganic Carbonate (DIC)
- Buffer intensity of water to pH change due to background alkalinity
- Dissolved oxygen
- Chlorine residual
- Temperature

Water stagnation also affects the degree of corrosion. Several other factors can affect corrosion of lead and copper but they cannot be easily altered by a water system.

The corrosive nature of water and the resultant solvency of lead and copper pipes conveying such water through internal distribution systems vary as follows:

- Low alkalinity soft water at pH levels less than the pH saturation of the particular water (see below) is associated with both plumbosolvency and cuprosolvency which increase as pH levels in the water decrease.
- In the case of copper pipes, corrosivity is also associated with hard, high alkalinity, groundwater sources with high constituent DIC levels i.e. carbonates and bicarbonates in waters sourced usually from boreholes or wells in limestone areas.

Cuprosolvency, when exposed to corrosive waters, can be more acute in newer pipe systems due to increased solubility of copper and the consequent inability of pipe systems to develop inner protective coatings. Older copper pipes may have developed a stable inner coating which can resist subsequent dissolution of copper if exposed to more corrosive waters.

Saturation pH (pHs) is a parameter specific to each water supply and is primarily related to the remaining alkalinity in the water following treatment and the temperature of the water, although hardness also has a minor effect. Low residual alkalinity results in high pHs values, while temperature increases result in decreased pHs values.

The formation of an internal calcium carbonate protective coating is related to raising the pH of the water to a level sufficiently above the pHs value. The difference between the water pH and the calculated pHs is called the water's Langelier Saturation Index (LSI):

LSI = pH of the water – calculated pHs of the water

In order to form a slight coating, the optimal LSI should be 0.2-0.3 pH units.

Because increased temperature decreases pHs, hot water systems are more scale forming than cold water systems. Indeed, it is possible that cold water systems can be corrosive to metals and hot water systems can be scale forming whilst conveying the same source water.

The most common method used by WSAs in Ireland to protect older lead pipes (typically those installed pre-1970s) against plumbosolvency is the promotion of internal coat formation by addition of alkali to raise the pH of treated water above its saturation pH (pHs) and induce the formation of an inner protective coating of calcium carbonate.

Flow proportional dosing of orthophosphate into water at relatively low dose rates to limit cuprosolvency, is practiced by over 50% of water utilities in the US. Orthophosphate promotes the formation of internal cupric phosphate coatings in the pipes which are less soluble and therefore mitigates the dissolution of copper pipes by more corrosive waters.

Where cuprosolvency is a potential problem (e.g. in both very low and very high alkalinity waters) the following actions should be considered:

- Prior to designing and installing internal plumbing systems the chemistry of the source water should be assessed to determine the suitability of new copper pipe plumbing systems
- Where the copper residuals levels within existing copper distribution systems exceed the parametric value of 2mg/l.[48] The following mitigation measures to limit cuprosolvency should be considered-
    - Engage initially with Irish Water (IW) to ascertain whether
        - the municipal water supply can be replaced or
        - the municipal water supply can be process optimised to promote the formation of an inner coating of calcium carbonate within the copper water distribution pipes. This may not always be possible, particularly in high alkalinity water where alkalinity buffers the water against pH change.
- If the options above are not possible to facilitate the flow proportional dosing of orthophosphate at low dose rates into the water to form an inner coating within the lead and copper plumbing materials and so form different compounds which have a lesser tendency to dissolve.

Water Hardness

Water is considered hard if it forms scale particularly in heating systems or if by virtue of its precipitation of soap or suppression of lather formation, additional detergent is required for proper cleaning.

All natural waters contain, in various concentrations, dissolved salts, which dissociate in water to form charged ions. Hardness is a measure of the amount of calcium and magnesium in water and is expressed as the combined concentration of calcium and magnesium and reported as $CaCO_3$ mg/l.

Water hardness is often categorised as:

- Soft water - <75mg/l $CaCO_3$
- Moderately hard water - 75mg/l to 150mg/l $CaCO_3$
- Hard water - > 150mg/l $CaCO_3$

Although from a human health perspective hard water is regarded as superior to soft water, due to an inverse relationship between the incidence of cardiovascular disease and water hardness, the need for softened water in healthcare facilities for purposes other than drinking and cooking may require consideration. Water containing scale-forming ionic impurities, particularly calcium and magnesium, can seriously affect the reliability and operating efficiency of a boiler system and can result in the clogging of hot water system small bore pipes.

Softening of a hard water supply may be required on water feeds to:

- Boilers and hot water supply systems to prevent internal sludge and lime scale build-up
- Mixing devices (including thermostatic mixing valves (TMVs)) and blending valves to avoid clogging of control ports and showerheads by lime scale
- Laundries

Contingency Planning

The provision of public water supplies is undergoing major reform. Currently, Drinking Water Incident Response Plans (DWIRP) are prepared by the LA / IW and are activated where there is an incident that causes or threatens death, injury or serious disruption of essential services. Each DWIRP includes scheme data on each water supply identified including water source type, description of raw water quality, water treatment data, alternative supply options for the area served and a list of sensitive customers such as hospitals and nursing homes. Procedures are outlined which include a requirement for the LA to contact the HSE should an incident of medium or high severity occur.

Healthcare facilities should develop their own contingency plans for major disruptions to the incoming water supply which should include details of the supply and contact details for relevant personnel in IW. It should also include provision for alternative water supply arrangements and the risks associated with these alternative supplies. Contingency plans must also be considered at the design stage. Some supplies have 24-48 hour water storage capacity to cover interruptions in the supply and this should be factored into the contingency plan.

The operational requirements for dealing with contamination of a water supply that results in a change to taste, colour, or odour of the water are detailed in UK HTM-00.[74]

Rainwater Harvesting

Rainwater can become contaminated with microorganisms including *Campylobacter, Cryptosporidium, Escherichia coli, Giardia, Legionella, Mycobacterium* species and *Pseudomonas aeruginosa*. Contamination can arise as a result of:

- Direct faecal deposition by birds and small mammals e.g. rodents, bats or cats
- Decay of accumulated organic debris e.g. rotting vegetation
- Deposition of airborne microorganisms

Rainwater can also become contaminated with chemicals including atmospheric pollutants, pesticides and heavy metals.

Healthcare facilities may be tempted to install rainwater harvesting systems as a means of conserving water use. However, the installation of these systems may not be financially viable especially if they are being retrofitted. There are several other water conserving options that should be implemented before considering rainwater harvesting. Under no circumstances should harvested rainwater be used where immunocompromised patients are being treated.

3.5 Water System Design

Hot and cold water systems should be designed in such a way as to minimise or prevent conditions which permit the growth of waterborne microorganisms and biofilm and also to allow easy cleaning and disinfection. The overall choice of system depends on the size and configuration of the building and the needs of the occupants.

A key issue is whether cold water storage is required and if so, how much. Healthcare and catering activities rely on the continuous availability of hot and cold water. Hot and cold water storage systems are often over-sized in relation to the actual usage because of uncertainties at the design stage leading to an excessive safety margin. If at the design stage there is a need to allow for future growth in demand, this should be organised in a modular fashion. However, multiple linked storage tanks can lead to unequal flow rates and possible water stagnation.

Sufficient circulation and hydraulic balance within a water distribution system are critical. It is important to ensure adequate access to components of the system for cleaning and servicing.

Materials, Fixtures and Fittings

All materials, fixtures and fittings should be approved by the UK's water regulations advisory scheme (WRAS) (www.wras.so.uk). In the absence of an equivalent Irish scheme the recommendations of the UK's WRAS should be followed. The WRAS publishes up-to-date lists of satisfactory materials and fittings in the Scheme's Water Fittings and Materials Directory.

Materials

- Non-metallic materials
  Materials such as natural rubber, hemp, linseed oil-based jointing compounds and fibre washers should not be used in water systems. The material composition of common components such as washers, pipe sealants and flux products, amongst others, should be checked.

- Flexible hoses
  In 2010, The Department of Health, UK, issued guidance recommending that a risk assessment be conducted and that flexible hoses should be replaced where indicated.[75, 76] In limited circumstances, where they are essential, they should not be lined with ethylene propylene diene monomer (EPDM) but with alternative WRAS approved lining materials. Care should be taken not to kink or distort flexible hoses during installation.

- Low-corrosion materials
  Low-corrosion materials (copper, plastic, stainless steel etc.) should be used where possible. Where water is particularly soft a risk assessment should be carried out early in the design stage to determine which are the most suitable materials to be used.

Fixtures and Fittings

- Clinical hand wash sinks[66]
  - should be large enough to contain most splashes
  - should be sealed to a waterproof splash-back
  - should not have a plug or recess capable of taking a plug
  - should not have an overflow.

- Taps
  - Alignment
    Taps should not be aligned so that water flows directly into the waste water outlet (drain) as splashing would result in dispersal of contaminated droplets.
  - Taps should ideally be removable and easily dismantled for cleaning and disinfection[65]
  - Non-touch / infra-red / sensor taps

    Although sensor taps are recommended to improve hand hygiene, evidence suggests that there is a greater risk of internal surfaces and components of these types of taps becoming contaminated with microorganisms and biofilm in comparison to manually operated taps.[77-86] In addition, routine flushing of sensor taps requires personnel to remain at the tap for the duration of flushing.

    If considering installing or using sensor taps, a risk assessment should be undertaken, particularly if considering use in Augmented Care Units (ACUs).[66] They are not recommended where the frequency of use is low.[87] If required, sensor taps with automated programmable flushing capability could be considered but records of remote flushing must be maintained.[88] Because of the risk of contamination these types of taps may require additional routine maintenance. It may be appropriate to sample water from sensor taps to ensure they are being adequately maintained.

- Mixer taps

  Mixer taps with sealed cores should be avoided as they are difficult to adequately disinfect once contaminated. Spray type mixer taps should also be avoided.

  - Swan-neck taps

    Swan-neck taps are not recommended as a significant volume of water is retained within the tap after use which stagnates and can become contaminated.

- Thermostatic Mixing Valves (TMVs)
  - The purpose of TMVs is to deliver water to an outlet at a lower temperature (typically 41°C) than the circulating temperature. However, this means that water distal to the TMV will not be thermally controlled and the outlet cannot be flushed with water of a sufficiently high temperature.
  - The internal structure of a TMV is complex consisting of different components and materials. The greater the complexity within the design of an outlet the greater the risk of contamination.[86, 89]
  - A risk assessment is required to decide where TMVs are required and whether or not there is a need to remove TMVs in some areas.
  - Installation of non-TMV taps may be preferable in augmented care units where patients are unlikely to be using wash-hand basins.[65, 66]
  - Ideally, if TMVs are used, they should be situated within the body of the tap or if not, they should be sited as close as possible to the point of use.[65]
  - The branch supply to each TMV should be fitted with a non-return valve on both the hot and cold supply as close to the outlet as possible.
  - A single TMV should not serve multiple tap outlets.
  - Where a single TMV serves multiple shower heads, it is important to ensure that these showers are flushed frequently.

- Rosettes / flow straighteners

  Rosettes are used in taps to generate a straightened flow of water to enhance hand washing. However, a detailed inspection of rosettes taken from tap outlets in neonatal units in Northern Ireland during the outbreak of *Pseudomonas aeruginosa* found them to be heavily colonised.[86] *Pseudomonas aeruginosa* growth was lower on less complex rosettes or those made of metal. A risk assessment will determine if rosettes or flow straighteners should be removed.

- Aerators and strainers

  Aerators and strainers have been demonstrated to be associated with an increased risk of contamination due to the capture of biofilm.[89] A risk assessment will determine if they should be removed.

Water system components that may mitigate risk

- Central absolute bacteria filters

  These filters are installed as close to the heat source/calorifier outlet as possible. The filters range in size from 0.2 to 0.65 micron. They operate by continuously cleaning the system and assist in preventing the build-up of deposits at final outlets. They are generally protected upstream by either a 1 or 5 micron particulate filter and in some circumstances by a strainer upstream of that. The pressure drop and/or flow-rate through the filter should be monitored via the Building Management System (BMS). Provided they are installed as close to the heat source/calorifier outlet as possible and in accordance with supplier/manufacturer specifications and UK HTM 04-01, they may be a cost effective method to reduce system particulate and sediment levels.

- Intelligent water management systems (IWMS)

  Intelligent water management systems should be encouraged particularly in new build projects. A life cycle costing appraisal will determine their value for money (VFM) at the design stage. Retrofitting may not be economically viable. Alternately, elements of an IWMS can be installed and linked to the existing BMS on site. Such elements include water meters, temperature sensors, tank level water sensors, control valves, balancing valves, biocide level sensors and pressure drop sensors. A number of companies provide packaged solutions which address these aspects. Some of these packaged intelligent systems provide preventive measures that assist in avoiding stagnation in the water system. They can also reduce personnel and operating costs, for example, through controlled flushing measures carried out in an efficient manner. Overall these systems provide for better water quality management, enabling better control, monitoring, recording and communication, all of which are essential elements of a water management system in a healthcare facility. However, the water distribution system's pipework must be configured appropriately to work with IWMS.

- Other components
  The risk assessment may indicate a need to employ a variety of other engineering controls to reduce the risk of contamination, for example:
  - Backflow prevention devices
  - Venturi-type valves to induce circulation
  - Purge valves to dump stagnant water
  - Balancing valves on the flow and return system
  - Shunt pumps to reduce stratification in cylinders
  - Pressure control and non-return valves to equalise pressures in the hot and cold water supplies to combination taps.[68]

3.6 Unit/Ward Design

Unit or ward design is important to minimise the opportunity for water distribution system contamination.

- Clinical hand wash sinks
  - Designers must achieve a balance between the provision of sufficient numbers of clinical hand wash sinks to encourage staff compliance with hand hygiene recommendations and the provision of an excessive number that will result in some water outlets being under-utilised. The greater the number of water outlets installed the greater the chance that there will be insufficient flow through some outlets with subsequent water stagnation and contamination of outlets and regions of the water distribution system near water outlets.[65, 66, 88] International evidence now recommends alcohol-based handrub (AHR) as an alternative to soap and water except when hands are visibly contaminated or after caring for a patient with suspected or confirmed *Clostridium difficile*.[90-94] A risk assessment should be undertaken to review the numbers and placements of clinical hand wash sinks.[66, 88]
  - Accessibility of clinical hand wash sinks: All clinical hand wash sinks should be readily accessible. If outlets are difficult to access they will be infrequently used resulting in insufficient water flow, stagnation of water and potential contamination of outlets and regions of the water distribution system near these outlets.
  - Splash containment: Contaminated water that is allowed to splash from outlets and sinks onto adjacent patient care areas can result in colonisation and infections in patients, as well as being a health and safety risk. This should be considered during the design phase. In existing facilities measures should be taken where necessary to prevent or contain splashes such as erecting a barrier between sinks and adjacent patient care or preparatory areas.[95] Splash containment is particularly important where flow straighteners and aerators have been removed as this may result in increased turbulence and pressure in the water flow.[87]
- Showers
  - Showers (excluding safety showers) should not be fitted where they are likely to be used less than once a week. In existing builds a risk assessment may indicate the need to remove some outlets.
  - Shower cubicle design should allow for adequate cleaning and not leak or accumulate water.
  - Safety and emergency showers should not be installed on the end of lines and should be flushed as per national guidelines for control of Legionellosis.[60]
- En-suite facilities
  - When designing en-suite facilities, sanitary assemblies should be sited in series with a toilet connected to the final element to ensure sufficient water throughput.
- When removing outlets the branch hot and cold water pipes should be removed back to the main distribution pipework to remove dead legs.[65]
- Portable cooling units / devices
  - Wet evaporative cooling systems and coolers, including portable devices, should not be used. If portable comfort cooling / room cooling devices are required a dry unit should be used. The Infection Prevention Control Team must be consulted before any such unit is procured or utilised.

3.7 Cleaning and Secondary Disinfection of Water Distribution Systems

Cleaning

Cleaning is a prerequisite for disinfection and must precede disinfection to remove biomass, deposits and other contaminating substances. The effectiveness of any disinfectant will be reduced in the presence of biofilm, chemical and inorganic deposits within the water distribution network and corrosion within the system. The frequency and method of routine cleaning should be identified during the risk assessment.

It is essential that there is a regular programme for cleaning and descaling, or replacement of water outlets, hoses and TMVs where there may be direct or indirect water contact with patients.[68] Manual cleaning of showerheads and hoses to remove scale and other deposits should be carried out at least quarterly and more frequently if required.[87] TMVs should be cleaned and descaled as per manufacturers' recommendations.[68] Water storage tanks and hot water calorifiers should be cleaned annually.

Secondary Disinfection

Secondary disinfection of water distribution systems is only part of an overall prevention and control strategy. Before any secondary disinfection method is considered, a risk assessment should be carried out to verify that there are no management processes or mechanical steps that can be taken regarding plant, equipment or pipework configuration that would avoid the need for a secondary disinfectant. Cleaning must precede disinfection.

The effects of disinfection methods on planktonic bacteria differ significantly to the effects on sessile bacteria contained within biofilms. It has been estimated that 95% of all microbial cells present in drinking water distribution systems exist within biofilms that are adherent to pipe surfaces. Only 5% exist in the water phase.[96] Every effort should be made to ensure that new water systems and equipment are supplied free of biofilm. Sustained eradication of biofilm in existing complex water systems is challenging.

The ideal disinfection method should achieve the following:

1. Inactivate microorganisms in circulating water
2. Control/prevent/remove biofilm and inactivate associated biofilm microorganisms
3. Have minimal adverse effects on the fabric of the water distribution network and be safe for human contact.

All biocidal products to be placed on the market in Ireland must be notified to the Department of Agriculture, Food and the Marine (DAFM) and if authorised a pesticide control service (PCS) number is issued. Only products with a PCS number can be legally placed on the Irish Market. Registers of notified and authorised biocidal products are published and updated by the DAFM on a regular basis. Readers should refer to Chapter 2, Section 2.6, and contact the Pesticide Registration and Control Division within the DAFM (http://www.pcs.agriculture.gov.ie/biocides.htm) if they require further information.

Selection of the appropriate secondary disinfection method will be directed by the findings of the risk assessment. Factors that influence selection are listed in Table 3.5. The chemical composition of source water should be fully evaluated prior to selection. Expert advice may be required when selecting a secondary disinfection method.

Table 3.5: Factors that influence selection of the appropriate secondary disinfection method for healthcare facilities

• Age of the building
• Layout of the water distribution system within the building
• Pipework and materials used in the water distribution system
• Uses of the building
• Patient risk groups and high risk units within the facility
• Source water characteristics
• Degree of existing contamination
• Need for systemic or focal disinfection
• Availability of sufficient technical support and maintenance capacity
• Availability and performance of dosing and monitoring equipment
• Cost-effectiveness

Secondary Disinfection Methods

A systematic review of scientific and grey literature from 1993-2013 was carried out to identify the main secondary disinfection methods used in healthcare facilities against water-borne organisms and biofilm (Table 3.6). The bulk of the literature was specific to the control of *Legionella* bacteria. Literature on effective disinfection methods against other waterborne organisms was limited and predominantly published during 2009-2013. Thus literature in this area should be reviewed periodically.

Table 3.6: Secondary disinfection methods applied to healthcare facility water distribution systems

Method	Disinfectant
Systemic continuous	Temperature control regime
	Chlorine dioxide
	Monochloramines
	Copper-silver ionisation
	Electrochemically activated water
Systemic intermittent	Thermal disinfection (Superheat and flush)
	Shock hyperchlorination
	Shock chlorine dioxide
	Silver catalysed hydrogen peroxide
Focal continuous	UV
	Ozone

Systemic disinfection methods aim to disinfect the entire distribution system including distal outlets. Focal disinfection methods disinfect only a portion of the distribution system acting at the point of application with no residual effect. Continuous secondary disinfection methods that may be employed in healthcare facilities may not respond effectively to sudden unanticipated significant contamination of the incoming water supply due to major disruptions or repairs. Key points with regard to disinfection methods are presented below and further detail is available in Appendix 3.

Systemic Continuous Methods

Temperature Control Regime

Water temperatures must be maintained within the recommended values.[68]

- Keep hot water hot and cold water cold
- Hot water should leave the calorifier above 60°C
- Hot water should not return to the calorifier below 50°C
- Circulate hot water in the system flow at 55°C
- Cold water should be stored and distributed below 20°C

Further detail on temperature control is available in Appendix 3. Achieving the temperatures listed above may not be sufficient to prevent water system contamination. There is evidence that microorganisms including *Pseudomonas aeruginosa*, NTM, *Amoebae, Sphingomona,* and *Novosphingobium* readily grow at temperatures below 20°C. Achieving more optimal temperatures than those currently recommended can be difficult and therefore an additional secondary disinfection method is often required.

Key points with regard to other methods are presented below and further detail is available in Appendix 3.

Chlorine dioxide (ClO_2)

Chlorine dioxide is a more effective disinfectant than chlorine [97-100] and can be used as both a continuous method and for remediation. It has greater microbiocidal activity and has a better ability to penetrate and remove biofilm.[98, 101] It is also less corrosive than chlorine.[102, 103] Chlorite is the main disinfection by-product (DBP) and is toxic to neonates if ingested.[104] No significant levels of trihalomethanes (THMs) are formed.[105] As a gas ClO_2 dissipates rapidly in the system, particularly the hot water system, and therefore it can be difficult to maintain an adequately high residual.[106] The concentration of ClO_2 at outlets should be at least 0.1 mg/L. There is evidence in the scientific literature that residual ClO_2 levels of greater than 0.2mg/L are required to gain effective control.[106-110] In Ireland there are no regulatory limits for the concentration of chlorine dioxide, chlorite or chlorate in drinking water.[48] The EPA in Ireland recommends application of WHO provisional individual guideline values of 0.7mg/L for both chlorite and chlorate.[104][iiii]

Monochloramines

Monochloramines are widely used in the US in municipal water supplies and a reduction in nosocomial Legionnaires' disease at the municipal level has been demonstrated.[111, 112] They are a cheaper alternative to chlorination and are effective against biofilm formation.[106] However evidence suggests that their spectrum of microbiocidal activity is narrower and the formation of DBPs and toxicity may limit their use.[113]

Copper-silver ionisation

Copper-silver ionisation is an effective method of controlling bacterial and biofilm contamination of water distribution systems. The 2014 Drinking Water Regulations (SI No 122 of 2014)[48] set a parametric value of 2.0mg/L copper for drinking water in Ireland. Ion concentrations, water pH and scaling must be regularly monitored. The cost-effectiveness of installing, operating and maintaining the system should be considered.

In accordance with Article 16(2) of Directive 98/8/EC,[114] a systematic examination of all active biocidal substances on the market was undertaken to determine whether or not these substances would be included in Annexes I, IA or IB of the Directive. With regard to the use of copper, or copper containing products, as biocidal products the ongoing use as PT2, PT5, or PT11 is permitted under the terms and conditions of a derogation granted by the EC [115] pending full approval. At the time of writing (February 2015) the evaluating Competent Authority was reviewing the requisite technical information.

[iiii] For information, in the UK drinking water quality regulations do not permit the combined concentration of ClO_2, chlorite and chlorate to exceed 0.5mg/ltr [Source = Water, England and Wales. The Water Supply (Water Quality) Regulations 2000 SI 2000 No. 3184 as amended by SI 2001/2885, SI 2002/2469, SI2005/2035 and SI 2007/2734]. The 4th edition of L8 (2014) recommends that where desired microbial control cannot be achieved without the combined total oxidant levels at the outlets exceeding 0.5 mg/l then the relevant outlets should be clearly labelled as unsuitable for drinking. [Source = Health and Safety Executive. Legionnaires' disease. Part 2: The control of *Legionella* bacteria in hot and cold water systems. HSG274 Part 2. HSE Books 2014]

Electrochemically activated water (ECA)

Electrolysis of aqueous sodium chloride (NaCl) solution results in the formation of sodium hypochlorite (NaOCl) / hypochlorous acid (HClO). On site generation of NaOCl avoids the need to handle toxic chlorine gas or the purchase of NaOCl which has a limited shelf-life. Research suggests that ECA solutions have greater antimicrobial efficacy than commercially available NaOCl and are effective at removing biofilm.[116]

Systemic Intermittent Methods

Thermal disinfection (superheat and flush) and shock hyperchlorination

Both are temporary measures that may be employed in limited circumstances such as:[68, 117]

- Prior to building occupancy
- When the water system or part of it has been substantially altered or entered for maintenance purposes in a manner that may lead to contamination
- During or following an outbreak or suspected outbreak of Legionnaires' disease or other waterborne micro-organism
- When environmental sampling shows an increase in colonisation.

These methods have no role in the ongoing prevention and control of water system contamination. Both methods are corrosive, in particular hyperchlorination. In addition, hyperchlorination can result in unacceptable levels of DBPs, particularly THMs.[118]

Silver catalysed hydrogen peroxide

This is a relatively new method which is being used in some healthcare facilities abroad. Intermittent doses on a shock basis at varying concentrations can be employed as a short term solution. It appears to be effective in removing biofilm.[87]

Focal Continuous Methods

Ultraviolet irradiation (UV)

UV is a relatively inexpensive supplemental method that is effective against a wide range of microorganisms. However, it is a focal method with no residual effect and little or no effect on established biofilm.[103, 119]

Ozone

Ozone is an effective but expensive focal disinfection method. Low water solubility, stability and inability to oxidise some organic compounds also restrict its application.[106] If used in the treatment of dialysis feed-water it must be removed by UV irradiation prior to use.[120, 121]

Other Method (No Longer Recommended)

Continuous chlorination

Continuous chlorination with traditional chlorine based chemicals (chlorine gas or liquid sodium hypochlorite) is no longer recommended due to the lack of efficacy, the corrosive effects on pipe work, poor penetration of chlorine into biofilm, chlorine resistance and the formation of THMs.[65, 68, 98, 103, 106, 122, 123]

3.8 Disposable Point-of-use Filters

Disposable point-of-use filters are attached to water outlets and act as a barrier to the passage of waterborne organisms at the point of water delivery.[103, 108, 124-126] They do not eradicate waterborne organisms. To be effective, the filter membrane must have a nominal pore size no greater than 0.2µm.[68, 125, 126] Where contamination of water or a water outlet has been identified they may allow for continuity of care in areas, especially areas where highly vulnerable patients are treated, e.g. burns units, transplant units, critical care units.[79, 103, 127] They should only be used whilst the source of contamination is being identified and rectified through engineering controls. Installation should be subject to a risk assessment, taking note of the reduced flow that will arise from increased resistance and the cost of installing and maintaining them. A risk assessment is also required prior to discontinuation of use.[87]

Disposable point-of-use filters are quick and easy to connect and exchange. However when connected to water outlets they can obstruct access to handwash basins resulting in splashes. Filters become occluded over time and must be changed regularly.[124, 126] They may also cause retrograde contamination of the distribution system.[68] Disposable point-of-use filters should be considered only as a temporary solution and complementary to a systemic disinfection modality.[65] Continuous long-term use of point-of-use filters is not recommended, except where there is no effective alternative.[68]

3.9 Water Quality in Specialist Units

This section refers readers to the existing guidelines on water quality for selected specialist units.

Endoscope Reprocessing Units

- HSE National Decontamination of Reusable Invasive Medical Devices Advisory Group. HSE standards and recommended practices for endoscope reprocessing units. Version 2.2, 2012.
- ISO 15883-4:2008 Requirements and tests for washer-disinfectors employing chemical disinfection for thermolabile endoscopes.
- Department of Health UK. Choice framework for local policy and procedures 01-06 (CFPP 01-06): Decontamination of flexible endoscopes, Parts 1-5. 2013.

Central Decontamination Unit (CDU)

- HSE National Decontamination of Reusable Invasive Medical Devices Advisory Group. HSE standards and recommended practices for Central Decontamination Units (CDUs). Version 2.0, 2011.

Hydrotherapy Units

- HPSC. National guidelines for the control of Legionellosis in Ireland, 2009. Report of Legionnaires' Disease Subcommittee of the Scientific Advisory Committee, 2009, Chapter 8, Section 8.5.
- WHO. Guidelines for safe recreational water environments. Volume 2: swimming pools and similar environments. 2006.
- Public Health Laboratory Service (PHLS). Hygiene for hydrotherapy pools. 2nd Ed, 1999.
- Pool Water Treatment Advisory Group (PWTAG). Swimming pool water: treatment and quality standards for pools and spas. 2nd Ed, 2009.
- PWTAG. Code of practice 1.13: the management and treatment of swimming pool water. 2013.

Dental Units

- HPSC. National guidelines for the control of Legionellosis in Ireland, 2009. Report of Legionnaires' Disease Subcommittee of the Scientific Advisory Committee, 2009, Chapter 8, Section 8.3.
- Department of Health, UK, Estates and Facilities Division. Health Technical Memorandum 01-05: Decontamination in primary care dental practices. 2nd Ed, 2013

Renal Dialysis Units

Currently there are no national guidelines on water safety and quality for renal dialysis units (RDU). To maintain acceptable water quality, a RDU should implement a formal quality management system for its water treatment and distribution system. It is recommended that the senior clinician in charge of a RDU is responsible for the overall clinical governance of the water treatment facility for the unit.[128] A list of relevant international guidelines and standards are provided in Appendix 2.

Chapter 4A: Infection Prevention & Control

KEY RECOMMENDATIONS

- The healthcare facility manager must ensure that the recommendations in this guidance document are implemented in their institution.
- Prevention and control of water related HCAI requires a multidisciplinary approach and must be monitored by the environmental monitoring committee or equivalent.
- Clinical areas where patients may be at increased risk of waterborne infection must be identified within each healthcare facility by the environmental monitoring committee or equivalent.
- Healthcare providers should be aware of the potential risk of HCAI from water sources and water outlets. In order to mitigate many of the infectious risks associated with water, all healthcare workers must adhere to the HIQA National Standards for the Prevention and Control of Healthcare Associated Infections (2009) and the National Guidelines for the Control of Legionellosis in Ireland (2009).
- A culture of adherence to hand hygiene should be embedded in all healthcare institutions. The healthcare facility manager must ensure that staff have access to appropriate hand hygiene facilities and that regular hand hygiene audits are performed, reported and actioned.
- The healthcare facility manager must ensure that clinical hand wash sinks should be dedicated for the purposes of hand washing only and that alternative sinks and sluices are available for other purposes.
- Household/cleaning staff must clean clinical hand wash sinks in a manner that minimises the risk of contamination of the tap from organisms in the basin trap.
- The augmented care unit manager must ensure that water outlets in augmented care units that are not used frequently each day are flushed on a daily basis.
- The Infection prevention and control team must monitor clinical isolates of *Pseudomonas aeruginosa* from augmented care units and all clinical isolates of *Legionella* species as alert organisms.
- The Infection prevention and control team must have an active surveillance programme in place in each healthcare facility to detect alert organisms, clusters of infection, outbreaks, unexpected antimicrobial resistance mechanisms and unexpected infections.
- If an outbreak is suspected, an outbreak control team (OCT) with multi-disciplinary representation should be established by the healthcare facility manager.

NEONATAL UNITS

- Infants born at extreme prematurity (less than 28 weeks gestation) may have fragile skin which may breakdown easily during the early days of life; these infants are usually placed in a humidified incubator. Clinical staff must use sterile water or saline for washing non-intact or fragile skin, including during nappy change.
- Clinical staff may use tap water for bathing other high risk infants with intact skin, who do not require placement in a humidified incubator, provided there are no current clinical incidents suggesting water system contamination. However, if surveillance of infection identifies an outbreak or increased incidence of infection with water-borne organisms, clinical staff should use sterile water for bathing high risk infants (such as <1500g weight, central vascular catheter, endotracheal intubation or other invasive device) until an infection control investigation and water testing concludes that tap water is safe for bathing.
- Clinical staff should use tap water for washing neonates with normal healthy skin without invasive devices.
- The neonatal unit manager must ensure that when an incubator is being humidified, a sterile water reservoir and sterile water must be used. The reservoir and water must be changed daily. A re-usable reservoir must be cleaned and sterilised between uses in a central decontamination unit.
- The ward manager must ensure that frozen breast milk must never be defrosted by placing the container in tap water, unless the tap water has been boiled first. Breast or formula milk must never be warmed by placing the container in tap water, unless the tap water has been boiled first.

Healthcare providers should be aware of the potential risk of HCAI from water sources and water outlets.[77, 129] Many of the infectious risks associated with water can be mitigated by adhering to national infection prevention and control standards.[58, 60] Specific recommendations to further minimise risk associated with water are identified and discussed in this document. These recommendations may apply to certain healthcare roles, healthcare facilities, practices and procedures, augmented care units and in the event of an outbreak associated with a potential water-borne source. This Chapter is divided into recommendations for: (A) all healthcare facilities, (B) additional recommendations for augmented care units and (C) management of an outbreak.

4.1 Governance Structures

4.1.1 Healthcare Facility Manager/Person with Corporate Responsibility

The Healthcare facility manager has overall responsibility for ensuring that the recommendations in this guidance document are implemented in their institution. Healthcare facility managers must ensure that healthcare institutions adhere to relevant national guidance including National Guidelines for the Control of Legionellosis in Ireland (2009) and National Standards for the Prevention and Control of Healthcare Associated Infections (2009).

Healthcare facility managers must ensure that sufficient and appropriate hand hygiene facilities are available in all clinical areas. Healthcare facility managers must ensure that hand washing facilities comply with the National Guidelines for Hand Hygiene in Irish Healthcare Settings.[90] The UK document Health Building Note 00-10 Part C-Sanitary assemblies, provides detailed requirements for clinical hand wash sinks.[130]

The Healthcare facility manager must ensure that an outbreak control committee is established promptly when necessary. See Chapter 4C: Management of an Outbreak, for further information.

4.1.2 Environment Monitoring Committee

An environmental monitoring committee (EMC) or equivalent committee must be in place in each healthcare facility. The EMC should be chaired by the healthcare facility manager or a representative from the senior management team of the institution. The EMC is a multi-disciplinary committee which is responsible for, *inter alia,* the programme to prevent and control water-associated healthcare infection, including review of local surveillance data, approving the flushing programme and annual risk assessment. Clinical areas where patients may be at increased risk of water-associated infection should be identified within each healthcare facility (see Table 4.2 in Chapter 4B: infection prevention and control in augmented care units). Additional information on the EMC is available in the National Guidelines for the Control of Legionellosis in Ireland (2009) Chapter 8: *Legionella* in Specific Risk Settings. [61]

4.2 Hand Hygiene

Microorganisms may be transmitted to a patient from an environmental source or from another patient via the hands of healthcare workers. All healthcare workers must adhere to the World Health Organization (WHO) 5 moments for hand hygiene and comply with the Guidelines for Hand Hygiene in Irish Health Care Settings.[90, 131] A culture of adherence to hand hygiene must be embedded in all healthcare institutions.

Due to the association between hand hygiene dispensers and outbreaks, empty containers of liquid soap, foam soap, hand disinfectant, alcohol gel and alcohol-based handrub products should be discarded after use and must never be topped-up.[121]

4.3 Water Outlets

Ensure regular documented cleaning, decontamination and maintenance schedule for all water outlets, including shower heads.[60]

4.3.1 Hand Hygiene Facilities

The distal ends of a water system, including clinical hand wash sinks, can be reservoirs and disseminators of *Pseudomonas aeruginosa* and other gram negative species.[116] There is evidence of transmission of *Pseudomonas aeruginosa* from water systems to patients and vice versa.[77] Sinks must be cleaned in a manner that minimises the risk of contamination of the tap from organisms in the basin trap (see Appendix 4). Clinical hand wash sinks must have a regular documented maintenance and cleaning schedule.

Table 4.1. Use of Clinical Hand Wash Sinks

Clinical hand wash sinks should only be used for the purposes of hand washing
• Signage should be in place to communicate this instruction • Clinical hand wash sinks must not be used for the disposal of any fluids including body fluids; use the dirty utility area / sluice room for this purpose • Clinical hand wash sinks must not be used for the disposal of medications or nutritional feeds including breast and formula milk • Clinical hand wash sinks must not be used for cleaning equipment • Clinical hand wash sinks must not be used for storing equipment or other unnecessary items

Clinical hand wash sinks should be sufficient in number and location to facilitate staff adherence to hand hygiene and sufficient in size to prevent splashing of the surrounding area. See Chapter 3 for specific design recommendations. Healthcare staff should be aware of current concerns regarding non-touch / infra-red / sensor taps especially when placed in augmented care units, as discussed in Chapter 3 Section 3.5, Water Systems Design, Fixtures and Fittings: Taps.[132]

4.3.2 Flushing

Healthcare staff should be aware that under-utilised outlets may increase the risk of water stagnation and subsequent contamination. The EMC and the Unit/Ward clinical manager must ensure that all infrequently used outlets are flushed at least once per week in accordance with National Guidelines for the Control of Legionellosis in Ireland (2009).[60] Outlets in augmented care units that are not in frequent daily use must be flushed on a daily basis.[64, 88] See Appendix 5 for flushing recommendations.

See Chapter 3 Section 3.6, Unit / Ward Design for discussion regarding the optimal number of clinical hand wash sinks. Specific guidance on the number of clinical hand wash sinks in different healthcare areas will be recommended in the next revision of the Guidelines for Hand Hygiene in Irish Healthcare Settings 2015.

4.3.3 Ice-Making Machines, Bottled Water Coolers, Plumbed-In Water Coolers and Water Fountains

Ice-making machines have occasionally been implicated in healthcare associated infection.[133] When ice is required, use an automatic dispenser and avoid open chest storage compartment.[123] See Chapter 4B regarding use of ice for high-risk patients.

The microbiological quality of potable mains water (drinking water) supplied to plumbed-in water coolers and water fountains that are connected to mains water can deteriorate rapidly. Deterioration in water quality may occur due to stagnation or to biofilm formation in taps, filters and/or drip trays, especially if taps are manufactured from plastic. All ice and drinking water units should be subject to routine cleaning and disinfection to minimise potential infectious risks to patients, healthcare staff, visitors and other individuals and to ensure output water is of potable quality. The external surfaces and dispensing taps must be cleaned frequently, according to local policy. The critical internal water-contact areas must be cleaned and disinfected regularly (at least monthly in healthcare settings) including the internal water reservoir or chill-tank, the waterways and the dispensing taps. Ensure that regular cleaning, disinfection, servicing and maintenance is in accordance with locally agreed policy and international standards and guidelines.[134, 135]

4.3.4 Decorative Water Features

Decorative water features have been associated with outbreaks of Legionnaires' disease and other healthcare associated infections.[136-138] Such decorative features pose unwarranted risks in any healthcare setting and should never be installed in any area of a healthcare facility.

Healthcare facilities with existing decorative water features in non-clinical areas should regularly test and maintain the feature according to National and International Standards. The Environmental Monitoring Committee must have oversight of water test and maintenance results.

4.4 Clinical Procedures

Use of Water for Patient Care Activities

Tap water may be used for patient washing and bathing in general healthcare units and for all patients in adult and paediatric augmented care units. For neonates in augmented care units see specific guidance in Chapter 4B under 'Neonatal Units'.

- Sterile solutions should be used for cleaning non-intact skin and mucous membranes with the exception of chronic leg ulcers[139]
- Sterile water must be used when water is required for administering any medication or treatment requiring water e.g. intravenous medications, nebulisers
- Powdered infant formula feeds should be prepared using potable (drinking) water and in accordance with the manufacturer's instructions (reference: Guidance Note No. 22. Information Relevant to the Development of Guidance Material for the Safe Feeding of Reconstituted Powdered Infant Formula (2012; Revision 2). Food Safety Authority of Ireland.)

Insertion and Maintenance of Invasive devices

Clinical healthcare workers must use an aseptic non-touch technique for insertion of all invasive devices. Clinical healthcare workers must adhere to relevant national guidelines including:

- Prevention of intravascular catheter-related infection in Ireland (2009). SARI sub-committee (http://www.hpsc.ie/Publications/)[140]
- Guidelines for the Prevention of Catheter-Associated Urinary Tract Infection (2011). SARI sub-committee (http://www.hpsc.ie/Publications/)[141]
- Guidelines for the prevention of ventilator associated pneumonia in adults in Ireland (2011). SARI working group (http://www.hpsc.ie/Publications/)[142]

4.5 Equipment and Environment

Cleaning and Decontamination of Re-usable Invasive Medical Devices

Single use items must never be re-used.[143, 144] Ensure compliance with Health Service Executive (HSE) (2007) *Code of Practice for Decontamination of Reusable Invasive Medical Devices.*[34]

Endoscopy Units and Endoscopy Washer Disinfectors (EWD)

Flexible endoscopes, due to their fragility, will not withstand standard thermal disinfection. Therefore chemical disinfection is utilised when reprocessing a flexible endoscope, most commonly in a washer disinfector. Cases of healthcare associated infection, outbreaks and pseudo-outbreaks have been reported following inadequate cleaning and disinfection of the endoscope, particularly relating to the air, water and biopsy channels.[145, 146] The final rinse water used to remove all traces of disinfectant from the endoscope following decontamination has also been associated with cases of healthcare associated infection, outbreaks and pseudo-outbreaks.[147-149] The final rinse water utilised should comply with stringent microbiological controls. Periodic testing of the final rinse water is required and remedial actions should be triggered by non-conforming results.[35, 36, 150]

Water for Haemodialysis

Haemodialysis requires water of an appropriate quality in the preparation of dialysis fluid. This is to protect haemodialysis patients from adverse effects from chemical or microbiological contamination in the water or improperly prepared dialysis fluid. Water treatment facilities for haemodialysis in healthcare facilities need an associated quality system that accounts for governance, planning, commissioning, installation, operation, maintenance, and water monitoring.[128, 151-155]

Dental Chair Unit Water

Dental chair units are equipped with intricate looms of narrow bore waterlines that are particularly prone to bacterial biofilm contamination. This water is aerosolised by high-speed dental instruments and ultrasonic scalers, thus exposing patients and dental healthcare staff to aerosolised microbial contaminants and bacterial endotoxins.[156, 157] There is no specific Irish or European legislation that regulates the quality of dental waterline output water. However,

dental waterlines should be disinfected regularly or continuously with a chemical disinfectant/agent that effectively eliminates waterline biofilm and provides good quality output water.[5, 60]

Therapeutic Pools e.g. Hydrotherapy and Birthing Pools
Therapeutic pools used in healthcare facilities need to be formally managed to ensure that patients utilising these facilities are not exposed to potential pathogens and avoid acquiring a healthcare associated infection. This is achieved by regular maintenance, chemical disinfection and periodic water quality monitoring.[158]

Environmental Hygiene
Ensure compliance with National Cleaning Standards Manual (HSE, 2006).[159] Disposable colour coded items should be used where possible. Contamination of cleaning products, after they have been opened and are in use, has been linked to outbreaks; empty containers should be discarded after use and must never be topped-up.[160, 161]

When cleaning sinks, the taps (faucets) should be cleaned first, followed by the sink and lastly the drain. See the sink cleaning protocol template in Appendix 4.

Cleaning and Decontamination of Healthcare Equipment
Do not wash any patient equipment in clinical hand wash sinks. Healthcare equipment (non-invasive) should be cleaned, decontaminated, dried and stored in accordance with local policy and based on manufacturer's instructions.

4.6 Surveillance of Infection

See Chapter 2 regarding mandatory notification of infectious diseases in accordance with legislation. The infection prevention and control team must ensure that an active surveillance programme is in place in each healthcare facility to detect alert organisms, clusters of infection, outbreaks, unexpected antimicrobial resistance mechanisms and unexpected infections.

Each acute healthcare facility and each microbiology laboratory is strongly recommended to participate in the European Antimicrobial Resistance Surveillance Network (EARS-Net) which includes surveillance of invasive *Pseudomonas aeruginosa* infection.[162]

Chapter 4B: Infection Prevention and Control in Augmented Care Units

Patients in augmented care units (see Table 4.2) are at increased risk of infection with *Pseudomonas aeruginosa* and other related organisms.[1-3, 6, 163] These infections include intravascular catheter associated infection, ventilator associated pneumonia, sepsis, urinary tract infection and skin and soft tissue infection.[164] The distal ends of water outlets have been identified as a reservoir for *Pseudomonas aeruginosa* and have been linked through molecular typing to high-risk patient clinical infections.[10, 89, 165, 166] Additional control measures and risk assessment are required for patients who are at increased risk for such infections.

Table 4.2: Clinical settings where patients are high-risk for waterborne infections

Augmented Care Units (ACU's)	Additional clinical settings, based on local risk assessment, that should be included as an augmented care setting for the purposes of this document
All Intensive Care Units including adult, paediatric and neonatal Neonatal High Dependency Units (level 2 neonatal unit) Burns units Transplant units	Profoundly immunosuppressed patients as a result of disease or therapy, including malignancy and recent major surgery Patients with extensive breaches in dermal integrity Other patients as determined by local risk assessment

Patients with cystic fibrosis invariably become colonised with *Pseudomonas aeruginosa* and may develop infections with a wide variety of organisms that may be found in water such as *Stenotrophomonas maltophilia* and *Burkholderia cepacia.* In the main, the presence of these organisms is related to the patient's underlying disease rather than exposure to potentially contaminated water sources. Therefore, patients with cystic fibrosis are not considered high-risk for the purpose of this guidance.

Renal patients undergoing dialysis have traditionally been considered at-risk for *Pseudomonas aeruginosa* and related infections. However, recent enhanced surveillance of invasive *Pseudomonas aeruginosa* infection in Ireland has found that only 1% of cases are associated with haemodialysis. Therefore, haemodialysis units will not be considered an augmented care setting for the purpose of this document.[164] However, if a renal unit identifies water-borne infections as a risk in their institution, then it is appropriate that the renal unit be considered an ACU for the purpose of this guidance.

4.7 Flushing in Augmented Care

All water outlets in augmented care units should be in-use multiple times per day. Any water outlet that may not be in frequent daily use should be identified by the unit manager and those outlets must be flushed on a daily basis. Examples of infrequently used outlets may include single en-suite rooms and temporarily closed wards or departments. Outlets that require routine flushing must be documented. Records of flushing must be stored for at least 1 year. See Appendix 5 for Flushing Protocol. The EMC must ensure that regular audit of flushing is performed, documented and actioned.

4.8 Use of Water for Patient Care Activities in Augmented Care

Tap water may be used for washing adult or paediatric patients in augmented care units, provided there are no current clinical incidents suggesting water system contamination. Care must be taken during bathing to prevent contamination of invasive devices, as outbreaks of bacteraemia have been described in critical care units following exposure of central vascular catheters to hospital water supply during bathing.[167, 168] For neonates in augmented care units see specific guidance in this Chapter under 4.9 Neonatal Units.
Potable mains water may be used for drinking, provided there are no current incidents suggesting water system

contamination. Caution is advised when considering water coolers for patient use in high risk areas. Deterioration in water quality may occur due to stagnation or to biofilm formation in taps, filters and/or drip trays, especially if taps are manufactured from plastic.

Ice is not recommended for use in augmented care units and for patients who are at high risk of water-borne infections. Use of ice has been associated with rare but important infections, outbreaks and pseudo-outbreaks.[169-171] On occasion, ice may be used for high risk patients when the clinical benefit of using the ice outweighs the risk. In such circumstances, ice should only be used under senior medical instruction.[88]

With respect to the humidifiers in ventilator circuits and continuous positive airway pressure (CPAP) circuits, sterile water must be used.

4.9 Neonatal Units

Invasive *Pseudomonas aeruginosa* infection in neonatal patients has been linked to contaminated water.[84, 172] Neonates <1500g are particularly vulnerable to such infections, especially if they are placed in a humidified incubator or if they have an invasive device in-situ such as an endotracheal tube or a central vascular catheter. Invasive *Pseudomonas aeruginosa* infection in very low birth weight infants is often associated with a high mortality.[173] Fortunately, such infections are uncommon in infants in the first few months of life. There were two cases of invasive *Pseudomonas aeruginosa* infections reported in infants less than 1 month of age in 2014, from a total of 182 cases reported nationally (see Chapter 1).

Bathing / Washing

The type and frequency of washing (e.g. nappy change, top and tail, bed bath or immersion bath) is determined by the clinical team caring for the infant.

- Infants born at extreme prematurity (less than 28 weeks gestation) may have fragile skin which may breakdown easily during the early days of life; these infants are usually placed in a humidified incubator. Sterile water or saline must be used for washing non-intact skin, including during nappy change.
- Tap water may be used for bathing high risk infants with intact skin, who are not placed in humidified incubators, such as infants <1500g birth weight with central vascular catheters, endotracheal intubation or the presence of other invasive devices, provided there are no current clinical incidents suggesting water system contamination.[88] However, if surveillance of infection identifies an outbreak or increased incidence of infection with water-borne organisms, sterile water should be used for bathing high risk infants until an infection control investigation and water testing concludes that tap water is safe for bathing.
- Washing with tap water is indicated for neonates with normal healthy skin without invasive devices.

Incubators

Humidified incubators may be provided for infants less than 28 weeks gestation or birth weight less than one kilogram in order to maintain their body temperature and to reduce fluid loss. These incubators present a potential risk to the occupant for water-associated infection, especially *Pseudomonas aeruginosa*. The neonatal unit manager must ensure that when an incubator is being humidified, a sterile water reservoir and sterile water is used. The reservoir and water must be changed daily. A re-usable reservoir must be cleaned and sterilised between uses in a central decontamination unit.

Non-humidified incubators present a lower risk to the occupant from water-associated infection. All incubators should be regularly cleaned and decontaminated by trained competent personnel (once or twice weekly depending on patient risk and between each patient use). The incubator must be completely dismantled, cleaned, decontaminated and dried before using again as per local agreed procedure. The serial number of the incubator must be recorded. There is no requirement to use sterile water to clean incubators.[88] Tap water and detergent may be used. The critical factor is thorough drying of all parts of the incubator and mattress before use.

Therapeutic Cooling

A closed system must be used for infants that require cooling. Sterile water must be used in the system. There should be no direct contact between the infant and the water. Ice or ice packs must not be used for passive or therapeutic cooling.

Infant Feeds

If breast milk is not used to feed an infant, sterile ready-to-feed formulas are recommended for infants in the majority of healthcare institutions. However, ready-to-feed formula may not be available for all specialised feeds. If a powdered infant formula feed is required, it should be prepared using boiled potable (drinking) water and in accordance with the manufacturer's instructions.[174]

Frozen breast milk may be defrosted safely using one of the following methods:

- Defrost using a warming/thawing device designed to ensure no direct contact with the syringe/bottle and non-sterile water
- Defrost in a designated milk fridge
- Defrost at room temperature and discard any unused milk

Frozen breast milk must never be defrosted by placing the container in tap water, unless the tap water has been boiled first.[81, 88]

Breast or formula milk may be warmed safely using one of the following methods:

- Use a warming device designed to ensure no direct contact with syringe/bottle and non-sterile water
- Remove from fridge one hour before use
- Use warmed sterile water

Breast or formula milk must never be warmed by placing the container in tap water, unless the tap water has been boiled first.[88]

4.10 Surveillance of Infection in Augmented Care Units

Infection prevention and control teams must ensure that high-risk units have an ongoing surveillance system in place whereby unusual clusters of colonisation/infection due to *Pseudomonas aeruginosa* and other related gram negative water-associated organisms (including those due to potential environmental sources) are detected in a timely fashion. Clinical isolates of *Pseudomonas aeruginosa* from augmented care units and all clinical isolates of *Legionella* species should be monitored as alert organisms.[81, 88]

If such a surveillance system is not already in place, high-risk units should perform a retrospective review of invasive infections to ensure that there has been no recent episode(s) of potential outbreak. Ensure full and appropriate investigation of any such outbreak(s), including a risk assessment of water as a potential source.

4.11 Water Testing

Monitoring of water supplying an augmented care unit for *Pseudomonas aeruginosa* may be required, based on risk assessment.[88] Water testing is recommended during an outbreak or if surveillance identifies an increased incidence of infection. Water testing may also be indicated following a single invasive *Pseudomonas aeruginosa* infection, if the organism is an unusual pathogen in the augmented care unit. Furthermore, evidence suggests that there is a greater risk of the internal surfaces and components of non-touch or sensor taps becoming contaminated with micro-organisms and biofilm in comparison to manually operated taps. Therefore, water testing may be considered by the environmental monitoring committee for augmented care units with sensor taps. See chapter 5 regarding water testing.

4.12 Risk Assessment in Augmented Care Units

A risk assessment should be undertaken in augmented care units to mitigate risk and to minimise exposure of patients to contaminated water. The environmental monitoring committee or equivalent committee must ensure a safe water system (see Chapter 3), appropriate materials, fixtures and fittings for all water outlets (see Chapter 3) and documented flushing of infrequently used outlets (Appendix 5). Furthermore, the infection prevention and control team must ensure timely surveillance of water-associated infection; that infection prevention and control policies are in place and infection prevention and control audits are conducted. If surveillance of infection indicates a possible outbreak, this should be thoroughly investigated by an outbreak control team including obtaining water samples for testing (see Chapter 5). Appropriate corrective actions and preventive actions should be agreed.

Chapter 4C: Management of an Outbreak

An outbreak is suspected when two or more patients with invasive infections are epidemiologically linked. In certain clinical circumstances an outbreak may be declared following a single invasive case e.g. multi-drug resistant *Pseudomonas aeruginosa* or healthcare associated Legionnaires' disease.[60] An outbreak control team (OCT) with multi-disciplinary representation should be established by the healthcare facility manager.[175]

Table 4.3: Outbreak Control Team (OCT) Membership

Senior clinical staff from affected area(s)
Hospital management
Nursing/Midwifery management
Infection prevention and control
Engineering/facilities/estates
Clinical microbiology consultant / Infectious diseases consultant
Specialist in Public Health Medicine
Household / hygiene manager
Risk Manager
Principal Environmental Health Officer (as required)
Health and Safety Manager (as required)
Press Officer (as required)

The Director of Public Health should be informed of the outbreak. Public health may be part of the OCT particularly when more than one institution is involved or if there has been transmission to/from the community.

Initial Investigation of the Outbreak

The OCT must investigate the potential outbreak by careful assessment of all the epidemiological, microbiological and environmental information available.[176]

Table 4.4. Preliminary Investigation of an Outbreak

Date of onset of symptoms in index case
Date of onset of symptoms in subsequent infected cases (symptomatic cases)
Type of infection(s)
Risk factors for infection including invasive device(s), surgery or other medical procedure(s)
Patient morbidity and mortality
Identification of colonised cases (asymptomatic cases)
Consider look-back for recent laboratory confirmed cases
All affected patients' entire inpatient and outpatient journey including
Unit, ward and bed locations
Staff contact(s)

Initial Management of the Outbreak

Isolation

- All neonatal cases, both infected and colonised infants, should be isolated individually or cohorted together. Adult and older paediatric cases may be isolated or cohorted together if advised by the infection prevention and control team.
- Strongly consider temporary closure of the affected area(s) if the outbreak is associated with high morbidity or mortality or the organism is a multi-drug resistant organism that is not endemic in your institution.
- Timely communication with patients and parents/guardians of paediatric patients is essential, particularly regarding whether they have an infection or are colonised.

Screening: patients, staff, environment and water testing

- Patients that have been in close contact with cases should be screened. Communicate with other institutions if contacts of affected cases were transferred prior to screening. The infection control team will advise on the appropriate specimens for screening for the specific outbreak organism.
- The environment in the affected area(s) may be implicated in the outbreak or may be heavily contaminated.[177, 178] Consider obtaining swabs and specimens from environmental sites prior to cleaning.

Table 4.5. Suggested Environmental Sites for Screening

Sites	Examples
Moist areas	Sinks and drains Taps/faucets Showers and showerheads Baths Sluices
Frequently touched items	Keyboards Telephones Light switches Door handles Infusion pumps Ventilator equipment
Devices used on more than one patient	Blood pressure cuffs Thermometers Stethoscopes Commodes Point-of-care testing machines Portable radiology machines Breast pumps
Water	See Chapter 5 for water testing

- The infection prevention and control team should advise the occupational health department if staff screening is necessary. Staff screening is usually not required for water-associated infections.

Control Measures

- Inform staff of the outbreak and emphasise the importance of hand hygiene.
- There should be a thorough deep-clean and chlorine disinfection in the affected area(s), paying particular attention to moist areas, sinks and taps, frequently touched items and devices used on more than one patient.
- Sterile water may be considered for washing high risk patients until the results of water testing exclude tap water as the likely source of the outbreak. High risk patients include infants <1500g birth weight with a central venous catheter, endotracheal tubes or other invasive device in place. Following consultation with the infection control team at-risk patients in augmented care units, burns units or other high risk patients may also require washing with sterile water.

- If water from outlets is suspected or confirmed as the source of infection, consider immediate corrective measures such as use of alcohol gels after handwashing or temporary placement of point-of-use filters[125] and using sterile water in place of tap water for at-risk patients and/or their environment.
- Preventive engineering measures must be prioritised immediately. See Chapter 3 regarding preventive measures.

Communications Strategy

- Agree a communications strategy to provide clear, consistent and accurate information and to keep relevant persons appropriately informed e.g. affected patients and their parents/guardians, management, staff in the affected area(s), Director of Public Health, the general public and the media, as required.

Follow-Up Investigation

- Investigate any change in practice, product or fixture that may have caused or be implicated in the outbreak.
- Review potential risks associated with the water system in the affected area(s)
- Review potential risks associated with the use of invasive devices in the affected area(s)
- Review potential risks associated with the use of all water in the affected area(s) including humidified incubators, incubators, ventilators, nebulisers, medications, enteral feeds, ice, drinking water, bathing, hand hygiene etc.
- Review occupancy levels and nurse to patient ratios.
- Review space between beds/cots/incubators and investigate whether overcrowding may be associated with the outbreak.
- If a source has not been identified after the initial descriptive investigation, consider an analytical study such as a case-control study.

Follow-Up Measures

- Provide support, advice and guidance to individuals directly involved.
- Review patient, environmental and water screening results.
- Type organisms and store for possible future tests.
- Monitor effectiveness of control measures and ensure that preventive actions take place as soon as possible.
- Declare the outbreak over when it is safe to resume normal services
- Debrief all staff involved.
- Produce a final report on the outbreak.

Chapter 5: Microbiological Parameters

KEY RECOMMENDATIONS

- The microbiological examination of water from the healthcare facility environment is necessary both in the routine monitoring of decontamination procedures and in the investigation of contamination incidents and outbreaks of healthcare associated infection.
- Sampling should be undertaken by staff trained in the appropriate technique for taking water samples including the use of aseptic technique to minimise extraneous contamination.
- Pre-flush and post-flush water samples may be indicated depending on the nature of the outbreak and/or the purpose of the sampling. If contamination is detected, compare the pre- and post-flush bacterial counts. A substantially higher bacterial count in the pre-flush sample, compared with the post-flush, should direct remedial measures towards the tap and associated pipework and fittings near to that outlet. A higher bacterial count in the post-flush sample than in the pre-flush sample suggests stagnation in the water system and inadequate flushing. A similar bacterial count in pre-flush and post-flush samples indicates that attention should focus on the whole water supply, storage and distribution system.
- All laboratories carrying out environmental water testing should be accredited for the methods used and participate in appropriate external proficiency schemes.
- Laboratory testing requirements for different water samples and interpretation of results must be in accordance with international standards.

Introduction

The microbiological examination of water from the healthcare facility environment is necessary both in the routine monitoring of decontamination procedures within the healthcare facility and in the investigation of contamination incidents and outbreaks of healthcare associated infection. For example, regular monitoring of the microbiological quality of renal dialysis water, hydrotherapy water and endoscopy rinse water plays an important role in protecting patients from exposure to potentially infectious waterborne microorganisms. Similarly, microbiological testing of the water system at defined intervals for *Legionella* species helps to ensure that healthcare facilities' water system is well controlled and that water used for the care and management of patients does not pose a risk to those patients and/or staff. Monitoring of water supplying augmented care units for *Pseudomonas aeruginosa* may be required based on risk assessment.

Patients and staff of the healthcare facility may also be exposed to potential infectious risks from drinking water which should be examined for potable quality.

In recent years drinking water in many healthcare facilities is provided by way of bottled water via dispensers or cooled/chilled and/or filtered water supplied with mains water. The quality of water for human consumption is regulated by the European Union (Drinking Water) Regulations 2014 and European Communities (Natural Mineral Waters, Spring Waters and Other Waters in Bottles or Containers) Regulations 2007 and the corresponding Irish legislation (i.e. SI No. 122 of 2014 and SI No. 225 of 2007). Concerns have been raised over the quality of water from water dispensers, coolers and filtered water units due to their potential to transmit infection, especially to immunocompromised individuals. Water dispensers, water coolers and filtered water units can themselves act as reservoirs of contamination of output water intended for human consumption if the equipment is not well maintained and subjected to regular planned preventative cleaning and maintenance. Consideration should also be given to the frequency of use of water dispensers and coolers and their location. Poorly maintained and infrequently used water dispensers, water coolers and filtered water units maybe particularly problematic due to water stagnation and environmental heat gain depending on their physical location. Water dispenser, water cooler or filtered water unit taps and associated pipe work are frequently manufactured from plastic materials, which are particularly prone to microbial biofilm contamination. These units and the water they provide should be subject to periodic microbiological testing to ensure good water quality.

The microbiological examinations required for the different water sources in the healthcare facility environment are listed in Table 5.1. These examinations are referenced against the relevant national guideline or directive and the international standard methods on which the microbiological testing should be based.

Table 5.1: Microbiology Testing for Water Systems in the Health Care Environment

Water Type/System	Target Organism/Parameter	Testing Frequency
Potable Water [47, 179-184]	Enumeration of total coliforms and *Escherichia coli* Further parameters may be required as determined by the supervisory authority or local risk assessment: Total colony count at 22°C Enumeration of enterococci Enumeration of *Clostridium perfringens*	Audit monitoring
Healthcare facility hot and cold water system in augmented care units [64, 185]	Isolation and enumeration *Pseudomonas aeruginosa*	Requirement for testing is determined by risk assessment and in accordance with recommendation in Chapter 4B of this guideline
Healthcare facility hot and cold water system[186-188]	*Legionella* species	Frequency is determined by risk assessment and in accordance with National Guidelines for the Control of Legionellosis in Ireland (2009). HPSC.[60] Two to 14 samples should be obtained, depending on the overall number of outlets
Bottled and Mineral Water[49, 179, 181-183, 185] (Natural Mineral waters, spring Waters and other waters in Bottles or containers)	Enumeration of coliforms and *E. coli* Enumeration of enterococci Enumeration of *Pseudomonas aeruginosa* Enumeration of sulphite reducing anaerobes Total colony counts	Frequency is determined by risk assessment
Bottled water dispensers, and mains supplied water coolers/ filtered water units	Total viable bacteria count Enumeration of *Pseudomonas aeruginosa* Enumeration of coliforms and *E. coli* Enumeration of enterococci	Frequency is determined by risk assessment
Endoscopy rinse water[36, 185, 189]	Total viable bacteria count Enumeration of *Pseudomonas aeruginosa* Detection and enumeration of *Mycobacterium* species in endoscopy waters	In accordance with HSE Standards and Recommended Practices for Endoscope Reprocessing Units. (2012).[150]
Dialysis water[153]	Total viable bacteria count	In accordance with ISO 13959:2009[153]

Water Type/System	Target Organism/Parameter	Testing Frequency
Hydrotherapy/Spa Pool Water[181, 185]	Enumeration of coliforms and *E. coli* Enumeration of *Pseudomonas aeruginosa* Total colony counts	Weekly for hydrotherapy pool water
Dental chair unit waterline output water[5, 60, 157, 186, 187, 190-193]	Total viable aerobic heterotrophic bacterial count on R2A agar at 20-22°C after 7-10 days. *Legionella* species	Frequency is determined by risk assessment and in accordance with National Guidelines for the Control of Legionellosis in Ireland (2009). HPSC.[60]

5.1 Sampling

Examination of different types of water in the healthcare environment is important in monitoring the effectiveness of maintenance and control procedures and also for identifying potential sources of infection. Table 5.2 gives a summary of the types of sample bottles used for the range of analyses that are required in the healthcare setting.

Table 5.2: Sample bottles required for the collection of water for different microbiological and chemical analyses (adapted from Examining Food, Water and Environmental Samples from Health Care Environments. Public Health England, 2013)[194]

Test Required	Sample Bottles
Coliforms, *Escherichia coli, Pseudomonas aeruginosa*, aerobic colony counts, environmental *Mycobacteria*	1 x sterile 500 ml plastic bottle containing an appropriate neutraliser to neutralise any residual disinfectant in the water (e.g. sodium thiosulphate) (The most commonly used neutraliser for chlorinated or brominated water systems and those using ozone or hydrogen peroxide, is sodium thiosulphate. For mains water and hydrotherapy pools, 18 mg/L sodium thiosulphate should be added. However, for cooling towers, 180 mg/L (i.e. sufficient to neutralise 50 mg chlorine per litre) must be used.)
Legionella and other pathogenic bacteria (such as *Salmonella, Campylobacter* and verotoxigenic *E. coli*) where required	1 x sterile 1 litre bottle or 2 x sterile 500 ml plastic bottles (as above)
Endotoxin	Designated "Pyrogen-free" containers
Chemical parameters	Specific bottles should be requested from laboratory depending on tests required

5.2 Procedure for sampling taps and tap output water for the microbiological examination of *Pseudomonas aeruginosa* in augmented care units and healthcare settings

(based on Appendix 3, HTM 04-01: Addendum, March 2013)[64]

Basic Principles

- Sampling should be undertaken by staff trained in the appropriate technique for taking water samples including the use of aseptic technique to minimise extraneous contamination. The method used in this guidance may differ from the collection of water samples for other purposes (for example sampling for *Legionella*).

- The main strategy for sampling is to take the first sample of water (pre-flush) delivered from a tap at a time of no use (at least 2 hours or preferably longer) or, if that is not possible, during a time of its lowest usage. This will normally mean sampling in the early morning, although a variety of use patterns may need to be taken into account. A 500mL container is recommended and this should be filled almost to the brim ie 500mLs.
- If *P. aeruginosa* has been found in a pre-flush sample, take a second paired set of samples. The first would be a pre-flush sample as before. Then run the tap for two minutes and take a second identical post-flush sample. Bacteria in this second sample (termed post-flush) are more likely to originate further back in the water system. A substantially higher bacterial count in the pre-flush sample, compared with the post-flush, should direct remedial measures towards the tap and associated pipework and fittings near to that outlet. A similar bacterial count in pre-flush and post-flush samples indicates that attention should focus on the whole water supply, storage and distribution system. A more extensive sampling regimen should be considered throughout the water distribution system, particularly if that result is obtained from a number of outlets.
- Although water sampling is the principal means of sampling, there may be occasions when water samples cannot be obtained immediately for analysis. In the event of a suspected outbreak, swabbing water outlets (as per section 5.4 of the Microbiology of Drinking Water (2010) – Part 2.26 Practices and Procedures for sampling)[195] to obtain strains for typing may provide a means of assessing a water outlet, but this does not replace water sampling.
- The water outlet must be clearly identified; system schematics indicating each numbered outlet to be sampled are helpful in this respect.
- Dependent upon the water distribution system design and the type of water outlet, the water feed to the outlet may be provided by:

    a. A separate cold-water supply and hot-water supply to separate outlets

    b. A separate cold-water supply and hot-water supply, which may have its final temperature controlled by the use of an integral TMV within the outlet

    c. A separate cold-water and a pre-blended hot-water supply that has had its temperature reduced by a TMV prior to delivery to the outlet

- Disinfectants in the water, such as chlorine or chlorine dioxide, will have residual activity after taking the sample and may inactivate bacteria in the sample prior to its processing. To preserve the microbial content of the sample, neutralise oxidising biocides by dosing the sample bottle with 18 mg of sodium thiosulphate (equating to 18 mg/L in the final sample, which will neutralise oxidising biocides by dosing the sample bottle with 19 mg of sodium thiosulphate (equating to 18 mg/L in the final sample, which will neutralise up to 50 ppm hypochlorite). Sterile bottles are normally purchased containing the neutraliser. Ethylenediaminetetraacetic acid (EDTA) may be used as a neutraliser for systems treated with copper and silver ions (BS 7592:2008).[196] Where disinfectants are being applied to the water system take advice on the appropriate neutralisers to use.
- The tap should not be disinfected by heat or chemicals before sampling (pre- or post-flush) nor should it be cleaned or disinfected immediately before sampling.

Procedure for Obtaining Tap Water Samples

Label a sterile collection vessel (200-1000 mL volume) containing a suitable neutraliser for any biocide the water may contain. The labelling information should contain details of the tap location, hot/cold/blended outlet, sender's reference, pre- or post-flush, person sampling, date and time of sampling.

Pre-flush sample

Take the pre-flush sample from a tap at a time of no use (at least 2 hours or preferably longer) or, if that is not possible, during a time of its lowest usage. Ensure samples are taken aseptically using clean hands or sterile gloves and that no contamination from the outer surface of the tap reaches the sample. Aseptically (that is, without touching the screw thread, inside the cap or inside of the collection vessel) collect at least 200mL water in a sterile collection vessel containing neutraliser (see Figure 5.1). Replace the cap and invert or shake to mix the neutraliser with the collected water.

For separate hot- and cold-water outlets, each outlet is individually tested with its own collection vessel and outlet identifier.

For blended outlets (that is, where both hot and cold water come out of the same outlet):

- sample water with the mixing tap set to the fully cold position using an individual collection vessel and outlet identifier, and note the temperature setting
- sample the blended outlet set to the maximum available hot water temperature using an individual collection vessel and outlet identifier, and note the temperature setting

Post-flush sample

Where this is required, allow the water to flow from the tap for 2 minutes before collecting at least 200 mL water in a sterile collection vessel with neutraliser. Replace the cap and invert to shake to mix the neutraliser with the collected water. This sample, when taken together with the pre-flush sample, will indicate whether the tap outlet and its associated components are contaminated or if the contamination is remote from the point of delivery.

Figure 5.1: Aseptic Collection of Tap Water Sample

Procedure for Obtaining Shower Water Samples

If a water sample from a shower is required, then place a sterile bag over the outlet. Using a sterile scissors, cut a small section off the corner of the bag and collect the sample in a sampling container (see Public Health England's (2013) 'Guidelines for the collection, microbiological examination and interpretation of results from food, water and environmental samples taken from the healthcare environment'). Appropriate precautions should be taken to minimise aerosol production as described in BS 7592:2008.[196]

The collected water should be processed within 2 hours. If that is not possible, then it should be refrigerated at 2-8˚C within 2 hours and processed within 24 hours.

Procedure for Obtaining Tap Swabs

To take a swab sample, remove a sterile swab from its container and insert the tip into the nozzle of the tap. Care should be taken to ensure no other surfaces come into contact with the tip of the swab. Rub the swab around – that is, move it backwards and forwards and up and down, as much as possible, on the inside surface of the tap outlet or flow straightener (see Figure 5.2). Replace the swab carefully in its container, again ensuring no other surfaces come into contact with the tip of the swab. Place the swab in a transport medium or maximum recovery diluent (MRD) and send to the laboratory.

Figure 5.2: Swabbing the Inside Surface of the Tap Outlet or Flow Straightener

5.3 Procedure for Sampling Potable Water

(From ISO 19458 :2006 Water Quality- Sampling for Microbiological analysis)[184]

Apparatus and Materials

In addition to sample containers, the following items may be necessary

- Hand hygiene facility
- Gas blow lamp and refill
- Ethanol or isopropanol 70%, hypochlorite solution (1 g/l), jars or beakers, disinfecting wipes
- Lighter or matches
- Markers, pencils, labels
- Spanners, pliers, screwdrivers, knife
- Portable refrigerators or refrigerated compartments in vehicles; alternatively icebox and ice or ice packs,
- Thermometer
- Water system map, list of sampling points, sampling forms
- Apparatus to measure pH, chlorine, dissolved oxygen, conductivity
- Sterile gloves

Procedure for Collecting Potable Water from a Tap

- Scrape off any dirt (scale, slime, grease or other extraneous matter) which could fall off, before filling the bottles.
- Do not sample taps with leaking spindles.
- Take out any faucet nozzle or other attachment or insert (spanners and pliers shall be available).
- Ensure samples are taken aseptically using clean hands or sterile gloves and that no contamination from the outer surface of the tap reaches the sample.
- Disinfect the tap preferentially by flaming or, if not possible, by other disinfection methods (hypochlorite, 70% isopropanol).
- Allow the water to flow just long enough to ensure that the water has no residual thermal or disinfectant effect.
- Place the bottle under the tap without closing and re-opening the tap.
- Leave some air space in the bottle to allow for adequate shaking before analysis.
- Do not use this water sample for the measurement of temperature or any other on-site tested parameter.

Transport and storage

- Keep the time between sampling and analysis in the laboratory as short as possible. For drinking waters, analysis should ideally be started within the same working day.
- Protect samples from sunlight. Cool samples — ideally (2-8˚C) — during transport (e.g. by using refrigerated transport, ice packs or melting ice) unless otherwise stated in specific standards. Be careful not to put ice-packs in direct contact with the sample, as this can result in freezing. Adjust the number, volume and position of ice packs according to samples number, mass and initial temperature. For samples transported for periods over 8 hours, it is necessary to monitor and record the temperature. Transport conditions shall be documented.
- Warm and cold samples must be segregated.
- For guidance on the transport and storage of water samples for physico-chemical, chemical, radiochemical and biological analyses, see ISO 5667-3:2012.[197]

5.4 Procedure for Sampling Water for *Legionella* Testing

(*based on National Legionella Guidelines 2009 and adapted from Examining food, water and environmental samples from healthcare environments, Microbiological Guidelines 2013, Public Health England)*[60, 194]

Water sampling for *Legionella* should not be carried out in isolation but should be done in conjunction with a review of the risk assessment, up-to-date schematic of water systems and review of relevant paperwork, previous monitoring results (both microbiological and temperature controls) and a review of current control measures. Sampling must be carried out on a risk basis. For example, water should be sampled from the areas where *Legionella* are likely to multiply, such as the warmest parts of a cold system, the coolest parts of a hot system or areas where there is low usage/ stagnation. Where there are several floors in the building under investigation, flow and return temperatures should be taken on each floor and to and from the calorifier or other heat source.

Individual staff members who may be particularly prone to an increased risk of *Legionella* infection due to underlying conditions or immunosuppression should not be involved in sampling operations in accordance with the National *Legionella* Guidelines 2009.[60] In areas where there is a significant risk of exposure to *Legionella*, PPE and respiratory filter masks should be worn based on a risk assessment in accordance with the National *Legionella* Guidelines 2009.[60]

Pre-flush Sample

A pre-flush sample is water collected immediately after the tap or fitting is opened. The tap or fitting should not have previously been disinfected, or water run to waste. The pre-flush sample represents water held within the tap or fitting and ideally, should be taken when the tap has not been used for several hours.

Post-flush Sample

A post-flush sample is water collected after the tap or tap fitting has been disinfected and water in the fitting has run to waste. The post-flush sample represents the quality of circulating water supplied to the tap or fitting.

A pre-and post-flush sample should be taken at all outlets sampled. Following sampling, all water samples for *Legionella* analysis should be stored at an ambient temperature (approximately 20°C), in the dark, and be transported to the laboratory as soon as possible, preferably the same day. If analysis is delayed samples should be stored so that processing can begin within 48 hours of collection.

Additional information should be gathered to help interpret the results. At a minimum, the following information should be included on the request form:

- The site and sample point
- The sample references and date
- The reason for sampling
- The temperature of the sample source (e.g. the temperature of a hot-water system at one minute after turning on the tap and at two minutes after turning on the cold tap)
- Any biocide used
- The timing of the dosage in relation to sampling
- The concentration detected at the time of sampling
- Any other risk factors of importance (e.g. closed system opened for maintenance)
- High risk of nutrient present, such as in plastics manufacturing plants
- Any cases associated with the site.

During the sampling all details that may help the implementation of possible remedial measures should be recorded. For example, obvious pressure and temperature drops or rises in the water circuits, the presence of iron sediment or sludge, the condition of the aerator and taps, the occurrence of scale, corrosion and the presence of various rubber and plastic attachments.

5.5 Renal Unit Waters

Water used in preparation of dialysis fluid is tested to determine whether it meets the minimum requirements for microbiological contamination.[198, 199]

- If the sample is to be collected from a tap used solely for sampling ensure that this has been appropriately sanitised.
- Aseptically open a labelled sterile water bottle (usually 500 ml bottle containing neutraliser) and fill almost to the brim with water; replace the lid. ***Note***: If only small volumes of liquid are available for sampling, a smaller sterile plastic container can be used, as neutraliser is not essential for this sample type.
- Store the water between 2 and 8˚C and return to the lab for examination ideally on the same day but always within 24 hours of collection.

5.6 Endoscopy Washer Disinfector Final Rinse Water

Final rinse water from automated washer/disinfectors should be sterile or very nearly so. Great care is therefore needed during collection of water samples in order to ensure that contamination is not introduced. The exact procedure will vary from one model to another, but advice should be sought from the manufacturer on the appropriate sampling procedure. The sample should be kept refrigerated if there is any delay before submitting to the laboratory. The guidance documents generally recommend weekly testing of final rinse water for TVCs and *P. aeruginosa*. However after establishing initial guidance compliance by trend analysis of such results, it would be reasonable to consider reducing the frequency of such testing (e.g. monthly) provided no alteration has occurred to the EWD or its water supply.

During investigations of poor results, investigate the method used for sampling. Collection of water samples prior to the final treatment process (e.g. supply water and break tank water) should be considered. In addition, the efficacy of filters should be checked, if relevant.

5.7 Dental Unit Waterlines

Procedure for Aerobic Heterotrophic Bacterial Count

- Dental units have dental waterlines supplying several instrument hoses, three-in-one air/water syringes, patient cupfiller and cuspidor bowl rinse outlets. All these waterlines are interconnected. Label sterile water bottle (usually 50-100 ml tubes/bottles containing neutraliser*). The labelling information should contain details of each waterline to be sampled, sender's reference, person sampling, date and time of sampling.
- Purge the 3:1 air/water syringe waterline, instrument hose waterline, patient cup filler waterline (where present) and cuspidor rinse waterline (where present) outlets of the dental unit for 2 minutes before collecting water samples.
- Aseptically open the tube/bottle and collect 50 ml of water from each outlet.
- Samples of water should also be taken from independent water reservoir bottles where used.
- Store the water between 2 and 8˚C and return to the microbiology laboratory for analysis ideally within 24 hours of collection.

*Waterline disinfection chemicals leave a residue in waterline output water that require neutralisation prior to determination of bacterial counts (e.g. sodium thiosulphate, polysorbate, saponin etc.) otherwise the counts obtained may be inaccurate. Advice on the appropriate neutraliser for a particular waterline disinfection agent should be sought from the dental unit manufacturer and/or the microbiology laboratory undertaking water testing.

5.8 Procedure for Sampling Swimming, Spa and Hydrotherapy Pool Water

(based on Health Protection Agency, 2006; Pool Water Treatment Advisory Group UK, 2009)[200]

Normally a single sample of pool water is taken. The most appropriate site for taking a single sample from the pool is where the water velocity is likely to be at its lowest and away from fresh water inlets or outlets. Depending on the size of the pool, it may be advisable to take samples from other sites to establish whether there are "dead legs/ends" in the water circulation. In investigations, it is advisable that additional samples are taken from the balance tank.

1. Outside shoes should be removed or plastic shoe coverings should be worn if entering swimming pool areas.
2. Wipe the outside of a sterile bottle (500 ml bottle containing neutraliser) with an alcohol wipe if not individually packed, and label with a waterproof marker.
3. Aseptically open the bottle.
4. Immerse the bottle, keeping the long axis approximately horizontal but with the neck pointing slightly upwards to avoid loss of the neutralising agent.
5. Once the bottle is immersed to about 200-400 mm (8-16") below the surface, tilt the bottle to allow it to fill, leaving a small headspace.
6. On removal from the water, immediately replace the cap and shake the sample to disperse the neutralising agent.
7. Water samples should be stored between 2˚C and 8˚C, and submitted to the laboratory in a timely way to ensure that they are examined on the day of collection or at least within 24 hours of the collection.

If both routine testing parameters and *Legionella* are required, then separate 1 litre and 500 ml samples should be taken.

It is good practice to determine total and combined disinfectant levels and pH value from the same site as the microbiological sample. These should be determined in a separate sample collected in a bottle without any neutralising agent (e.g. a sterile plastic universal) and the tests carried out at the pool-side. These results together with information on the number of users in the pool at the time of sampling should accompany the sample to the laboratory. Also note the number of bathers and the type of disinfectant in use.

5.9 Interpretation of Microbiology Results

The testing parameters, frequency of testing, result interpretation, and outline of actions required are outlined in Tables 5.3-5.8.

Laboratory Facilities

All laboratories carrying out environmental water testing should be accredited for the methods used and participate in appropriate external proficiency schemes. Laboratory facilities should be available in each health service executive area and should operate to the International Standard ISO 17025[201] and/or ISO 15189.[202]

Table 5.3: Testing Options and Interpretation of Results for Hot and Cold Water Systems

Hazard/ Hygiene Indicator	Timing/ Frequency of Testing	Result	Interpretation	Action	References
Legionella	As indicated by risk assessment	>1000 cfu/l	UNSATISFACTORY	If only a minority of samples are positive, the system should be re-sampled. If a similar count is found again, a review of the control measures and risk assessment should be carried out to identify any remedial actions. If the majority of samples are positive, the system may be colonised. Disinfection of the system should be considered and an immediate review of control measures and risk assessment should be carried out to identify any other remedial action required.	(60)
		>100 but <1000	System under Review	Re-sample and review control programme.	
		<100 cfu/l	SATISFACTORY	No action; system under control	
Pseudomonas aeruginosa	In augmented care units, if indicated by risk assessment	>10 in 100ml	UNSATISFACTORY	Investigate cause and put corrective actions in place. Re-sample after 3 weeks	(64)
		1-10 in 100ml	UNDESIRABLE	Re-test and refer back to those responsible for the Water Safety Plan to determine what actions may be required.	
		0 in 100ml	SATISFACTORY	No action; system under control	

Table 5.4: Testing Options and Interpretation of Results for Renal Dialysis Fluid and Water Used for the Preparation of Dialysis Fluid

Hazard/ Hygiene Indicator	Timing/ Frequency of Testing	Result	Interpretation	Action	References
Aerobic Colony Count	Monthly (or more frequently if necessary)	>100/ml	UNSATISFACTORY	Take out of use until corrective action implemented	(153)(198)(155)
		50 - 100/ml	BORDERLINE	Investigate cause and put corrective action in place	
		0 - <50/ml	SATISFACTORY	No action; system under control	
Endotoxin/ml		>0.25 EU/ml	UNSATISFACTORY	Take out of use until corrective action implemented	
		0.125 - 0.25 EU/ml	BORDERLINE	Investigate cause and put corrective action in place	
		<0.125 EU/ml	SATISFACTORY	No action; system under control	

Table 5.5: Testing Options and Interpretation of Results from Renal Dialysis Ultrapure Fluid and Water Used for Preparation of Ultrapure Fluid

Hazard/ Hygiene Indicator	Timing/ Frequency of Testing	Result	Interpretation	Action	References
Aerobic Colony Count	Monthly (or more frequently if necessary)	≥10 in 100ml	UNSATISFACTORY	Investigate cause and put corrective action in place	(199)(155)(153)
		<10 in 100ml	SATISFACTORY	No action; system under control	
Endotoxin/ml		≥0.03 EU/ml	UNSATISFACTORY	Investigate cause and put corrective action in place	
		<0.03 EU/ml	SATISFACTORY	No action; system under control	

Table 5.6: Testing Options and Interpretation of Results for Endoscopy Final Rinse

Hazard/Hygiene Indicator	Timing/ Frequency of Testing	Result	Interpretation	Action	References
Aerobic Colony Count	Weekly	>100 in 100 ml	UNACCEPTABLE	Discuss with Infection Control Team; undertake a risk assessment; consider taking washer/disinfector out of use (particularly for endoscopes used for sterile sites such as endoscopic retrograde cholangiopancreatography (ERCP) and bronchoscopes).	(150)
		10-100 in 100ml	UNSATISFACTORY	Discuss with Infection Control Team; complete risk assessment to investigate potential problems; super-chlorinate or repeat self-disinfect cycle	
		1-9 in 100ml	ACCEPTABLE*	*Acceptable provided that *Pseudomonas aeruginosa* is not detected	
		<1 in 100ml	SATISFACTORY	No action; system under control	
Environmental *Mycobacteria*	Quarterly	>0 in 100ml	UNSATISFACTORY	Investigate immediately and take repeat sample	
		0 in 100ml	SATISFACTORY	No action; system under control	
Pseudomonas aeruginosa	Optional – consult with microbiologist	>0 IN 100ml	UNSATISFACTORY	Investigate immediately and take repeat sample	
		0 in 100ml	SATISFACTORY	No action; system under control	
Endotoxin	Not routinely required	>0.25 EU/ml	UNSATISFACTORY	Risk low even above this level but would usually be associated with high microbial counts and subject to remedial action	

Table 5.7: Testing Options and Interpretation of Results for Dental Chair Unit Waterline Output Water Samples

Microorganisms	Timing/ Frequency of Testing	Result	Interpretation	Action	References
Aerobic heterotrophic bacterial count from waterline output water on R2A agar following 7-10 days incubation at 20-22°C. Waterline supply water should also be tested. These tests can be undertaken by commercial laboratories or specialist microbiology laboratories.	At least twice yearly provided effective periodic or residual waterline disinfection protocol in place. Otherwise monthly.	>500 cfu/ ml	UNSATISFACTORY	Investigate waterline contamination control measures. Immediate disinfection of waterlines and cleaning and disinfection of reservoir bottle (where used) with effective waterline disinfectant and protocol recommended by the dental unit manufacturer. Retest following disinfection.	(190)(191)(157)
		0-500 cfu/ml	SATISFACTORY	No action; system under control	

Table 5.8: Testing Requirements and Interpretation of Results for Hydrotherapy Water Samples

Microorganisms	Timing/ Frequency of Testing	Result	Interpretation	Action	References
Escherichia coli	Weekly (collect sample while pool is in use)	>0 in 100ml	UNSATISFACTORY	Investigate immediately and take repeat sample	(200)
		0 in 100 ml	SATISFACTORY	No action; system under control	
Coliform bacteria (Total coliforms)		>10 in 100ml	UNSATISFACTORY	Investigate immediately and take repeat sample	
		1 - 10 in 100ml	ACCEPTABLE*	*This level is considered acceptable provided that Aerobic Colony Count is <10/ml, *E. coli* is not detected, disinfectant & pH values are acceptable and coliforms are absent in repeat samples	
		0 in 100ml	SATISFACTORY	No action; system under control	

Microorganisms	Timing/ Frequency of Testing	Result	Interpretation	Action	References
Pseudomonas aeruginosa		>50 in 100ml	UNACCEPTABLE	Close pool and seek advice on remedial actions required	
		>10 in 100ml	UNSATISFACTORY	Investigate and take repeat sample	
		1-10 in 100ml	BORDERLINE	Take repeat sample	
		0 in 100ml	SATISFACTORY	No action; system under control	
Aerobic Colony Count		>100/ml	UNSATISFACTORY	Immediate investigation required	
		10 - 100/ml	BORDERLINE	Take repeat sample. Acceptable in the absence of *E. Coli* or coliforms. Repeated raised counts require further investigation.	
		0 - <10/ml	SATISFACTORY	No action; system under control	
Staphylococcus aureus	As part of wider investigations only – in discussion with local microbiologist	>0 in 100ml	UNSATISFACTORY	Investigate immediately and take repeat sample	
		0 in 100ml	SATISFACTORY	No action; system under control	

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Appendix 1.
Summary of Irish Legislation and Key National Standards, Code of Practice and Guidelines

Item of legislation/guidance	Link	Comment
Republic of Ireland statutory Instruments (SIs)	http://www.irishstatutebook.ie/	Access to specific items of Irish legislation
Health and Safety Authority	www.hsa.ie	Comprehensive details of Irish health and safety legislation
Safety, Health and Welfare at Work Act 2005 (No. 10 of 2005)	http://www.irishstatutebook.ie/2005/en/act/pub/0010/)	General duties of employers to employees and to other persons including patients in hospitals and other healthcare facilities
Safety, Health and Welfare at Work (General Application) Regulations 2007 (SI No. 299 of 2007)	http://www.irishstatutebook.ie/2007/en/si/0732.html	Duties of employers in relation to workplace equipment, inspection of equipment and maintenance
Safety, Health and Welfare at Work (Biological Agents) Regulations, 1994 as amended in 1998 (SI No. 146 of 1994 and SI No. 248 of 1998)	http://www.irishstatutebook.ie/1994/en/si/0146.html	Sets down the minimum requirements for the protection of workers from the health risks associated with biological agents in the workplace
Infectious Diseases Regulations 1981 (SI No. 390 of 1981) Infectious Diseases (Amendment) Regulations 1985 (SI No. 268 of 1985) Infectious Diseases (Amendment) Regulations 1988 (SI No. 288 of 1988) Infectious Diseases (Amendment) Regulations 1996 (SI No. 384 of 1996) Infectious Diseases (Amendment) Regulations 2003 (SI No. 707 of 2003) Infectious Diseases (Amendment) Regulations 2007 (SI No. 559 of 2007) Infectious Diseases (Amendment) Regulations 2011 (SI No. 452 of 2011)	http://www.irishstatutebook.ie/1981/en/si/0390.html http://www.irishstatutebook.ie/1985/en/si/0268.html http://www.irishstatutebook.ie/1988/en/si/0288.html http://www.irishstatutebook.ie/1996/en/si/0384.html http://www.irishstatutebook.ie/2003/en/si/0707.html http://www.irishstatutebook.ie/2007/en/si/0559.html http://www.irishstatutebook.ie/2011/en/si/0452.html	A number of specified waterborne infectious agents are covered under these items of legislation including *Legionella* bacteria and *Pseudomonas aeruginosa*.
Safety, Health and Welfare at Work (Chemical Agents) Regulations, 2001 (SI No. 619 of 2001)	http://www.irishstatutebook.ie/2001/en/si/0619.html	This legislation applies to any healthcare facility where hazardous chemical agents are used. This includes cleaning agents, disinfectants and biocides. The employer must identify all the chemical agents at his/her enterprise, determine the hazards associated with them, evaluate the risks and put appropriate measures in place to protect employees and other persons, including patients.

The quality of water intended for human consumption with the European Union is regulated by Council Directive 98/83/EC	http://www.fsai.ie/uploadedFiles/Legislation/Food_LegisationLinks/Water/EU_Directive_98_83_EC.pdf	EU Directive on the quality of water for human consumption
European Union (Drinking Water) Regulations 2014. (SI No. 122 of 2014)	http://www.irishstatutebook.ie/pdf/2014/en.si.2014.0122.pdf	Irish legislation transposing 98/83/EC into Irish law
European Communities (Natural Mineral Waters, Spring Waters and Other Waters in Bottles or Containers) Regulations 2007 (SI No. 225 of 2007) European Communities (Natural Mineral Waters, Spring Waters and Other Waters in Bottles or Containers) (Amendment) Regulations 2007 (SI No. 686 of 2007)	http://www.irishstatutebook.ie/pdf/2007/en.si.2007.0225.pdf http://www.irishstatutebook.ie/2007/en/si/0686.html	Irish legislation regulating the quality of water intended for human consumption which is not a natural mineral water or a spring water and is placed on the market for sale in either bottles or containers
The Health Information and Quality Authority (HIQA) National Standards for the Prevention and Control of Healthcare Associated Infections 2009	http://www.hiqa.ie/publication/national-standards-prevention-and-control-healthcare-associated-infections	National standards for use across the Irish health and social care system
The Health Information and Quality Authority (HIQA) National Standards for Safer Better Healthcare 2012	http://www.hiqa.ie/publications/national-standards-safer-better-healthcare	These standards promote responsibility and accountability for the quality and safety of services provided or funded by the HSE
The Health Protection Surveillance Centre (HPSC) National Guidelines for the Control of Legionellosis in Ireland, 2009	http://www.hpsc.ie/A-Z/Respiratory/Legionellosis/Publications/	Comprehensive guidance for minimisation of *Legionella* risks in a wide range of settings including healthcare facilities. Much of this guidance is also relevant to the minimisation of risks associated with other waterborne microorganisms
Health Services Executive Code of Practice for Decontamination of Reusable Invasive Medical Devices: Recommended Practices for Endoscopy Units	http://www.hse.ie/eng/services/Publications/services/Hospitals/HSEPublications/Code_of_Practice_for_Decontamination_of_Reuable_Invasive_Medical_Devices_4.pdf	A guide to the standards of practice required in the decontamination of reusable invasive medical de-vices in Endoscopy Units based on current legal requirements and professional best practice

Appendix 2:
Key regulations, standards, codes of practice and guidance for engineering controls

Legislation, Codes of Practice and Standards

The various categories of Legislation, Codes of Practice and Standards that should be used are described below.

Irish legislation and regulations of particular relevance

- Building Control Acts 1990 and 2007
- Building Regulations (1997-2012) particularly Part G regarding hygiene
- Building Control Regulations (1997-2013)
- Building Control (Amendment) Regulations 2013
- Irish Health and Safety Legislation as outlined in Chapter 2.

Technical guidance documents are available on how to comply with building regulations.

Statutory Inspections: Checks, inspections or tests specified in a Statutory Instrument i.e. Act and/or Regulation that are a legal requirement.

Codes of Practice: The Department of Health in the UK has published several Health Building Notes (HBN) and Health Technical Memoranda (HTM) in this area. These codes of practice typically give practical guidance on their subject matter. They are not legally binding and as such do not have to be followed exactly. However, where the code of practice gives practical guidance on relevant statutory provisions then compliance or non-compliance with those provisions of the code may be admissible in evidence in any criminal or civil proceedings. A person may also be able to comply with the law by adopting alternative measures to those set out in a code of practice, provided that those alternative measures achieve the objective of the statute or regulation to which the code of practice relates. However, in a safety and health prosecution or a civil liability claim the onus of proof would rest with the defendant to show that he/she was not negligent and/or in breach of a statutory duty so far as is reasonably practicable to prevent against injury.

Irish Standards (IS): Refers to Irish standards published by the National Standards Authority of Ireland (NSAI), which operates under the National Standards Authority of Ireland Act, 1996, on behalf of the Minister for Jobs, Enterprise and Innovation. These standards are standard specifications for their topic area and conformance with the standard as certified by NSAI provides proof of compliance with requirements of national standard specifications approved by the Minister for Jobs, Enterprise and Innovation.

Irish Standards EN (IS EN): European Standards (EN) aim to establish a European wide standard in a given subject area. European standards are typically produced by European technical committees and must be given the status of a national standard, either by publication of an identical text or by endorsement. Conflicting national standards should typically be withdrawn. These standards when transposed into an Irish context are denoted as IS EN.

British Standards (BS): Standards produced by the British Standards Institute. These are referenced in this text only where an applicable Irish code of practice or standard (either IS or IS EN) does not exist.

Additional guidance and standards of relevance

- Health and Safety Executive. Legionnaires' disease. The control of legionella bacteria in water systems. Approved code of practice and guidance on regulations. L8 (Fourth edition) HSE Books 2013
- Health and Safety Executive. Legionnaires' disease. Part 2: The control of legionella bacteria in hot and cold water systems. HSG274 Part 2. HSE Books 2014
- Health and Safety Executive. Legionnaires' disease: Technical guidance. HSG274 Part 3. HSE Books 2013
- Chartered Institution of Building Services Engineers (CIBSE) guidance including but not limited to:
  - TM13: Minimising the risk of Legionnaires' disease, 4th Ed, 2013
  - Commissioning Code W: Water distribution systems, 2010
  - Guide G: Public health engineering, 2004 (*currently under review*)

- Building Services Research and Information Association (BSRIA) guidance including but not limited to:
  - Commissioning Water Systems (BG 2/2010)
  - Pre-Commission Cleaning of Pipework Systems (BG 29/2012)
  - Commissioning Job Book - A framework for managing the commissioning process (BG 11/2010)
  - Guide to Legionellosis – Risk Assessment (AG 20/2000)
  - Guide to Legionellosis – Operation and Maintenance (AG 19/2000)
  - Guide to Legionellosis – Temperature Measurements for Hot and Cold Water Services (AG 4/1994)
  - Legionellosis Control Log Book (AG 21/2000)
- Irish / European / British Standards including but not limited to:
  - BS 8580:2010 Water quality. Risk assessments for Legionella control. Code of practice
  - BS 8558:2011 Guide to the design, installation, testing and maintenance of services supplying water for domestic use within buildings and their cartilage. Complementary guidance to BS EN 806
  - BS EN 806:2000 Specifications for installations inside buildings conveying water for human consumption (Parts 1 to 5)
  - BS 6920:2000 Suitability of non-metallic products for use in contact with water intended for human consumption with regard to their effect on the quality of water
  - Additional standards, as relevant, produced by the European Committee for Standardisation Technical Committee 164 (CEN/TC 164 Water Supply) listed at https://www.cen.eu/cen/Sectors/TechnicalCommitteesWorkshops/CENTechnicalCommittees/Pages/Standards. Aspx?param=6145&title=CEN/TC%20164# (accessed 10/05/2013)

Standards for Water Quality in Renal Dialysis Units

- ISO 13959:2009, Water for haemodialysis and related therapies.
- ISO 11663:2009, Quality of dialysis fluid for haemodialysis and related therapies.
- ISO 26722:2009, Water treatment equipment for haemodialysis applications and related therapies.
- ISO 23500:2011, Guidance for the preparation and quality management of fluids for haemodialysis and related therapies.
- ISO 13958:2009, Concentrates for haemodialysis and related therapies.
- European Pharmacopoeia (PhEur) 5th Edition Monograph 1167: Water for diluting concentrated haemodialysis solutions. European Pharmacopoeia Commission, 2005.
- American National Standards institute/Association for the Advancement of Medical Instrumentation (ANSI/AAMI) standard RD62:2006, Water treatment equipment for hemodialysis applications.
- Department of Health, UK, Estates and Facilities Division. Renal Care Health Building Note 07-02: Main Renal Unit, 2013.
- Department of Health, UK, Estates and Facilities Division. Renal Care Health Building Note 07-01: Satellite Dialysis Unit, 2013.

Additional Key Guidance

Irish Guidance

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Appendix 3:
Secondary disinfection of healthcare facility water distribution systems

The following appendix will review available chemical and thermal secondary disinfection methods and focus on aspects to consider when choosing an appropriate regime. A systematic review of scientific and grey literature was carried out between 1993 and 2013.[1-72] The majority of the literature found was specific to the control of *Legionella*. Literature on effective disinfection methods against other waterborne organisms was sparse and predominantly published in the last four years. Thus literature in this area should be reviewed periodically.

As stated in Chapter 3, secondary disinfection is not a substitute for

- good engineering design
- correct installation
- effective system maintenance

The selection of a secondary disinfectant method(s) should be based on a comprehensive, up-to-date, site specific risk assessment and expert advice may be required. Readers should also be aware that all biocidal products are subject to regulation (see Section 2.6, Chapter 2 and http://www.pcs.agriculture.gov.ie/biocides.htm)

Evidence on Specific Disinfection Methods

Temperature Control Regime

Application

Temperature of at least 60°C in hot water storage tanks/cisterns/calorifers.

Minimum returning water temperature of 50°C.

Minimum temperature at the most distant taps or outlets should be 55°C and be achievable within one minute at outlets.

Cold water should be stored and distributed at a temperature below 20°C.

At cold water draw-off points, a temperature of no greater than 2°C above the temperature measured in cistern and cold water tanks should be reached within two minutes.

Recommended Use

Continuous

Spectrum of Microbiological Activity

Broad

Evidence of Effectiveness

Returning hot water and hot water at outlets lower than the recommended temperature have resulted in colonisation of water systems with *Legionella*, and cases and outbreaks of legionellosis. However, there is also evidence of colonisation of hot water systems with *Legionella*, and cold water systems with *Legionella*, mycobacteria and *Pseudomonas*, when water temperatures are within recommended values.

Advantages

No special equipment required.

No disinfection by-products are produced.

Does not affect taste or odour of the water.

Disadvantages

Difficult to maintain adequate hot water temperature.

High temperatures pose a risk of scalding.

High energy use associated with maintenance of hot water temperatures.

Cost

Relatively expensive.

Key message

Water temperatures must be maintained within recommended values but this may not be sufficient to prevent water system contamination. Additional disinfection method is often required.

Chlorine Dioxide (ClO_2)

Application

Chlorine dioxide is a gas produced by activating sodium chlorite with an oxidizing agent or an acid source. It must be manufactured on site as it decomposes readily and presents toxicity hazards when stored. The injected dose should be in the region of 0.5mg/L. Concentration of ClO_2 at the sentinel taps (nearest and furthest taps) should be at least 0.1 mg/L. There is evidence in the scientific literature that residual ClO_2 levels of greater than 0.2mg/L are required to gain effective control. Chlorine dioxide generated on-site and used as a chemical for the treatment of water intended for human consumption is subject to the European Standard EN 12671:2009.

Recommended Use

Can be used as both a continuous systemic disinfection method and as an intermittent shock method.

Particularly effective in small systems with low cold water temperatures, non galvanised piping and low total organic carbon.

Spectrum of Microbiological Activity

Superior activity (compared to chlorine) against spores, bacteria, viruses, and protozoan cysts.

Better biofilm penetration. Better method for removing and preventing biofilm.

Evidence of Effectiveness

Effective method, however evidence strongly indicates that decontamination of the system is not immediate and can take six months or longer to achieve. A laboratory controlled trial comparing the efficiency of six different disinfectants found that ClO_2 was the most efficient for the reduction of *Legionella*, protozoa and biofilm.

Advantages

Longer residual activity in system than chlorine therefore more effective in dead legs.

Less corrosive than chlorine. Overall evidence appears to suggest that corrosive effect of ClO_2 alone is not significant.

Destroys phenols that cause odour and taste problems.

Effective over wide pH range.

Does not react with organic material to form trihalomethanes.

Lower dosages of ClO_2 can be used to obtain same results as chlorine or ozone.

During application of ClO_2 as a shock method the water system can be used, excluding for consumption.

Disadvantages

Due to its gaseous nature ClO_2 evaporates in hot water systems therefore maintaining a sufficient residual at distal sites can be difficult and may require installation of an additional ClO_2 delivery system.

Requires handling of toxic chemicals by facilities' staff. It is explosive. Strict adherence to health and safety precautions required.

The major by-product from the reduction of ClO_2 is chlorite and levels should be monitored. High concentrations of total organic carbon (TOC) and reduced metals in water can consume ClO_2 and produce chlorite. High pH values (pH >9.0) can also lead to enhanced chlorite production. Chlorite is toxic for neonates if ingested.

Chlorate and chloride also formed.

Can cause increased levels of copper in distribution system if copper supply pipes are used.

Dosing equipment requires regular maintenance.

Forms iodinated disinfection by-products when iodide is present in source water.

Taste problems can become an issue at high ClO_2 dosage levels.

Cost

Cost effective, however higher initial installation costs.

Key Message

ClO_2 is a cost-effective method for use as a secondary disinfectant in healthcare facilities. It acts against planktonic and sessile micro-organisms and can remove and prevent biofilm.

Copper-Silver Ionisation (Cu-Ag)

Application
Copper and silver ions are generated by electrolysis and bind to bacterial cell walls causing disruption and lysis. Ionisation systems can be installed on the incoming mains supply or on independent hot or cold water systems.

Values of >0.2mg/L copper and >0.02mg/L silver at outlets are recommended. Ranges used = 0.2-0.8mg/L copper and 0.02-0.08mg/L silver and are dependent on distribution system factors and levels of contamination.

Recommended Use
Continuous secondary disinfection of water distribution system. May be used in conjunction with other methods, e.g. Chlorine or Chlorine Dioxide.

Spectrum of Microbiological Activity
Copper and silver are bactericidal against *Legionella*, *Pseudomonas aeruginosa*, *Stenotrophomonas maltophilia*, *Acinetobacter baumannii.*

Can penetrate established biofilm

Recent studies suggest it may be effective in decreasing fungal colonisation of water distribution systems

Cu-Ag used alone and at appropriate concentrations is not effective against protozoa or viruses and may not be effective against mycobacteria.

Although not common, emergence of *Legionella pneumophila* resistance to copper-silver ions has been reported. Mietzner et al (2005) reported reduced susceptibility of *Legionella pneumophila* to the antimicrobial effects of copper-silver ions. Lin et al (2011) stated that their data indicate that resistant strains can cause hospital acquired Legionnaires' disease. Stout (2012) reported very slow *Legionella* kill rates in hospitals using Cu-Ag continuously for prolonged periods.

Evidence of Effectiveness
There is good evidence of effect against *Legionella* with evidence of greater effectiveness against *Legionella* than thermal disinfection, hyperchlorination or UV irradiation. Evidence is strongest for effect in recirculating hot water systems. More recent evidence demonstrates effect against other organisms, including *Pseudomonas.*

Advantages
Ions can accumulate within biofilm resulting in a prolonged bactericidal effect

Biocidal effect not reduced at higher water temperatures

No toxic by-products for humans. Toxic for many aquatic organisms

Not corrosive

Slower rebound recolonisation if system is inactivated compared to hyperchlorination or thermal disinfection

Disadvantages
Ion concentrations must be regularly monitored. The Drinking Water Regulations SI No 278 of 2007 set a parametric value of 2.0mg/L copper for drinking water in Ireland. There is no parametric value for silver and the WHO state that levels up to 0.1mg/L could be tolerated without risk to health. L8 (4th edition) recommends weekly checking of the rate and release of copper and silver ions and monthly checking of copper and silver ion concentrations at sentinel outlets.

Effectiveness of copper-silver ionisation is reduced at higher pH (pH >7.6-8.0) therefore the pH of water must be regularly monitored.

Effectiveness can be reduced by hard water as scale can build up on electrodes. Electrodes within the ionisation system should be monitored and descaled regularly. If water softening systems are used, the ionisation system must be fitted after the softening system to avoid removal of some of the copper and silver ions.

Effectiveness of silver ions is reduced if high levels of chlorides or nitrates in water.

Should not be used in water systems supplying dialysis machines.

Low-volume systems can experience excessive build-up of copper and silver in water holding tanks.

Copper levels greater than 1mg/L can cause discoloration of laundry, surgical instruments and sanitary wear.

Cost
Cost is dependent upon the number of systems required and how frequently electrodes need to be replaced. There is also the ongoing cost of ion concentration monitoring and system maintenance.

Key Message
Effective method of controlling *Legionella* and other bacterial contamination of water distribution systems. Ion concentrations, water pH and scaling must be regularly monitored**.** The cost-effectiveness of installing, operating and maintaining the system should be considered.

Monochloramines

Application
Ammonia and chlorine are dosed in a controlled manner to produce monochloramines.

Significantly less effective than chlorine therefore requires higher concentrations and longer contact times.

Recommended Use
Continuous secondary disinfection of water distribution system.

Spectrum of Microbiological Activity
Narrower spectrum of microbiological activity particularly against viruses, *Giardia* and *Cryptosporidium*. However it does appear to be effective against *Legionella* bacteria.

Evidence of Effectiveness
Evidence of effectiveness varies depending on whether monochloramine is being used as a primary or secondary disinfectant. It is widely used in the US in municipal water supplies and a reduction in nosocomial Legionnaires' disease at the municipal level has been demonstrated. However other studies demonstrated an increase in colonisation with mycobacteria, coliforms and heterotrophic bacteria.

Effective against the formation of biofilms and demonstrated ability to penetrate biofilms.

Longer term studies are required.

Advantages
Disinfection residual in the system is more stable and persistent than chlorine. Therefore it provides better protection against bacterial re-growth.

In comparison to chlorine it does not react as readily with organic materials to form trihalomethanes.

Minimal corrosion problems (excluding copper and elastomer).

Wider working pH range than chlorine.

Less affect on taste and odour if correctly produced.

Disadvantages
Haemodialysis patients are at risk of chloramine-induced haemolytic anaemia and less commonly methaemoglobinaemia. There have also been reports of erythropoietin resistance linked to chloramine exposure. If monochloramine is used as a secondary disinfectant it must be removed in renal units by granulated activated charcoal filters. Consideration should be given to the use of an alternative disinfection method.

Monochloramine must be produced on site and production must be carefully controlled to ensure that other chloramines (dichloramine and trichloramine) are not formed.

Excess ammonia can result in nitrification and increased nitrate levels. Increased nitrate levels are particularly toxic to young infants. They also increase nutrients in water that can support the growth of heterotrophic bacteria.

Blending of chlorinated and chloraminated water can result in a reduced residual and the formation of dichloramine which has a strong taste in water.

Corrosion of lead and copper pipes resulting in increased levels in water. Some research suggests that it may also be associated with increased blood lead levels.

Degradation of natural rubber and elastomers.

Toxic to fish

Cost
Inexpensive

Key Message

Longer term studies are required before recommending as a widespread secondary disinfection method. Spectrum of microbiological activity may not be sufficiently broad and the risk:benefit ratio may be poor.

Thermal Disinfection (Superheat and Flush)

Application
Temperature of calorifier/hot water heater is raised to 70-80°C and the water is circulated throughout the hot water system for at least one hour.

Each distal outlet should be run sequentially, from the nearest point to the furthermost outlet, for five to 30 minutes at a temperature of at least 65°C.

Temperature on the return connection should not fall below 60°C.

Recommended Use
Prior to building occupancy.

If the water system or part of it has been substantially altered or entered for maintenance purposes in a manner that may lead to contamination.

During or following an outbreak or suspected outbreak of Legionnaires' disease or other waterborne microorganism.

If environmental sampling shows an increase in colonisation.

Spectrum of Microbiological Activity
Broad

Evidence of Effectiveness
This method can produce a reduction in water system contamination. However, the effect is short lived and recolonisation can occur, even after repeated superheating. There is some evidence of serogroups of *L. pneumophila* exhibiting thermotolerance. Less effective in large buildings where maintaining temperatures above 65°C at outlets is difficult.

Advantages
No special equipment required.

No disinfection by-products are produced.

Does not effect taste or odour of the water.

Disadvantages
Risk of scalding.

Hot water services cannot be used until water temperatures have dropped to normal maintenance values.
Onerous and time consuming.

Not effective beyond thermostatic mixing valves and therefore of limited value where these are installed.

Cost
Relatively inexpensive

Key message
Superheating is a temporary measure that may be employed in limited circumstances. It has no role in the ongoing prevention and control of water system contamination.

Shock Hyperchlorination

Application
Chlorine is added to the cold water storage cistern to achieve a concentration of 20-50 mg/L (20-50 ppm).

It is then allowed to flow to all parts of the water distribution system and left to stand for at least one hour at 50 mg/L or at least two hours at 20 mg/L.

There should be a free chlorine residual of at least 2 mg/L throughout the water distribution system.

pH of the water should be maintained at 7.0-8.0.

The system is then flushed with fresh water.

Recommended Use
Prior to building occupancy.

If the water system or part of it has been substantially altered or entered for maintenance purposes in a manner that may lead to contamination.

During or following an outbreak or suspected outbreak of Legionnaires' disease or other waterborne microorganism.

If environmental sampling shows an increase in colonisation.

Spectrum of Microbiological Activity
Limited as many microorganisms display varying levels of resistance to chlorine e.g. *Legionella*, *Pseudomonas*, non-tuberculous mycobacteria, amoeba associated bacteria, and protozoa.

Not effective against established biofilm and readily inactivated by presence of sludge and sediment deposits.

Evidence of Effectiveness
When compared to other disinfection methods, it was shown to be one of the least effective methods. Any effect is temporary and short-lived, even with repeated applications.

Advantages
Systemic disinfection modality with residual disinfectant in system.

Disadvantages
Water system cannot be used during application.

Disinfection by-products, e.g. trihalomethanes, are produced when there is a high organic content in water and/or system.

Many organisms are resistant.

Limited biofilm penetration.

Highly corrosive.

Sensitive to pH variation.

Affects taste and odour of the water.

Cost
Relatively expensive

Key message
This method is a relatively expensive temporary measure that may be employed in limited circumstances. It has no role in the ongoing prevention and control of water system contamination.

Ultraviolet (UV) Irradiation

Application
UV irradiation is biocidal between wavelengths of 180 and 320 nm (optimum germicidal range of 250-270 nm), and minimum exposure dosage of 30,000 µW-s/cm^2.

Recommended Use
Supplemental disinfection method e.g. for high risk areas or units.

May be effective as the sole disinfection modality if the area to be disinfected is small.

May be effective if UV installed in a new build at time of construction.

Spectrum of Microbiological Activity
Extensive. However, less effective than chlorine against viruses.

Not effective at removing or preventing biofilm.

Evidence of Effectiveness
Effective when used in conjunction with other disinfection methods such as thermal disinfection or monthly shock hyperchlorination and applied near the point of use.

Efficacy of UV irradiation is optimised if it is installed on the incoming water main of a new hospital, where there is no established biofilm.

Flow range and source water quality must be considered before installing a UV reactor system.

Advantages
No disinfection by-products.

Does not affect taste or odour of the water.

Easy to install.

Not effected by pH or temperature.

No adverse effects on plumbing materials.

Disadvantages
Only effective at or very close to the point of application. No residual disinfectant.

Poor penetration in established biofilms.

UV lamps are susceptible to scale and mineral deposits and must be cleaned regularly.

Intensity of UV lamps declines over time.

Pre-filtration of water may be required to reduce turbidity and to minimise scale formation on UV lamps.

Cost
Cost effective

Initial installation costs

Key Message
Relatively inexpensive supplemental method that is effective against a wide range of micro-organisms.

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Appendix 4:
Sink Cleaning Protocol Template

Equipment and material required

Disposable gloves

Tweezers

Non reusable disposable colour coded cloth

Dedicated bucket/basin of hot water

Spray bottle/container

Detergent

Method

1. Display the warning sign
2. Wash hands and put on gloves
3. Remove any foreign objects from the basin with tweezers and dispose of appropriately *
4. Spray/wipe detergent on to handle and tap surfaces
5. Wipe handle and tap surfaces with a disposable cloth
6. Spray outside surface of basin and wipe with a disposable cloth
7. Spray/wipe inside of sink including outlet and wipe with non reusable disposable cloth
8. Dispose of the non reusable disposable cloth
9. Using a new dry non reusable disposable cloth polish handles and tap
10. Polish other stainless steel surrounds as necessary and dispose of cloth/paper towel
11. Remove gloves and decontaminate hands

*Report any foreign object(s) or faults to the head of department/cleaning supervisor

REMEMBER TO CLEAN IN THE CORRECT ORDER

1) First step: clean and dry tap(s)

2) Second step: clean sink surface

3) Third step: clean the wastewater outlet

Appendix 5:

Water Outlet Flushing Protocol Template

Rationale: In order to ensure the quality and safety of the water supply it is essential that all infrequently used outlets must be flushed weekly in all areas other than augmented care units. In augmented care units if water outlets are not in frequent daily use, flushing on a daily basis is recommended. This may be determined by local risk assessment in the first instance and should include en-suite facilities in isolation rooms and in clinical areas when temporary service closures take place. To support healthcare facilities the following template is a minimum guide which should be considered further with local risk assessment as it is acknowledged there may be significant variances in each healthcare facility with types of taps and showers, water pressure and contamination levels .

Weekly
Flushing of infrequently used water outlets

- Run cold for three minutes
- Run hot for three minutes once water is hot

Daily
In augmented care settings flushing of infrequently used water outlets

- Run cold for one minute
- Run hot for one minute once water is hot

Keep a central register of the flushing regimes for each department including frequencies and ensure signed record of the flushing procedure is available in each clinical area.

Please note
The door(s) to en-suite facilities and bathrooms should remain closed during the flushing period, and a notice should be affixed to the door indicating that cleaning is in progress and that the facility is out of use.

The following staff should be excluded from the flushing procedures:

- Staff with cancer, chronic lung or kidney disease, immunosuppression, especially those on long-term steroid therapy, and staff who have had an organ transplant.
- Staff who believe they are immunocompromised or belong to any of the above categories, should contact the Occupational Health Department in confidence.

Appendix 6:
Details of consultation process 15th January – 2nd March 2014

The consultation document was made available via the HPSC website www.hpsc.ie, highlighted in Epi Insight, Volume 15, Issue 2, February 2014 and emailed directly to the following:

- Chief Medical Scientists
- Department of Health
- Dr Kevin Kelleher, Assistant National Director Health & Wellbeing - Public Health Child Health, HSE
- Dr Philip Crowley, National Director Quality and Patient Safety Division, HSE
- Dr Stephanie O'Keeffe, Director of Health & Wellbeing, HSE
- Engineers Ireland
- Environmental Health Association of Ireland
- Environmental Protection Agency
- Faculty of Dentistry, RCSI
- Faculty of Occupational Medicine, RCPI
- Faculty of Paediatrics, RCPI
- Faculty of Pathology, RCPI
- Faculty of Public Health Medicine, RCPI
- Federation of Irish Nursing Homes
- Health and Safety Authority
- Health Service Executive
- Hospital Managers
- HPSC Scientific Advisory Committee
- HSE Clinical Leads
- HSE National Incident Management Team
- HSE Nursing and Midwifery Services
- HSE Regional Directors of Performance and Integration
- HSE Regional Quality and Risk Managers
- Infection Prevention Society
- Infectious Disease Society of Ireland
- Intensive Care Society of Ireland
- Irish Association of Critical Care Nurses
- Irish College of General Practitioners
- Irish Dental Association
- Irish Patients Association
- Irish Society of Clinical Microbiology
- Irish Society of Gastroenterology
- Irish Thoracic Society
- Medical Officers of Health
- Nursing Homes Ireland
- Philip Ashcroft, UK
- Royal College of Physicians of Ireland
- Royal College of Surgeons in Ireland
- Specialists in Public Health Medicine
- Surveillance Scientists Association of Ireland

Consultation submissions were received from the following individuals and groups and discussed in March 2014:

- Dr Phil Jennings, Director of Public Health, HSE Midland Area
- Dr Maureen Lynch, Consultant Microbiologist, Mater Misericordiae Hospital
- Irish Dental Association
- Necon Technologies Ltd
- Mr Lorcan O'Brien, Senior Environmental Health Officer
- Mr Peter Smyth, Assistant National Director, Estates, HSE Dublin North East
- Mr Gerard Doody, Quality Manager, PHL, Waterford
- Department of Microbiology, Tallaght Hospital
- Health and Safety Authority
- Ms Aoife Gardiner, A/Senior Environmental Health Officer,
- Mr Ray Philpot, Rotunda Hospital
- National Maternity Hospital, Holles Street
- Ms Mary Clare Kennedy, Infection Prevention & Control Nurse, St. Luke's General Hospital & Kilcreene Orthopaedic Hospital, Kilkenny
- Ms Sheila Donlon, Infection Control Nurse Manager, HSE HPSC
- Dr Fidelma Fitzpatrick, RCPI and HSE Clinical lead - Prevention of Healthcare-associated Infection & Antimicrobial Resistance
- Dr Eoghan O'Neill, Consultant Microbiologist, James Connolly Memorial Hospital
- Dr Dan Corcoran, Consultant Microbiologist, Cork University Hospital
- Environmental Protection Agency
- Dr Tessa Greally, Specialist in Public Health Medicine, HSE MW
- Department of Agriculture, Food and the Marine
- Ms Susan Kelly, Surveillance Scientist, Cavan General Hospital
- Food Safety Authority of Ireland
- Mr Michael F Joyce, Water Services Director, Ryan Hanley

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