

Chapter 8: *Legionella* in Specific Risk Settings

8.1 Healthcare setting

Approximately a quarter of all reported legionnaires' disease cases acquire their infection inside a hospital.⁸³ Figure 8 outlines the pathogenesis of nosocomial pneumonias. There are recognised risk factors for legionnaires' disease at an individual patient level (see Chapter 1, Section 1.5). Similarly it has been reported that certain hospitals are at increased risk. Hospitals caring for immunocompromised patients such as organ or bone marrow transplant recipients are at increased risk of outbreaks of legionnaires' disease.⁸⁴⁻⁸⁶ Hospital size may also be an important risk factor. In the United States 31 out of 32 hospitals with published nosocomial outbreaks had 200 staffed beds or more.⁸⁷

Pathogenesis of nosocomial bacterial pneumonia

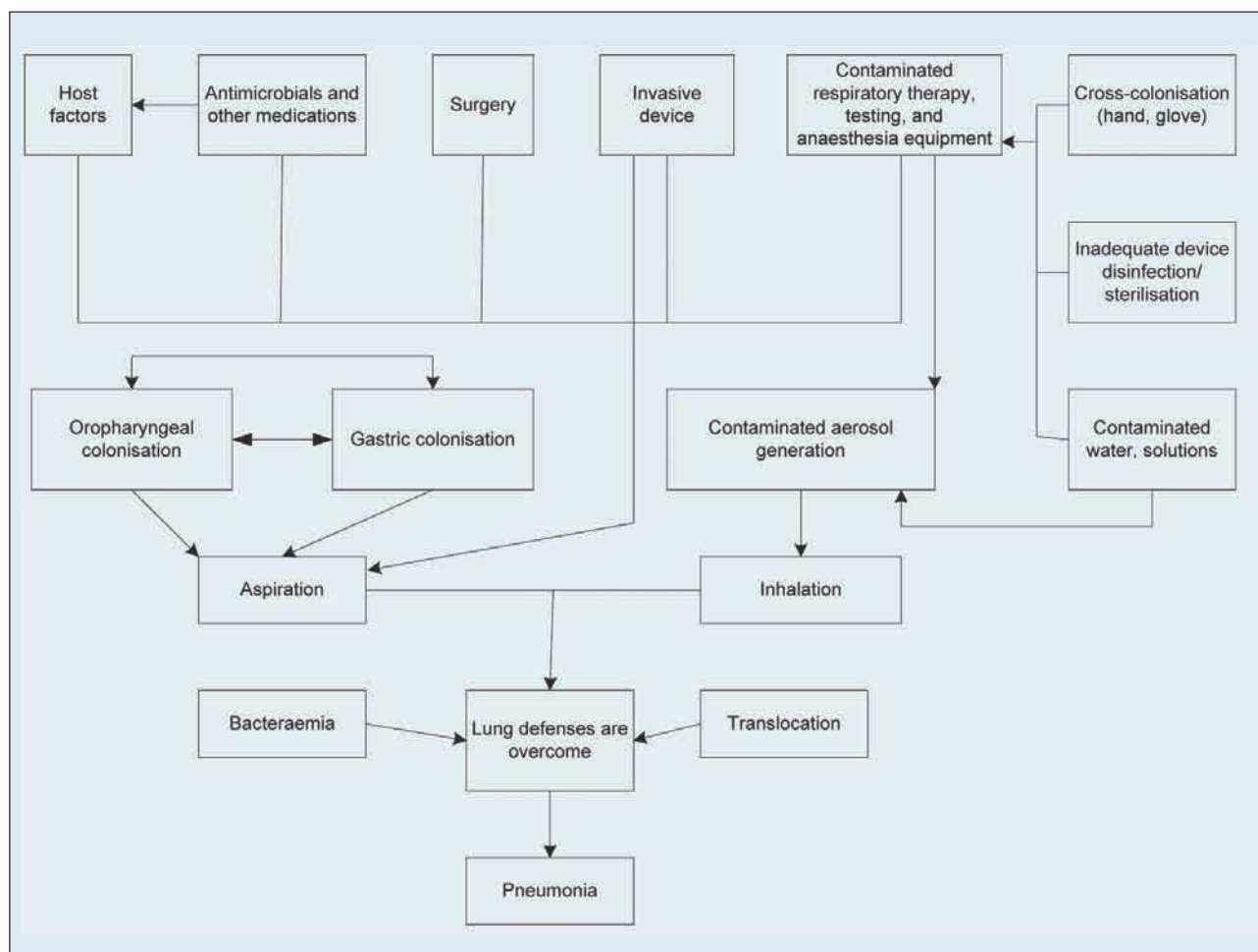


Figure 8. The pathogenesis of nosocomial bacterial pneumonia⁸⁸

Most nosocomial outbreaks have been linked to *Legionella* colonising the hot water system^{29,89} and several environmental surveys including one in Ireland have demonstrated the presence of *L. pneumophila* in hospital water distribution systems.⁹⁰⁻⁹² Other identified sources of nosocomial legionnaires' disease that have been reported include contaminated cooling towers that were located near to a hospital ventilation air intake,¹¹ respiratory therapy equipment that was cleaned with unsterilised tap water,⁹³ ice machines,⁹⁴ and aspiration of contaminated water associated with nasogastric feeding or swallowing disorders.^{9,95}

8.1.1 Recommendations for control of nosocomial legionellosis

Measures for the control of nosocomial legionellosis should include:

- Educating physicians to heighten their suspicion for legionnaires' disease and to use appropriate *Legionella* diagnostic tests for pneumonia patients
- Educating hospital personnel e.g. doctors, nursing staff, infection prevention and control, engineering and maintenance staff about measures to control nosocomial legionellosis
- Maintaining a high index of suspicion for the diagnosis of legionnaires' disease especially in high-risk groups⁸⁴
- Establishing mechanisms to provide clinicians with appropriate laboratory tests for the diagnosis of legionnaires' disease.

Interrupting transmission of *Legionella* species

(a) Nebuliser equipment

Most if not all medical devices and medications have the potential to cause adverse effects. The Report on Legionellosis at Waterford Regional Hospital (September, 2003)⁹⁶ recommends that "single patient use" nebulisers should be cleaned following use as outlined below:

- Use a quality-controlled standardised system
- Records of each cleaning should be maintained
- Following cleaning, nebulisers should be rinsed with sterile water and not tap water or distilled water
- They should be thoroughly dried inside and outside
- After drying, nebulisers should be stored in a dust proof container and
- Labelled with the patient's details and date.

Where the above is not feasible, cannot be guaranteed or is not resource efficient, single use disposable nebulisers should be used. All relevant personnel should clearly understand the symbol indicating single use (see symbol in Appendix I).⁹⁷ Single use nebulisers are not suitable for re-use. All relevant personnel should clearly understand the consequences both in terms of patient safety and personal professional responsibility of poor practice in this area. Each care setting's infection prevention and control manual should incorporate details on the appropriate use and care of nebulisers.

For general practices, single use nebulisers are recommended.

Ideally, the practice for patients living in their own homes should be as above i.e. single patient use and rinsing with sterile water following cleaning. However, if this is not feasible, cooled boiled water should be used.

(b) Water distribution system

- Meet design requirements such as those outlined in the UK HSC document, *Legionnaires' disease; the control of Legionella bacteria in water systems. Approved code of practice and guidance*.⁶⁴ Refer also to Section 5.1.6 in the risk assessment chapter – reducing *Legionella* risks in new and refurbished buildings
- All hospitals should be obliged to carry out a formal risk assessment of the control and prevention of *Legionella* bacteria.

Prevention in hospitals

The following summaries are based on HSE South Eastern area's policies and procedures for the control of *Legionella* bacteria in water systems in healthcare settings and outline the actions that should be taken by those principally concerned.⁹⁸

Manager of the facility

- The manager of the facility/institution is responsible for the appointment of a nominated/responsible person and the provision of adequate support/resources to enable them to carry out their duties
- In the event of a case of legionellosis the manager is responsible for the provision of details of

the risk assessment for legionellosis and hospital procedure for the control and prevention of legionellosis to the investigation control team

- The manager should establish and chair an incident control team in healthcare settings
- The manager of an acute hospital should chair their local Environmental Monitoring Committee (EMC).

Environmental Monitoring Committee

- The subcommittee recommends that an EMC should be established in each Health Service Executive area to cover all HSE long-stay institutions/healthcare facilities e.g. mental health and physical disability facilities. They should also be established in all acute hospitals
- 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
 Consultant Microbiologist
 Director of Nursing
 Infection Prevention and Control Nurse Specialist
 Clinical Risk Manager
 Health and Safety Officer
 Environmental Services Officer
 Technical Services Officer or equivalent
 Director of Public Health or designate
 Principal Environmental Health Officer

- 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 *Legionella*
- The EMC will advise that technical responsibility for *Legionella* prevention and control in the healthcare facility/system should be given to a competent person who will be accountable to the general manager/hospital manager/CEO
- The EMC should regularly review (not less frequently than annually) the healthcare premises' performance for *Legionella* control 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 nosocomial legionellosis (see Chapter 1, Section 1.3) and the need to carry out bi-annual sampling for *Legionella* spp, using appropriate literature as guidance (see Chapter 6 on sampling)
- Implementation of the advice given by the EMC is the responsibility of the manager with corporate responsibility for the healthcare facility/institution.

Technical services officer or equivalent

The technical services officer or equivalent should:

- Ensure that new systems are designed to the correct standards such as those outlined in the UK HSC document, *Legionnaires' disease; the control of Legionella bacteria in water systems. Approved code of practice and guidance*.⁶⁴ S/he should consult with clinicians and microbiologists on special design for protection of high-risk patients e.g. ensuring that the siting of air intakes are away from cooling towers

- Provide an expert back-up service to maintenance and other operational departments, as required
- Carry out specific projects as assigned, e.g. re-design of systems
- Provide technical advice to line management and other departments at the various levels.

Maintenance/engineering personnel or equivalent

- The responsible person appointed must conduct periodic environmental monitoring where indicated (water sampling and temperature recording), notify any unacceptable results and arrange for appropriate remedial action (this will include dental unit water supplies)
- The responsible person appointed should carry out a risk assessment of the water system(s)
- S/he should ensure that routine inspections, maintenance and disinfections are carried out as scheduled and specified
- S/he should ensure that water system modifications and works are carried out in accordance with policy, safely and to specification
- S/he should ensure that all water system records are created, maintained, kept up-to-date and are accessible.

Director of public health/consultant in public health medicine

The director of public health (DPH)/consultant in public health medicine (CPHM) should:

- Arrange appropriate epidemiological investigation of a case or outbreak of legionnaires' disease. This should be done in liaison with the clinical microbiologist where one is employed
- Inform HPSC of a case or outbreak of legionellosis
- Inform the HSA of a case or outbreak of legionellosis
- Ensure relevant clinicians and general practitioners (GPs) in the area are informed of a case or outbreak where appropriate.

Microbiologist

The microbiologist should:

- Assist at design stage of a new hospital unit or modification by defining where high-risk clinical activities take place e.g. transplant units, intensive care units
- Provide advice on sources and ecology of *Legionella* and on measures likely to prevent or eradicate colonisation of hospital water systems
- Educate physicians to heighten their suspicion of legionnaires' disease and ensure appropriate diagnostic tests are used for patients with pneumonia
- Advise on the microbiological confirmation of any case of legionnaires' disease
- Notify the MOH of any case of legionnaires' disease
- Alert other hospital consultants when there is a confirmed case of nosocomial legionnaires' disease
- Arrange laboratory testing of clinical and environmental samples.

Infection prevention and control clinical nurse specialist

The infection prevention and control clinical nurse specialist should:

- Formulate infection control policies as considered necessary by the EMC and provide staff education on these policies
- Provide advice on infection prevention and control, where appropriate, to staff formulating other *Legionella* control policies
- Educate personnel on the infection prevention and control aspects of such policies.

Senior medical officer in department of public health

The senior medical officer (SMO) should:

- Confirm any report of legionellosis
- Investigate the case, liaising with other members of the investigating team to identify potential sources of infection

- Complete the HPSC enhanced surveillance form (Appendix J) and collect any additional relevant information using Checklist 4 and 5 in Chapter 9, Section 9.2 by interviewing the patient or surrogate
- Identify any additional risk groups by using the enhanced surveillance form and checklist.

Principal environmental health officer

The principal environmental health officer (PEHO) should:

- Liaise with the SMO and public health department re potential sources of infection identified on investigation of the case
- Coordinate the examination of potential environmental sources of infection. This includes decision-making re samples/environmental checks to be carried out and assessment of buildings, operational difficulties, etc. and where appropriate, the carrying out of such testing by the environmental health service
- In situations where the above expertise already exists (e.g. in the acute hospital setting) the PEHO should be kept fully briefed and advise on the appropriateness of actions taken.

Hospital clinician

The hospital clinician should:

- Assist at design stage of a new hospital unit or modification by defining where high-risk clinical activities take place e.g. transplant units, intensive care units
- Consider the diagnosis of legionnaires' disease in all cases of pneumonia and to request *Legionella* diagnostic tests if appropriate
- Notify the MOH of any case of legionellosis.

Principal dental surgeon

The principal dental surgeon should:

- Ensure that all currently available infection prevention and control measures are put in place to minimise the contamination of dental unit water lines and to advocate for further design improvements.

Environmental services officer or equivalent

There should be an environmental services officer or equivalent in all HSE areas and they should:

- Provide a central leadership role in the management of all environmental issues
- Provide advice to the EMCs on how other areas are achieving desired results
- Audit and report on compliance with guidelines and standards.

8.2 Travel-associated legionnaires' disease

With travel-associated legionnaires' disease it is important to realise that the source of a person's illness could be one of many places and not just the accommodation site itself. During any holiday, particularly in warmer climates people will come into regular contact with showers and air conditioning systems at multiple sites. However, if two or more cases are linked to the same site then it becomes more likely that this is the source of their infections. At this point samples of water may be taken from the site. If legionellae are found in the water samples, and if appropriate samples are available from the cases these can be compared to see if they are the same. Microbiological tests can be carried out which can prove that the site was the source of a patient's infection. However, this is not possible in most cases.

Legionnaires' disease is of particular relevance for travellers since the clients at a hotel may come from many different countries. The length of the incubation period means that many people who are infected while travelling will not become ill until after they return home. This can make it hard for the authorities in one country to locate the source of each case's infection. By pooling the data for a number of countries it is possible to identify accommodation sites that have been associated with more than one case. The authorities of the country in which the suspect site is located can then be informed.

The European Surveillance Scheme for Travel-Associated Legionnaires' Disease (EWGLINET) is one of the components of the European Working Group for Legionella Infections (EWGLI). EWGLINET operates as a disease-specific network according to Decisions 2119/98/EC⁹⁹ and 2000/96/EC¹⁰⁰ for the setting up of

a network for the epidemiological surveillance and control of communicable diseases in the Community. As of January 2008, 35 countries (24 European Union (EU) member states and 11 non-EU countries) were contributing or receiving data on travel-associated cases.¹⁰¹ Liaison with other international authorities takes place if the travel-associated infection is linked to countries outside Europe, e.g. the USA, Australia, Canada, the Caribbean and the Dominican Republic. The European Centre for Disease Prevention and Control will take over and operate this network in 2010.

Through the European Commission Directive for Package Travel 90/314/EEC of 13 June 1990,¹⁰² tour operators in Europe have a legal duty to protect the health and welfare of clients within the package they deliver. Procedures for reporting cases of travel-associated legionnaires' disease to tour operators were formalised and adopted by some European countries following the implementation of the directive. These procedures were updated in the review of the EWGLI guidelines which came into use on January 2005.²⁵ As a consequence, tour operators are no longer routinely informed about clusters of cases associated with tourist accommodation. However, the EWGLINET coordinating centre in London informs the International Federation of Tour Operators of large outbreaks or clusters of three or more cases. If a cluster involves three or more cases within a short period of time and one or more cases were in an Irish resident, HPSC as the EWGLINET collaborator in Ireland, would inform the Irish Federation of Tour Operators directly.

8.2.1 Reducing the risk of legionnaires' disease in hotels and other accommodation sites

The risk of legionnaires' disease can be avoided. Any organisation or premises (work-related or leisure-related) which does not have an active programme to control the growth of legionellae is negligent in ensuring the safety of its workers, visitors, guests and others (see Chapters 4 and 5 and Appendix H).

8.3 Dental chair unit waterlines

8.3.1 Introduction

Dental chair units (DCUs) are complex medical devices designed to provide the equipment and services necessary for the provision of a wide variety of dental procedures. Water is needed to cool and irrigate a range of instruments and tooth surfaces during dental procedures, as the heat generated can be detrimental to teeth. Water is also needed for oral rinsing during and following dental treatment and to flush the cuspidor (spittoon) bowl after the patient has finished rinsing. Dental unit waterlines (DUWs) are an essential component of modern DCUs and supply water as a coolant and irrigant to turbine handpieces, ultrasonic scalars, three-way air/water syringes, as well as supplying water for the patient rinse cup filler and cuspidor.

Many studies have shown that output water from DUWs is frequently contaminated with very high densities of microorganisms, especially bacteria.¹⁰³⁻¹⁰⁵ This is a universal problem and virtually all DUWs in standard DCUs are likely to be contaminated.¹⁰³⁻¹¹⁴ Figure 9 shows colonies of bacteria cultured from dental chair unit output water. The different size and colours of the colonies reflect the multi-species population of microorganisms usually found in dental chair unit waterline biofilm.



Figure 9. Colonies of bacteria cultured from dental chair unit output water

Bacterial contamination of DUWs is believed to originate in the DCU water supply which usually contains low levels of microorganisms. The main reason for the extensive contamination present in DUWs is

the complex waterline network within DCUs. This network consists of several metres of tubing with an internal diameter of a few millimeters in which water can stagnate when the equipment is not being used. Microorganisms in water entering the DCU water supply (mainly aerobic heterotrophic Gram-negative environmental bacteria) attach to the internal surfaces of the waterlines where they form microcolonies and eventually give rise to multispecies biofilm. These biofilms are composed mainly of bacterial exopolysaccharide, a slimy polysaccharide material produced by bacteria that is highly hydrated and contains both microcolonies and single cells, interspersed heterogeneously with channels or pores.

Biofilm forms because the water at the edges of the narrow-bore DUW tubing flows more slowly than water at the centre of the tubing and thus there is little or no disruption to the microorganisms present on the inside surface of the waterline. Contact with surfaces also causes the bacteria to become more adhesive. This allows the microorganisms to attach and proliferate whilst releasing some to continue on through the water supply, as planktonic forms, where they may be deposited at other sites within the tubing or are delivered directly into the mouths of patients during dental procedures. Thus biofilm provides a reservoir for ongoing contamination of dental unit output water. Most of the bacterial populations found in DUWs also occur in mains water where they are present in lower numbers. Biofilms often exhibit resistance to disinfectants due to delayed penetration into the polysaccharide matrix.^{115,116} The presence of Gram-negative bacteria in waterline biofilm can also result in the presence of bacterial endotoxin in DUW output water.^{117,118} Endotoxin consists of lipopolysaccharide (LPS) released from the cell walls of Gram-negative bacteria following cell death. Bacterial endotoxin levels $\geq 1,000$ endotoxin units/ml have been recorded in DUW output water.¹¹⁷ In contrast, the permissible levels of endotoxin allowed for sterile water for injection in the USA is 0.25 units/ml. Significant doses of endotoxin may cause adverse effects in susceptible individuals. The findings of recent studies suggest that temporal onset of asthma may be associated with occupational exposure to contaminated DUWs among dentists.^{119,120}

8.3.2 Risk to patients and dental healthcare personnel

The presence of high densities of microorganisms in dental unit water is a potential risk of infection for dental patients and staff and is incompatible with good hygiene and cross-infection control and prevention practices. Furthermore, studies have shown that waterborne bacteria are aerosolised during dental procedures and that dental personnel and patients are exposed to these microorganisms and fragments of biofilm. DUW contamination is of particular concern in the treatment of immunocompromised and medically compromised individuals. These groups of individuals frequently seek routine care in the modern dental surgery.¹²¹⁻¹²⁴

Some of the bacteria found in dental unit water are known to cause disease in humans. Of particular concern are *Pseudomonas*, *Legionella* and non-tuberculosis *Mycobacterium* species. *Pseudomonas* species, especially *P. aeruginosa*, are well-known opportunistic pathogens that can survive on a limited supply of nutrients, and which often exhibit resistance to antibiotics and disinfectants. It is important to emphasise that only a few cases of infectious disease transmission related to DUWs and related biofilm have been reported in the literature. However, there is considerable potential for infection with bacterial pathogens such as *P. aeruginosa*, *L. pneumophila* as well as other organisms. In 1987, Martin reported that abscesses caused by strains of *P. aeruginosa* in two immunocompromised patients were attributable to exposure to contaminated dental unit water. Martin also isolated *P. aeruginosa* from the oral cavities of 78 healthy patients for 3-5 weeks following exposure to dental unit water contaminated with *P. aeruginosa*.¹⁰⁸

There is no evidence that any patient has ever contracted legionellosis from a dental chair. Several studies however, have reported the presence of *Legionella* in DUWs.^{111,125} In 1995, Atlas *et al.*, reported the death of a Californian dentist resulting from legionnaire's disease possibly due to exposure to dental unit water.¹¹⁰ Occupational exposure to aerosols of waterborne bacteria, generated by dental unit handpieces, can also lead to colonisation of dental staff and a higher prevalence of antibodies to *Legionella*. One study of a group of dental staff with more than two years clinical experience revealed that 23% were IgG antibody-positive and 19% were IgM antibody-positive for *L. pneumophila* compared to IgG antibody-positive levels of 8% for individuals who had no clinical experience.¹²⁶ The possibility still remains that DUW-associated infections have gone unrecognised or unreported because of the failure to associate exposure to DUW aerosols with the development of specific infections.¹²⁵ Sporadic infections not requiring hospital admission are also less likely to be investigated or notified. There are also the recognised risk factors for legionnaires' disease to be taken into account (see Chapter 1, Section 1.5).

In recent years, there has been increased media and public concern about the lack of infection control within the healthcare system in general. Currently there are no microbial quality standards imposed for dental unit output water within the EU. However, it is not unreasonable to expect that the quality of dental unit output water should approximate the potable drinking water standards. The potable water (drinking

water quality) standards set for the EU, the USA and Japan are 100 cfu/ml, 500 cfu/ml and 100 cfu/ml, respectively, of aerobic heterotrophic bacteria.¹²⁷⁻¹²⁹ In 1995, the American Dental Association (ADA) established a goal for the year 2000 of ≤ 200 colony forming units (cfu) per ml of aerobic heterotrophic bacteria for dental unit output water.¹³⁰ However, this has not been achieved in practice. The current CDC guidelines for infection control in dental healthcare settings recommend that dental unit output water should contain ≤ 500 cfu/ml of aerobic heterotrophic bacteria.¹³¹

A recent symposium entitled *Microbiology of dental unit water lines; setting standards for the future*, that was held as part of the Pan-European Federation/International Association for Dental Research meeting held at Trinity College, Dublin, during September 2006 debated setting a standard for DUW output water quality.¹³² The symposium was the first occasion that scientists and clinicians from academia and dental practice came together in Europe to discuss the universal problem of DUW biofilm and practical solutions. The consensus from the symposium was that in the absence of an EU standard for DUW output water quality, every effort should be employed to ensure that DUW output water quality in Europe complies with the ADA standard of < 200 cfu/ml.

8.3.3 Control of *Legionella* bacteria in dental chair unit waterlines

Numerous suggestions for reducing the bacterial density in dental unit output water have been proposed but none have been universally accepted which are both efficient at eliminating biofilm, as well as being safe for patients. One widely used practice for reducing the bacterial density in dental unit output water involves flushing DUWs with water. Flushing DUWs at the start of the clinical session to reduce the microbial density in output water **does not** affect waterline biofilm or reliably improve the quality of the output water used during dental treatment.¹⁰⁹ Using tap water, distilled water or sterile water in a self-contained bottle reservoir system **will not** eliminate bacterial contamination in output water if waterline biofilms are not effectively controlled. While flushing can result in a reduction in microbial density by several orders of magnitude, studies have reported that microbial densities after flushing were still unacceptably high.¹⁰⁹

The most efficient means of maintaining good quality DUW output water is regular disinfection of DUWs with a disinfectant or biocide that removes biofilm from the waterlines resulting in output water of potable quality.^{104;105;133;134} Very few studies have actually investigated the efficacy of disinfectants to achieve these desired effects in DCUs. However, a number of recent studies have demonstrated the efficacy of a range of disinfectant products approved for DUW disinfection that efficiently remove biofilm and reduce bacterial density to potable water quality or better.^{104;105;133-135} However, biofilm regrowth can occur within a week or so following disinfection and so **DUWs should be disinfected at least once weekly with an appropriate disinfectant**. Disinfectants that contain a coloured dye are particularly useful as they permit the individual undertaking waterline disinfection to ensure that each waterline is filled with disinfectant by visual observation of the elution of the dye from handpiece, scaler, cupfiller and three-in-one syringe waterlines, etc. Care should be taken to avoid exposure to aerosolised waterline disinfectant.

A wide variety of commercial waterline cleaning products and systems are available.^{104;105;124;133-137} **Dental practitioners should contact the manufacturer of their specific DCU model for advice on products and procedures for waterline disinfection.** In DCUs supplied with a bottle reservoir, approved biocides can be added to the bottle, aspirated into the waterlines and left for an appropriate time to disinfect. Following disinfection, all of the waterlines should be thoroughly flushed to eliminate biocide. In DCUs supplied with mains water, dental practitioners should contact the DCU manufacturer for advice on biocide delivery. Some brands of DCU are supplied with an integrated waterline cleaning system.^{104;105;133} When choosing a biocide, users should ensure that the efficacy and safety of biocides for dental unit waterline disinfection have been determined independently and the results published in international peer-review journals.¹³⁷ Manufacturers should be able to provide this information.

For patient comfort, some DCU models provide heated water (approximately 20°C) to dental handpieces, ultrasonic scalers and air/water syringes - ideal conditions for the proliferation of *Legionella* bacteria. It is recommended that qualified maintenance personnel, having consulted the DCU manufacturer, should decommission the water heaters in such DCUs.¹³⁷

Dental healthcare personnel should be educated regarding water quality, biofilm formation, water treatment procedures and adherence to maintenance protocols. Dental practitioners should seek advice from the manufacturer of their dental unit or water delivery system to determine the most appropriate method for maintaining acceptable output water quality. In general, waterlines should be disinfected **at least** once a week with an approved biocide.

Microorganisms, blood and saliva from the oral cavity can enter the dental unit waterline system during patient treatment. Thus handpieces, ultrasonic scalers and air/water syringes should be operated for a minimum of 20 to 30 seconds after each patient to flush out retracted material. Even for devices fitted with antiretraction valves, flushing devices for a minimum of 20 to 30 seconds after each patient is appropriate. Care should be taken not to inhale the aerosol generated.

Water may be supplied to DUWs from a number of sources. These include connections to the public water supply mains, water storage tanks and independent reservoirs within the DCU. Disinfectant can be introduced into DUWs from independent reservoir bottles, or from disinfectant delivery devices connected to the DCU water supply. In the case of DCUs connected to public water mains supply, it is imperative that the connection is turned off prior to DUW disinfection to prevent contamination of mains water with disinfectant. After disinfection, DUWs should be thoroughly flushed with clean water before DCUs are used for patient treatments. The water distribution systems in some DCU models are fitted with an air gap that physically separates the water within DUWs from the supply water, thus preventing backflow of disinfectant or contaminated water into the supply water network.^{105;137} Saliva, blood and oral microorganisms can be aspirated into DUWs during patient treatments due to faulty handpiece antiretraction valves.^{131;138-140} This is more likely to be a problem in older DCU models, older handpieces and poorly maintained handpieces, although a recent Italian study of 54 DCUs, comprising 18 different models by six different DCU manufacturers demonstrated an antiretraction device failure rate of 74% (40/54 DCUs tested).¹⁴⁰

Dental handpieces that are connected to DUWs and which are used in the oral cavity, such as turbines, ultrasonic scalers and air/water syringes, should be run for a minimum of 30 seconds after each patient treatment to flush out patient material that may have been retracted into DUWs during use of the handpiece during patient treatment.

There is an onus on DCU manufacturers to consider the problem of DUW biofilm contamination when designing DCUs. In fact a variety of disinfection devices and systems are currently available for DUW disinfection, although detailed comparative studies have yet to be undertaken.^{105;133;137}

Regular disinfection of DUWs with an approved treatment regimen and biocide should also effectively control the levels of *Legionella* in DUWs. **There is no need for additional disinfection protocols.** Dental healthcare personnel should be familiar with the HPSC guidance for control of *Legionella*. Each practice should undertake a formal *Legionella* risk assessment which should be revisited and revised annually. All water systems (water tanks, etc.) should be maintained as outlined in Chapters 4 and 5. In relation to the water distribution system supplying the dental clinic, hot water should be circulated at a temperature of at least 50°C and cold water should be circulated at <20°C to minimise growth of *Legionella*. All redundant or seldom used sanitary ware (i.e. showers, wash hand basins, toilets) should be removed along with their supply pipes to prevent dead legs (areas where water can stagnate).

8.3.4 Portable ultrasonic scalers and mobile DCUs

Portable auxiliary units used by dental hygienists, such as independent ultrasonic scalers, also require cooling water. The DUWs in these units should also be subject to regular disinfection (at least once a week) with an approved biocide. The unit manufacturer should be consulted in relation to the type of biocide to be used. The DUWs of portable DCUs, such as those that may be used by defence forces medical units as part of mobile field hospitals or by Civil Defence units, should be subject to disinfection in the same way as conventional DCUs. Portable DCUs should have their DUWs drained when not in use or during storage. Following storage or during periods of infrequent use, DUWs should be disinfected prior to patient treatment.

8.3.5 Record keeping, equipment maintenance, quality assurance and periodic review of procedures

All DCUs should be serviced at appropriate intervals as recommended by the manufacturer. **The efficacy of waterline cleaning should be tested (total viable counts) periodically (six monthly) using validated procedures.** This can be achieved by determining the aerobic heterotrophic bacterial count in DCU output water immediately following disinfection on R2A agar following seven days incubation at room temperature (approx. 20°C).^{104;105;133} A variety of commercial laboratories can provide this service.

Written or electronic records of weekly waterline disinfection, equipment maintenance and periodic waterline cleaning efficacy testing should be retained.

8.4 Decorative fountains, water features and planters

Many modern buildings including hospitals and other healthcare facilities feature decorative fountains and planters in an effort to make patients and visitors more relaxed with their surroundings. These can be found both indoors and outdoors. The wet or damp surfaces of fountains and other water features or moist planter soils and trays readily become coated with a growing biofilm of microorganisms unless particularly well managed. This can act as a reservoir for their transmission and dispersion.^{141;142} Such features or activities near them may generate aerosols and thus pose a particular risk of infection by *Legionella* bacteria following aerosol inhalation.^{141;143-146}

8.4.1 Hospitals and healthcare institutions

Hospitals and other healthcare institutions (e.g. day clinics, nursing homes, homes for the care of the elderly) should not contain decorative fountains or other water features that generate aerosols, as the risk of disease transmission to immunocompromised and debilitated patients outweighs their benefit. However, when they are present in hospitals and other healthcare institutions, features that generate aerosols should be well maintained and periodically cleaned and disinfected with an effective biocide. All wetted surfaces should be disinfected and descaled if necessary. This position is supported by a guideline issued by the CDC for Environmental Infection Control in Health-Care Facilities.¹⁴⁷

Fountain and water feature maintenance should be integrated with the hospital/institution infection prevention and control and facilities maintenance programmes and should be tested periodically for the presence of *Legionella* bacteria. Fountain and water feature water recirculation systems and spray heads should be especially well maintained. Submerged lighting should be discouraged as this can contribute to heating of the water and result in water temperatures conducive to the growth and proliferation of *Legionella* bacteria.¹⁴¹ Maintenance of fountains and water features during the summer months is particularly important as elevated air and water temperatures will encourage the growth and proliferation of microorganisms.

Many hospitals and other healthcare institutions in Ireland already have water features that generate, or can generate, aerosols, mostly in public areas. If these cannot be maintained to minimise the risk of disease transmission as indicated above, they should be removed.

Decorative fountains and other water features should be excluded from hospitals and other healthcare institutions, at the design and planning stage.

Small decorative water features

In recent years, small decorative fountains and water features for use in buildings open to the public or for use in private homes have become very popular. These have been readily available to purchase in garden centres, DIY stores, etc. Recently, a small decorative fountain was shown to be the source of an outbreak of legionnaires' disease in the USA.¹⁴⁶ The authors believe that this was the first time that a small fountain with apparently limited aerosol-generating capability has been implicated as the source of a legionnaires' disease outbreak. Investigations of future community cases of legionellosis should consider exposures to small indoor decorative fountains, such as those that might be present in private homes, restaurants, hotels, or other businesses, as potential sources of *Legionella*. Small decorative fountains should not be used in buildings open to the public unless they are particularly well maintained. The public should be discouraged from using small decorative fountains and water features in the home unless adequate maintenance and disinfection procedures are provided with the manufacturer's instructions. In general, small water features should be drained and cleaned weekly and should be subject to manual dosing once a day with liquid chlorine to develop 3–5 ppm free chlorine (or equivalent) for one hour (observing adequate safety precautions).

8.4.2 Hotels, restaurants and other commercial buildings

Water features that generate, or can generate, aerosols are often present in public areas in hotels, conference centres and in other commercial buildings and institutions. All of the considerations outlined in the preceding section apply to fountains, water features, and misting devices in restaurant food display cabinets, etc. in these types of buildings. If they cannot be adequately maintained to minimise the risk of disease transmission as outlined in the preceding section, they should be removed.

8.4.3 Recommendations for maintenance of decorative fountains and water features

- Maintain cool water temperatures in decorative fountains and avoid submerged heat-generating lighting
- Use recirculated water. Recirculated water should be filtered and the filters examined, cleaned

and disinfected regularly. If water becomes cloudy or smelly (indicative of extensive microbial contamination), drain the feature completely, followed by thorough cleaning and disinfection. This is particularly important in dusty areas

- Avoid locating decorative fountains in high-risk areas including hospitals
- Ensure routine maintenance of decorative fountains and disinfection in accordance with the manufacturer's instructions. Automatic control and feed of biocide is preferable. Maintain at least 0.5 ppm free chlorine or equivalent continuously
- When water treatment is inactive for three or more days (less in high temperatures or dirty conditions), features should be drained completely, cleaned and disinfected
- A maintenance log should be maintained for all ornamental water features i.e. free chlorine levels, water temperature, visual inspection for cloudy water and areas of slime, filter inspections, filter cleaning, filter changes, pump cleaning (every 3 months), water changes and routine cleaning
- Cleaning and maintenance of ornamental water features should form part of the overall risk management strategy for the premises concerned. A competent person(s) should be responsible for maintaining the feature. It should form part of the normal infection control environmental sampling programme.

8.5 Spa pools

8.5.1 Definition

This section on spa pools is based on and should be read with particular reference to the following document: *Management of spa pools: controlling the risk of infection*, published by the UK Health and Safety Executive and HPA, 2006.¹⁴⁸ Available at http://www.hpa.org.uk/publications/2006/spa_pools/spa_pools.pdf.

A spa pool is a self-contained body of warm, agitated water designed for sitting or lying in up to the neck and not for swimming. It is not drained, cleaned or refilled after each user but after a number of users or a maximum period of time. It is filtered and chemically disinfected.¹⁴⁸

Spa pools contain water heated to 30°C - 40°C and have hydrotherapy jet circulation with or without air induction bubbles. They can be sited indoors or outdoors. Common terms for spa pools include hot spa, hot tub, whirlpool spa and portable spa. Jacuzzi is the registered trade name of a specific manufacturer and should not be mistaken for a generic name for spa pools.

Commercial spa pools

A commercial spa pool is an overflow/level deck spa pool installed in a commercial establishment or public building and generally used by people visiting the premises. Typical sites for commercial spa pools include hotels, health clubs, beauty salons, gymnasias, sports centres and clubs, swimming pool complexes and holiday camps. A spa pool in such a location is considered commercial even if payment for use is not required.

Thalassotherapy pools use seawater or sea products e.g. seaweed, for health or beauty benefits. Many of the principles that apply to spa pools also apply to these.³

A domestic spa pool installed in a hotel bedroom or holiday home should also be managed as a commercial spa pool. Similarly spa pools rented out to domestic dwellings for parties, etc. must also be considered commercial.

Domestic spa pool

A domestic spa pool or hot tub is a freeboard or overflow/level deck spa pool installed at a private residence for the use of the owner, family, and occasional invited guests.

Whirlpool baths

These are typically used in beauty parlours, health suites, hotels and dwellings. They are also being used in healthcare premises. Water within the bath is untreated and the bath is drained following each use. Whirlpool baths experience similar problems to spa pools with the formation of biofilm within the pipework system associated with the air and water booster jets, so regular disinfection is recommended. They are unsuitable for use in healthcare facilities as the risks outweigh the benefits.

Natural spas

The hazards associated with the use of natural spas are essentially the same as with artificial spa pools.¹⁴⁸

8.5.2 Infection risk

Spa pools are potentially a high-risk source of pathogenic microorganisms, including *Legionella*. They should be designed, installed, managed and maintained with control of microbial growth in mind.³ Spa pools are much smaller than swimming pools and have a higher ratio of bathers to water volume so the amount of organic material in spa pool water is far higher than in swimming pool water. They also have an extensive surface area within the pipes used to provide both the air and water-driven turbulence.¹⁴⁸ The pipes and balance tank are often inaccessible and difficult to clean and drain and may have areas of stagnation which allows biofilm to grow. The pipes above the waterline often do not receive disinfection from the pool water which also predisposes them to biofilm formation.³

Infectious agents can easily be introduced to a spa pool via bathers, from dirt entering the pool or from the water source itself. Once in the spa pool, conditions often exist which promote the growth and proliferation of these agents.¹⁴⁸ *Legionella* bacteria frequently grow in poorly designed and poorly managed spa pools. The water is vigorously agitated and this leads to the formation of aerosols that can be inhaled. This means even people not in the immediate vicinity of the spa pool can breathe in the aerosol.³ There have been a number of outbreaks of legionnaires' disease associated with spa pools in recent years.^{10;149} Spa pools are the commonest source of legionnaires' disease outbreaks on cruise ships (see Section 8.6). Water disinfection is therefore a key control measure in spa pools although the raised temperature and high organic content can make it difficult to maintain effective disinfection.¹⁴⁸

8.5.3 Duties of designers, manufacturers, importers and suppliers

Under section 16 of the Safety, Health and Welfare at Work Act 2005,¹⁵⁰ a person who designs, manufactures, imports or supplies a spa pool, must ensure, as far as is reasonably practicable, that the pool is designed and constructed so as to be safe and without risk to health when properly used by a person at work. They must ensure that adequate information is provided to ensure its safe use including information on its safe installation, maintenance, cleaning, dismantling or disposal. Any revisions of the information must also be provided if a serious risk to health or safety becomes known.

Consideration should be given to the materials used during design and installation, avoiding materials that support microbial growth. All parts of the system should be accessible to facilitate easy cleaning, disinfection and maintenance. Spa pools should not be located too near swimming pools.

8.5.4 Identification and assessment of the risk associated with spa pools

It is the responsibility of the person operating a spa pool (duty holder) to ensure that persons in or around the spa pool are not exposed to infectious agents including *Legionella* (not applicable to spa pools used for domestic purposes). In order to do this a written risk assessment must be undertaken. When conducting a risk assessment of a spa pool, the individual nature of the premises and spa pool should be considered. In this regard, it is important to have an up-to-date schematic diagram of the spa pool and associated plant. This can be used to decide which parts of the spa pool pose a risk to workers and users.¹⁴⁸

The person conducting the risk assessment should have adequate knowledge, training and expertise to understand and control the risk associated with *Legionella* in spa pools. They should also have the authority to collect all the information needed to do the assessment and to make the right decisions about the risk and precautions or control measures needed.

8.5.5 General factors to be considered in the risk assessment

General factors to be considered in the risk assessment include:¹⁴⁸

- The source of the water supply e.g. from the mains supply or an alternative
- Possible sources of contamination of the supply water e.g. biofilms within the pipework, bathers, soil, grass, and leaves (for outdoor spa pools)
- The normal operating features of the spa pool
- The people who will be working on or in the vicinity of the spa pool or using it
- The measures taken to adequately control exposure, including the use of PPE if necessary
- Breakdowns, etc.

8.5.6 Specific factors to consider

Specific factors to consider include:

- The type, design, size, approximate water capacity and designed bather load of the spa pool
- The type of dosing equipment including the use of automatic controls, pump arrangements, balance tanks and air blowers
- The piping arrangements and construction materials
- The type of filtration system
- The heat source and design temperature
- The chemical dosing equipment including chemical separation, PPE, and chemical storage arrangements
- The type of treatment to control microbiological activity e.g. chlorine or bromine. Bromine treated pools are more likely to have poor results than chlorine treated pools
- The method used to control pH, e.g. sodium bisulphate
- The cleaning regime – ease of cleaning, what is cleaned, how and when
- The testing regime including microbiological tests, the frequency of tests, operating parameters, action required when results are outside the parameters.

The significant findings of the risk assessment should be recorded. The written risk assessment should be linked to other health and safety records e.g.

- An up-to-date plan of the spa pool and plant
- The description of the correct and safe operation of the spa pool
- The precautions to take when running and using the spa pool
- The checks required to ensure the spa pool is working safely and
- Remedial action required in the event that the spa pool is not running safely.

The risk assessment should be reviewed at least annually and whenever there is a reason to suspect that it is no longer valid e.g.

- There are changes to the spa pool or the way it is used
- There are changes to the premises in which the spa pool is installed
- If changes are made to the disinfection procedures
- New information is available about the risks or control measures
- The results of tests indicate control measures are not effective
- An outbreak of disease e.g. legionnaires' disease is associated with the spa pool.¹⁴⁸

8.5.7 Managing the risk

Everyone involved in the risk assessment and management of spa pools should be competent, trained and aware of their responsibilities. The control measures and their implementation should be regularly monitored. Staff responsibilities and lines of communication need to be clearly defined and documented.¹⁴⁸

8.5.8 Records

The following records should be kept:

- The names of the people responsible for conducting the risk assessment, managing and implementing control measures
- The significant findings of the risk assessment
- The scheme for controlling the microbiological hazard and details of its implementation
- The results of any monitoring, inspection, test or check carried out on the spa pool, along with dates.

The records must be available for inspection by the HSA and should be available for inspection by environmental health officers. The results of monitoring, inspections, testing or checks should be kept for at least five years.

8.5.9 Monitoring

It is the responsibility of the owner to arrange routine microbiological or chemical testing. Poolside testing and recording of residual disinfectant and pH levels should be undertaken before the spa pool is used each day and thereafter at least every two hours in commercial spa pools. The following on-site indicators should be monitored:

- Colour of the water
- Clarity
- Temperature
- Chlorine (free, total and combined) or bromine levels in pool
- pH
- Number of bathers.

The residual disinfectant and pH levels that should be maintained are set out in Table 14 below:

Table 14. Desired disinfectant and pH levels

Disinfectant used	Desired level
Chlorine	Free chlorine residual of 3-5mg/l
Bromine	Total active bromine of 4-6mg/l
pH	7.0-7.6

Information obtained from regular monitoring can indicate:

- Whether or not water replacement and backwashing are being undertaken at sufficient frequency
- Disinfectant levels are adequate
- Show whether or not the operation of the water treatment plant is coping effectively with the bather load
- Highlight any unnecessary hand dosing of water treatment chemicals
- Provide information on the condition of the filter bed
- Provide advanced warning of failure of filter, pumps, valves, etc.

Laboratory analysis is not part of the daily regimen but frequency should be indicated by the risk assessment. The total dissolved solids (TDS) should be monitored daily, and the water balance weekly if required.

Routine microbiological analysis should also be undertaken to ensure that optimum water treatment conditions are being maintained. While chemical analysis is of benefit to monitor the efficiency of the water treatment system in dealing with the pollution loading, it is important that it is carried out together with microbiological analysis to enable a complete assessment of the water treatment operation and management.

Microbiological samples for indicator organisms should be taken at least once a month as a routine and quarterly for *Legionella*. More frequent sampling may be required depending on the risk assessment, e.g. if the spa pool is being intensively used or if there are any adverse health effects reported by the bathers. Spa pools that are situated outdoors have additional demands placed on the disinfection and filtration systems from environmental contamination by dust, debris, etc. Microbiological sampling should also be done when a spa pool is first used or recommissioned, or there are alterations in the treatment/maintenance regimes.

Routine sampling should be done when the spa pool is in use, preferably when heavily loaded or immediately thereafter. Table 15 shows the guidelines for interpretation of the *Legionella* sampling results.

Table 15. *Legionella* sampling

No. of <i>Legionella</i> bacteria (cfu/litre)	Interpretation
<100	Under control
≥ 100 to ≤ 1,000	Resample and keep under review Advise to drain, clean and disinfect Review control and risk assessment; carry out remedial actions identified Refill and retest next day and 2-4 weeks later
>1,000	Immediate closure. Exclude public from pool area Shut down spa pool Shock the spa pool with 50mg/l free chlorine circulating for one hour or equivalent Drain, clean and disinfect Review control and risk assessment; carry out remedial actions identified Refill and retest next day and 2-4 weeks later Alert the local departments of public health and environmental health Keep closed until legionellae are not detected and the risk assessment is satisfactory

Source: Adapted from the UK Health and Safety Executive/Health Protection Agency Management of Spa Pools¹⁴⁸

Well-operated spa pools should not normally contain *Legionella* species. The microbiological results should not be considered in isolation but in the context of the management records for the spa pool.

8.5.10 Summary of spa pool checks (excluding domestic pools)

Daily

Before opening the spa pool

- Check the log from the day before
- Check water clarity before first use
- Check automatic dosing systems are operating (including ozone or ultraviolet (UV) lamp if fitted)
- Check that the amounts of dosing chemicals in the reservoirs are adequate
- Determine pH value and residual disinfectant concentration.

Throughout the day

- Continue to check automatic dosing systems are operating (including ozone or UV lamp if fitted)
- Determine pH value and residual disinfectant concentration every two hours
- Determine the TDS, where appropriate.

At the end of the day after closing the spa pool

- Clean water-line, overflow channels and grills
- Clean spa pool surround
- Backwash sand filter (ensure water is completely changed at least every two days) - for diatomaceous earth filters comply with the manufacturer's instructions. Backwashing should be carried out last thing at night when there are no users in the pool. There is effectively no disinfectant in the water when backwashing is being carried out and leaving overnight allows the sand to settle again
- Inspect strainers, clean and remove all debris if needed
- Record the throughput of bathers, unless water is being changed continuously
- Record any untoward incidents.

To be done at every drain and refill

- Drain and clean the whole system including balance tank at least once weekly
- Clean strainers
- Check water balance after the refill, if necessary.

Monthly

- Microbiological tests for indicator organisms
- Full chemical test (optional)
- Clean input air filter when fitted
- Inspect accessible pipework and jets for presence of biofilm; clean as necessary
- Check all automatic systems are operating correctly e.g. safety cut-outs, automatic timers, etc.
- Disinfectant/pH controller - clean electrode and check calibration (see manufacturer's instructions).

Quarterly

- Thoroughly check sand filter or diatomaceous earth filter membranes
- Where possible clean and disinfect airlines
- *Legionella* tested by laboratory.

Annually

- Check all written procedures are correct
- Check sand filter efficiency.

Source: HSE and HPA Management of spa pools: controlling the risks of infection (summary of checks, Section 2.3.8)¹⁴⁸

8.5.11 Hydrotherapy pools

The terms hydrotherapy spas or hydrotherapy pools refer to heated water pools (typically 36°C -37°C) used for special medical or medicinal purposes. Hydrotherapy pools are usually located within healthcare facilities, in which healthcare staff such as physiotherapists, perform treatments on patients for a range of physical symptoms. Hydrotherapy pools are not drained, cleaned or refilled after each use but following a number of uses or a maximum time period. Many of the principles that apply to the control of *Legionella* and other potentially infectious microorganisms in swimming pools and spa pools also apply to hydrotherapy pools.^{148,151,152} **In general, much of the guidance provided in this document relating to spa pools can be directly applied to hydrotherapy pools.** Some additional guidelines regarding management of hydrotherapy pools to reduce infection risks, including *Legionella*, are provided below.

Appropriate management of hydrotherapy pools is necessary to maintain the proper balance of water conditioning (i.e. alkalinity, hardness, and temperature) and disinfection. The most widely used chemicals for disinfection of hydrotherapy pools are chlorine and chlorine compounds. Water supply pipes, pumps and filters have to be well maintained to minimise the potential of this equipment acting as a reservoir for waterborne microorganisms. Patients who suffer with faecal incontinence or who have open infected wounds should refrain from using hydrotherapy pools until their condition resolves.

Maintenance of hydrotherapy poolside

- The poolside area should be cleaned daily with pool water
- The poolside area should be cleaned weekly using a solution containing 200 ppm of free chlorine
- In the event of soiling, the soiled area should be cleaned immediately
- The pool chamber should be subject to regular maintenance.

Maintenance of hydrotherapy pool water

- There should be regular monitoring and record keeping
- The pool water turnover time should not exceed 60 minutes
- The appearance of the water at the beginning of each day should be noted with respect to colour and turbidity
- The pool water should appear clear before a patient enters. Turbidity, cloudiness or the presence

of visible particulate matter indicates poor water quality

- The number of patients treated in the pool at each session should be recorded (each hour of use should be divided into three 15-minute treatment sessions with a 5-minute break)
- Patients should not stay in the pool for more than one session
- Back flushing of water filters should occur at a frequency to maintain water quality
- The pool water volume should be maintained with water directly from a mains water supply
- Equipment used for measuring pH, chlorine levels, etc. should be well maintained and subject to periodic maintenance and calibration.

Testing of hydrotherapy pool water

- The pH of water should be measured at the beginning of the day, then every two hours and at the end of each day. It should be within the range 7.2 - 7.8
- The temperature of the water should be recorded twice daily and should be kept between 35.5°C and 36°C
- The free chlorine should be measured three times a day and should fall between 1.5 and 5.0 mg/l. The total chlorine should be measured once with the free chlorine to give the combined chlorine (total chlorine-free chlorine). Free chlorine should not exceed one-third of the total chlorine
- TDS should be measured daily and should not exceed 1,500 mg/l respectively.

Testing the microbiological quality of hydrotherapy pool water

- Total bacterial counts should be measured weekly and should ideally be below 10 cfu/ml and remedial action should be taken if the counts exceed 100 cfu/ml. Coliforms, *Escherichia coli* and *P. aeruginosa* should be less than 1 cfu/100 ml.

8.6 Legionellosis aboard ships

Travelling aboard ship or being aboard ship is an established risk factor for legionellosis. There have been numerous cases of legionellosis acquired on ships and thus appropriate management of wet environments on ships is vital to prevent such outbreaks.¹⁵³⁻¹⁵⁹ Essential control measures, such as proper disinfection, filtration and storage of source water, avoidance of dead legs and regular cleaning and disinfection of spa pools are required to minimise the risk of legionellosis on ships. The World Health Organization (WHO) currently provides comprehensive guidance on *Legionella* risk assessment and control measures in relation to ships in its document *Guide to Ship Sanitation*.¹⁶⁰ This document should be consulted for detailed guidance relating to the management of *Legionella* risks aboard ships.

8.6.1 Risk factors associated with ships

Ships are considered to be high-risk environments for the proliferation of *Legionella* bacteria for a variety of reasons:

- Source water quality could be of potential health concern if it is untreated or if only treated with a residual disinfectant prior to or upon uploading onto ships
- Water storage and distribution networks on ships are complex and could provide greater opportunities for bacterial contamination as ship movement increases the risk of surge and back-siphonage
- Bacterial proliferation is encouraged due to long-term storage and stagnation in tanks or within the water distribution pipework
- Loaded water may vary in temperature and under certain climatic conditions the risk of bacterial growth is increased because of higher water temperatures.

8.6.2 Controlling the risks

Ships should be supplied with potable water. However, even if there are low numbers of *Legionella* bacteria in the water taken aboard ship, *Legionella* bacteria can still proliferate due to factors within the ship environment, including periods of water stagnation and elevated water temperatures. The occurrence of high densities of *Legionella* bacteria in drinking water aboard ship is avoidable through the implementation of basic water quality management procedures:

- Only potable water should be supplied to ships. Water should be treated appropriately if it is

- uplifted from a non-potable or suspect source
- Residual disinfectant (e.g. > 0.5mg/litre free chlorine) should be maintained throughout the water distribution system
- Hot water should be produced and stored at > 60°C and delivered to outlets at ≥ 50°C
- Cold water should be maintained and delivered to outlets at < 20°C
- It is imperative that all pipework and storage tanks are insulated appropriately to ensure that hot and cold water are provided within the temperature ranges mentioned above.

High water temperature is the most efficient approach for continuous control in a hot water system. However, it is important to note that maintaining operating temperatures of hot water systems above 50°C may present a scalding risk at outlets. Maintaining cold water temperatures at < 20°C is very effective in preventing the proliferation of *Legionella* bacteria but may be difficult to achieve in some water distribution systems, particularly during warm weather. In the case of the latter, maintaining a residual disinfectant in the cold water distribution system (e.g. > 0.5 mg/litre free chlorine) is essential.

8.6.3 Maintenance

It is essential that the water distribution systems aboard ships are designed and maintained to minimise opportunities for proliferation of *Legionella* bacteria. Pumps, backflow prevention devices and thermostatic mixing valves should be installed correctly and maintained regularly by appropriately trained personnel. In relation to maintenance, the following points need be considered:

- A clear and accurate schematic of the water distribution system on the ship should be available
- Water flow in the distribution system should be maintained during periods of reduced activity
- Periodic maintenance and cleaning of water storage tanks should be carried out at appropriate intervals and should include where necessary draining, physical cleaning and biocide treatment
- Frequent monitoring of control measures is required to ensure that the system is operating within limits and to provide early warning of deviations. Monitoring should include:
 - Monitoring water temperature
 - Inspecting insulation of pipes
 - Monitoring biocide or disinfectant concentration and associated pH
 - Inspecting pipes, storage tanks, pumps and calorifiers
 - Inspecting backflow preventers
 - Microbial testing.
- *Legionella* can proliferate aboard ship in poorly maintained spa pools and whirlpools, and associated equipment. Specific risk factors include frequency of spa pool use and length of time spent in or around spa pools. *Legionella* levels can be kept under control through the implementation of appropriate controls, including filtration and maintenance of a continuous residual disinfectant biocide in spa pools, and the physical cleaning of all spa pool equipment including associated pipework and air conditioning units (see Section 8.5)
- Water used in decorative fountains and water sprays in HVAC* air-distribution systems should originate in the ship's potable water system and should be treated with biocide to avoid microbial build-up in the operation of the sprays and fountains. Decorative fountains and water sprays in HVAC air-distribution systems should be maintained free of algae and moulds (see Section 8.4)
- Showerheads should be cleaned and maintained regularly (see Chapter 5, Section 5.2.1).

*HVAC is an acronym for heating, ventilating and air conditioning