Health Protection Surveillance Centre

Feidhmeannacht na Seirbhíse Sláinte
Health Service Executive

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National Guidelines for the Control of Legionellosis in Ireland, 2009

Report of Legionnaires' Disease Subcommittee of the Scientific Advisory Committee

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Important Note

We wish to acknowledge that this document has been prepared and should be read with particular reference to the following documents:

Health and Safety Commission. Legionnaires' disease: the control of *Legionella* bacteria in water systems, approved code of practice and guidance. 3rd edition. UK Health and Safety Commission, 2000. ISBN 0 7176 1772 6. Available at www.hse.gov.uk/.

EWGLI. European guidelines for control and prevention of travel-associated legionnaires' disease. European Working Group for Legionella Infections, 2005. Available at www.ewgli.org/.

World Health Organization. *Legionella* and the prevention of legionellosis. Geneva: World Health Organization; 2007. Available at www.who.int/water_sanitation_health/emerging/legionella/en/.

Environment Agency, UK. The determination of *Legionella* bacteria in waters and other environmental samples (2005) – Part 1 – rationale of surveying and sampling. Bristol: Environment Agency; 2005. Available at www.environment-agency.gov.uk/static/documents/Research/book_200_1028650.pdf.

Joint Health and Safety Executive and Health Protection Agency Spa Pools Working Group. Management of spa pools: controlling the risk of infection. London: Health Protection Agency; 2006. Available at www.hpa.org.uk/web/HPAweb&HPAwebStandard/HPAweb_C/1200471665170.

Department of Health, UK, Estates and Facilities Division. The control of *Legionella*, hygiene, "safe" hot water, cold water and drinking water systems: Part B Operational management: Health Technical Memorandum 04-01 (ISBN 13 9780113227457). London: Stationery Office; 2006. Available at www.tsoshop.co.uk/.

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Foreword

Legionellosis is a disease comprising two distinct clinical entities: pontiac fever, a mild self-limiting influenza-like illness, and legionnaires' disease a more serious and potentially fatal form of the illness, characterised by pneumonia. Legionellosis is caused by *Legionella* bacteria which are ubiquitous in nature and can be found naturally in environmental water sources such as rivers, lakes and reservoirs. From there the organism can pass into sites that constitute artificial reservoirs such as water distributions systems in towns and cities. Outbreaks of legionnaires' disease have the potential to cause high levels of morbidity and mortality in those exposed.

In 2002, the Health Protection Surveillance Centre produced national guidelines for the surveillance, diagnosis, and clinical management of legionellosis. It also provided guidance on assessment and management of risks associated with *Legionella* in the environment. Following the publication of the independently chaired report on legionellosis at Waterford Regional Hospital in 2003, the Department of Health and Children requested the HPSC Scientific Advisory Committee to review and update the national guidance on legionnaires' disease. In light of this, the Legionnaires' Disease Subcommittee was re-established to undertake this task.

The recommendations in these guidelines are based on a review of international literature and an extensive consultation process with relevant professionals. I would like to take this opportunity to thank all the members of the subcommittee for their invaluable contributions to this report and also to acknowledge the work and commitment of Dr Lorraine Hickey, in producing this report.

Joan O'Donnell
Chairperson, Legionnaires' Disease Subcommittee
May 2009

Summary of Recommendations

Under the Infectious Diseases (Amendment) (No. 3) Regulations 2003 (S.I. No. 707 of 2003), which came into effect on 1 January 2004, laboratory and clinical notification of legionellosis (includes legionnaires' disease and pontiac fever) is mandatory. It is also mandatory for a medical practitioner and a clinical director of a diagnostic laboratory to notify the medical officer of health of any unusual clusters/outbreaks of legionellosis.

The Scientific Advisory Committee of the Health Protection Surveillance Centre was requested by the Department of Health and Children to review the national guidance on legionnaires' disease following the publication of an independently chaired report on legionellosis at Waterford Regional Hospital in 2003, in order that any revisions required to the Health Protection Surveillance Centre document might be made. In light of this, it was agreed to re-establish the Legionnaires' Disease Subcommittee to review the guidelines which were originally published in 2002.

The following are the recommendations of the subcommittee:

Surveillance and Laboratory Diagnosis

Enhanced surveillance of legionellosis should be maintained at a high level.

Rapid urinary antigen tests should be used more widely in acute hospitals to assist the diagnosis of legionnaires' disease when a patient presents with pneumonia. The urinary antigen test is more sensitive for diagnosing community-acquired and travel-acquired legionnaires' disease than nosocomial infection because the test is more sensitive for the Pontiac subtype of *L. pneumophila* serogroup 1 than for non-Pontiac strains of *Legionella*. Pontiac strains cause the majority of community-acquired and travel-acquired cases and are significantly less common in nosocomial cases. A patient with a pneumonia that does not respond as expected to antibiotic therapy should have culture and serology tests carried out.

Specimens should be sent for culture whenever possible but particularly, in nosocomial cases where non-Pontiac strains are more common, and in outbreak situations. Culture and typing are required for confirmation or exclusion of an implicated site or exposure as a source of infection. Culture on solid media is considered the 'gold standard' for the detection and enumeration of viable legionellae.

All laboratories performing diagnostic tests should be accredited for the methods used and participate in an appropriate external proficiency scheme.

An external proficiency scheme should be developed for Ireland.

Laboratory facilities for environmental testing should be available in each Health Service Executive area and should operate to the International Organization for Standardization standard ISO 11731-2:2004. Additional resources should be provided for this.

A National Legionella Reference laboratory should be established and accredited by the Irish National Accreditation Board for both clinical and environmental sample testing (based on ISO 15189:2007 and ISO 11731-2:2004 respectively), to act as a typing centre and to provide expert opinion on the microbiology of the organism. It should also take part in an external quality assessment scheme for the isolation of *Legionella* from water, sediment, sludges and swabs.

Legislation

The Department of Health and Children, and the Department of the Environment, Heritage and Local Government should consider:

- Legislative controls on standards of maintenance and disinfection of any equipment that poses a risk of producing aerosols contaminated with *Legionella* during normal and abnormal (e.g. during maintenance) operating conditions
- A system of statutory notification by the owner/occupier of high-risk sites e.g. cooling towers
- The provision of legislative backing to an appropriate statutory authority for the monitoring and control of high-risk sites, including those instances where there is a recognised public health risk e.g. guest accommodation and trade shows with open air fountains/spa pools, etc.

Provision should be made for adequate resources and training to ensure effective enforcement of existing legislation.

Employers should ensure, in accordance with the Safety, Health and Welfare at Work Act 2005, that possible exposure to *Legionella* bacteria has been considered and addressed in the drafting of a safety statement.

Risk Assessment

A systematic risk management approach, as advocated in the UK Health and Safety Commission's *'Legionnaires' disease: the control of Legionella bacteria in water systems, approved code of practice and guidance' (L8)*, should be adopted to prevent and control the risk of exposure to *Legionella* bacteria in water systems.

Persons undertaking a risk assessment and who devise and implement preventive measures should have the relevant skills, knowledge, training, and resources to carry out their tasks competently, effectively and safely. If the relevant expertise is not available within an organisation it should be sourced externally.

Ideally, those appointed to carry out a risk assessment should be independent of those appointed to implement the control measures and remedial actions.

Training

Those involved in environmental investigations of cases of legionellosis and in the assessment of control measures should have, in addition to knowledge of the ecology and epidemiology of legionellosis, prior training in both theoretical (e.g. desktop studies) and practical *Legionella* risk assessment (i.e. site visits). They also should have a basic knowledge of building services and have received training in appropriate sampling procedures. They should have a thorough knowledge of the relevant guidelines to be followed.

Healthcare Setting

An Environmental Monitoring Committee 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 Environmental Monitoring Committee 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* bacteria in healthcare premises and will provide advice on the implementation of the policies and procedures.

Clinical staff, microbiologists, infection prevention and control teams, maintenance and engineering staff of hospitals should be familiar with the recommendations described in this document for the control of nosocomial legionellosis.

Routine water sampling should be done at least twice yearly in healthcare facilities, including nursing homes and long-stay care facilities.

The number of samples taken should be based on the number of outlets in the water system as per the Dutch guidelines (see Table 11, Section 6.9.3).

Public Health

Under the Infectious Diseases (Amendment) (No. 3) Regulations 2003 (S.I. No. 707 of 2003), laboratory and clinical notification of legionellosis is mandatory. Cases should be notified to the medical officer of health in the relevant department of public health.

It is also mandatory for a medical practitioner and a clinical director of a diagnostic laboratory to notify the medical officer of health of any unusual clusters or changing patterns of illness and individual cases that may be of public health concern.

If the medical officer of health becomes aware of a cluster of cases s/he should inform the local healthcare institutions and microbiology laboratory.

Sporadic cases of legionellosis should be investigated fully in order to identify and eliminate possible sources of infection.

Investigation of an outbreak of legionellosis should be conducted by a multidisciplinary outbreak control team in a manner consistent with best practice.

Formal out-of-hours on-call arrangements should be put in place for all those involved in the surveillance and control of infectious diseases. This will have resource implications.

Dental Setting

Dental unit waterlines are a potential risk factor for legionellosis.

Each dental practice should undertake a formal *Legionella* risk assessment which should be reviewed and revised annually.

The quality of dental unit waterline output water should be formally tested (total viable counts) at least twice a year.

Dental unit waterlines should be subject to disinfection at least once per week with an approved and effective biocide.

Dental healthcare personnel should be educated regarding water quality, biofilm formation, water treatment procedures and adherence to maintenance protocols.

Dental healthcare personnel should be familiar with these guidelines.

Review

These guidelines should be reviewed in 2014 or sooner should new developments demand.

Chapter 1: Clinical Aspects of Legionellosis

1. 1 Introduction

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 incubation period is usually 24-48 hours. Patients recover spontaneously in 2-5 days. The second and the main subject of these guidelines is legionnaires' disease which is a severe and potentially fatal form of pneumonia. Symptoms include a flu-like illness, followed by a dry cough and progression to pneumonia. Diarrhoea, vomiting and mental confusion are common. The case fatality rate is about 12%, rising to about 30% in nosocomial cases.[1]

Legionnaires' disease was first recognised in 1976 following an outbreak of pneumonia among delegates at the annual convention of the American Legion held in the Bellevue Stratford Hotel in Philadelphia. In that outbreak 221 persons became ill and 34 died of a previously unknown disease.[2] *Legionella pneumophila* was the organism isolated.

1.2 *Legionella* – natural history of the organism

Legionella are Gram-negative bacteria that live as intracellular parasites of a variety of species of amoebae, protozoa and slime moulds in aquatic environments. Figure 1 shows an electron micrograph of an amoeba entrapping a *L. pneumophila* bacterium with an extended pseudopod.

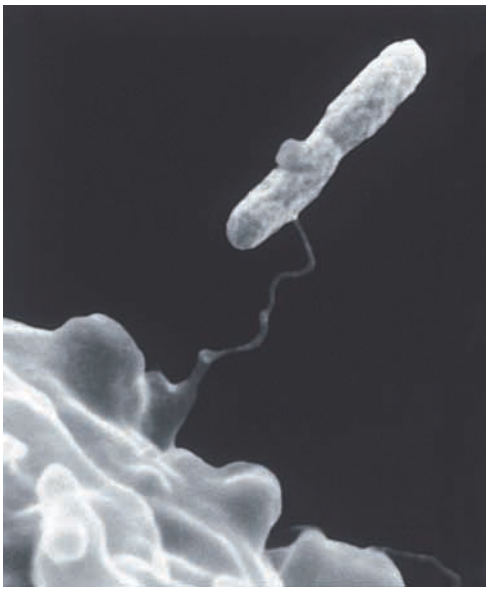

Figure 1. An amoeba entrapping a L. pneumophila bacterium. Courtesy of Fields BS. Legionella and protozoa: interaction of a pathogen and its natural host. Legionella, current status and emerging perspectives. Washington DC: ASM Press, 1993

To date, at least 50 *Legionella* species and 70 serotypes have been described.[3] At least 20 species are associated with causing disease in humans.[3] *L. pneumophila* serogroup 1 is the cause of 70-90% of all cases of legionnaires' disease where the aetiological agent has been isolated. *L. pneumophila* serogroup 1 can be further divided into many subtypes. One of these subtypes, the Pontiac subtype, is responsible for 85% of cases due to *L. pneumophila* serogroup 1.[4] Other species identified as causing pneumonia in humans include *L. micdadei, L. bozemanii, L. dumoffii,* and *L. longbeachae*.[3]

Legionella bacteria are ubiquitous in nature and can be found naturally in environmental water sources such as rivers, lakes and reservoirs, usually in low numbers. *Legionella* bacteria have also been isolated from potting soils, particularly in Australia.[5] From the natural source, the organism passes into sites that constitute an artificial reservoir (piped water in towns and cities, water networks, water systems in individual buildings, cooling towers, etc.).

Water temperatures in the range 20°C to 45°C favour growth of *Legionella* bacteria. The organisms do not appear to multiply below 20°C and are killed within a few minutes at temperatures above 60°C.[6] They are acid-tolerant and can withstand exposure to pH 2.0 for short periods. They have been isolated from environmental sources with pH ranging from 2.7 to 8.3.[7]

Legionella bacteria multiply within amoebae and protozoa. However, when environmental conditions are unfavourable e.g. absence of nutrients or temperature changes, the *Legionella*-infected amoebae encyst, allowing the survival of the host and the parasite until more favourable conditions allow excystment. In both natural and man-made water systems, *Legionella*-infected amoebae are found in association with microbial biofilm containing many different microorganisms (Figure 2).[4] The presence of sediment, sludge, scale and other material within water systems, together with biofilms, are thought to play an important role in the persistence of *Legionella* bacteria, providing favourable conditions in which the *Legionella* bacteria may grow. Environmental changes can disrupt the biofilm or dislodge portions of it and lead to a sudden and massive release of *Legionella* bacteria into the water system. If the water is then aerosolised and inhaled by humans or aspirated by humans, the bacteria can cause illness in susceptible individuals. *Legionella* bacteria also exist as free living organisms.[4]

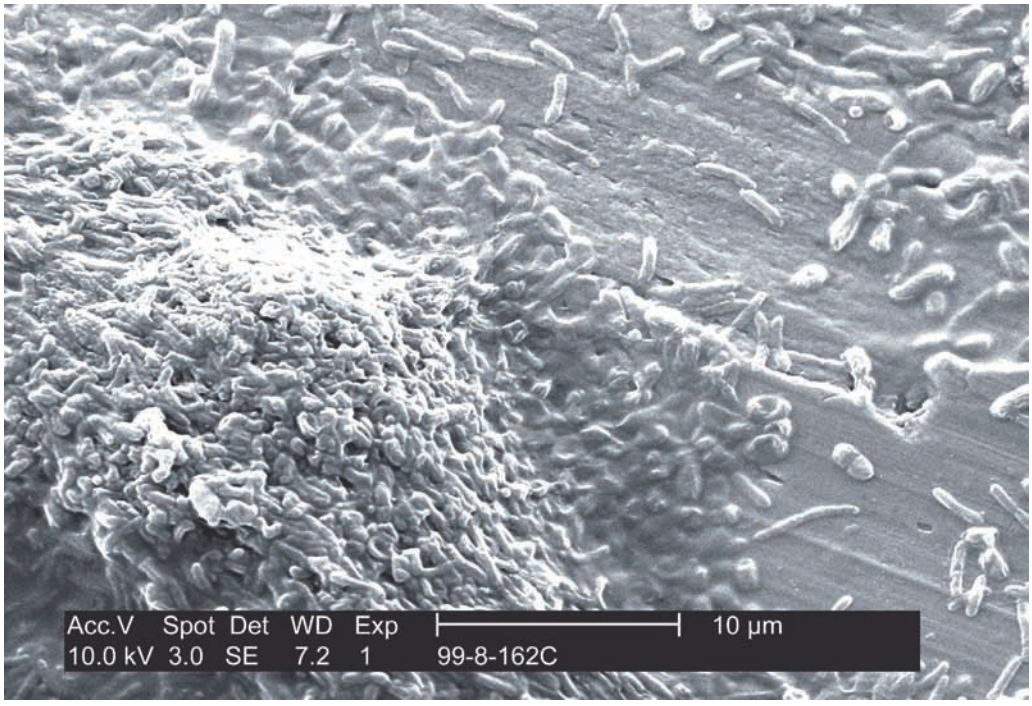

Figure 2. A scanning electron micrograph of L. pneumophila on potable water biofilms. Courtesy of Centers for Disease Control and Prevention/Janice Carr

Drinking water disinfectants such as free chlorine penetrate poorly into biofilms and *Legionella* bacteria are further shielded within the amoebae they parasitise.[8] Free chlorine levels in municipal drinking water are generally sufficient to neutralise free floating coliform bacteria but are often too low to kill *Legionella* bacteria living in biofilm. In addition, many drinking water disinfectants such as free chlorine do not reach distal sites in a water distribution system, can dissipate quickly in heated water, are often sequestered by biofilm, sludge and scale and are often removed during water filtering such as occurs in spa pools. Biofilm and sludge play an important role in protecting *Legionella* from the effects of thermal and chemical disinfection.

1.3 Recognised and potential sources of *Legionella* infection

The following are all 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.

1.4 Methods of transmission

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.[9] There is no evidence of person-to-person transmission.

1.5 Risk of infection

The infectious dose for *Legionella* bacteria in humans is unknown. Those at higher risk for legionnaires' disease include:

- People over 40 years of age[3]
- 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.

The incubation period is usually between 2 and 10 days although longer periods have been reported.[10] The risk of acquiring *Legionella* infection is principally related to the individual susceptibility of the subject exposed and the degree of intensity of exposure, represented by the quantity of *Legionella* present and the length of exposure. Attack rates during outbreaks of legionnaires' disease are low – less than 5%.[1] When a susceptible person inhales a contaminated aerosol consisting of droplets of the right size (1-5 micron), he or she can develop the disease.[11]

1.6 Treatment

Current recommendations for empirical antimicrobial therapy of community-acquired pneumonia include agents which provide cover for *Legionella* infection.[12-14] These recommendations incorporate evidence which increasingly favours combination empirical therapy for severe community-acquired pneumonia.

The inclusion of empirical cover for *Legionella* infection should also be considered in cases of nosocomial pneumonia, especially in severe cases and where there is a suspected risk of exposure to *Legionella* bacteria. Once the aetiology has been identified on the basis of reliable microbiological methods, antimicrobial therapy should be directed at that specific pathogen.

The preferred antimicrobial treatment of legionnaires' disease should be guided by the severity of the disease, degree of immunocompromise, and the availability and potential toxicity of individual drugs.[4] A detailed review by Diederen of current treatment options was published in January 2008.[15] This review emphasises that retrospective, adequate size clinical trials of antimicrobial therapy for legionnaires' disease have not yet been published. Three observational studies suggesting the possible superiority of levofloxacin therapy over therapy with macrolides are cited with the recommendation that these should be interpreted with caution.[16-18] In vitro data suggest that newer macrolides (azithromycin and clarithromycin) and many fluroquinolone agents show the best activity against *Legionella* species. Newer macrolides and levofloxacin are licenced by the US Food and Drug Administration for the treatment of legionnaires' disease and are considered preferable to erythromycin. The duration of therapy has to be decided on an individual basis but two to three weeks of therapy is generally recommended.

The British Thoracic Society (BTS) guidelines recommend clarithromycin ± rifampicin as the treatment of choice for legionnaires' disease with a fluoroquinolone as an alternative.[12;13] However, there is debate as to whether rifampicin provides additional benefit to patients with legionnaires' disease[19;20] and some authors suggest that co-administration of rifampicin is of questionable benefit and do not recommend it.[21]

The BTS are currently reviewing their guidelines on the management of community-acquired pneumonia in adults. The consultation process has now closed and it is expected that the guidelines will be available later this year at www.brit-thoracic.org.uk/.

The Infectious Disease Society of America (IDSA) in their 2003 guidelines recommends azithromycin or a fluoroquinolone (e.g. moxifloxacin or levofloxacin) as the preferred treatment for legionnaires' disease patients who are hospitalised. Erythromycin, azithromycin, clarithromycin, doxycycline, or a fluoroquinolone can be used for patients who do not require hospitalisation.[22] The more recent IDSA/ATS (American Thoracic Society) consensus guidelines on the management of community-acquired pneumonia in adults recommend a fluoroquinolone or azithromycin as the preferred antimicrobials with doxycycline as an alternative for treatment of pneumonia caused by *Legionella* species.[14] However, clarithromycin is the recommended macrolide in Ireland and the UK as intravenous azithromycin is currently not licenced in the UK or Ireland.

1.7 Definitions

Legionellosis is a statutorily notifiable disease in Ireland as defined by the Infectious Disease Regulations 1981 (S.I. No. 390 of 1981). Under the Infectious Diseases (Amendment) (No. 3) Regulations 2003 (S.I. No. 707 of 2003), which came into effect on 1 January 2004, laboratory and clinical notification of legionellosis is mandatory. Cases should be notified to the medical officer of health (MOH) in the relevant department of public health.

Clinical criteria

Any person with pneumonia

Laboratory criteria

Laboratory criteria for case confirmation
At least one of the following three:

- Isolation of any *Legionella* spp. from respiratory secretions or any normally sterile site
- Detection of *Legionella pneumophila* antigen in urine*
- *Legionella pneumophila* serogroup 1-specific antibody response

Laboratory criteria for a probable case
At least one of the following four:

- Detection of *Legionella pneumophila* antigen in respiratory secretions or lung tissue e.g. by direct fluorescent antibody (DFA) staining using monoclonal-antibody derived reagents
- Detection of *Legionella* spp. nucleic acid in a clinical specimen
- *Legionella pneumophila* non-serogroup 1 or other *Legionella* spp.-specific antibody response
- *L. Pneumophila* serogroup 1, other serogroups or other *Legionella* species: single high titre in specific serum antibody†

Epidemiological criteria

At least one of the following two epidemiological links:

- Environmental exposure
- Exposure to the same common source

Case classification

a. *Possible case* – NA
b. *Probable case*
   Any person meeting the clinical criteria **and** at least one positive laboratory test for a probable case **or** an epidemiological link
c. *Confirmed case*
   Any person meeting the clinical and the laboratory criteria for case confirmation.

Source: European Commission Case Definitions for Communicable Diseases[23]

**Currently available commercial urinary antigen tests only detect L. pneumophila serogroup 1*

†*In the UK, Health Protection Agency use a single titre of 1:128 or 1:64 in an outbreak*

Nosocomial (healthcare-acquired) case
Laboratory-confirmed case of legionnaires' disease that occurs in a patient who was in a hospital or other healthcare institution during the 10 days before onset of symptoms.

The following sub-divisions are used for classifying nosocomial cases of legionellosis:

Definitely nosocomial
Patients who spent all of the ten days in a hospital or other healthcare institution before onset of symptoms.

Probably nosocomial
Patients who spent between one and nine of the ten days in a hospital or other healthcare institution prior to onset of symptoms and either:

- Became ill in a hospital or other healthcare institution associated with one or more cases of legionnaires' disease **or**
- Yielded an isolate that was indistinguishable by monoclonal antibody (mAb) subgrouping, or by molecular typing methods from isolates obtained from the hospital water system at about the same time.

Possibly nosocomial
Patients who spent between one and nine of the ten days prior to onset of symptoms, in a hospital or other healthcare institution not known to be associated with any other cases of legionnaires' disease and where no microbiological link has been established between the infection and the hospital.

Source: UK Health Protection Agency Legionella case definitions[24]

Travel-associated cases

Single travel-associated case

A case of travel-associated legionnaires' disease is defined as a case who, in the ten days before onset of illness, stayed at or visited an accommodation site that had not been associated with any other cases of legionnaires' disease, **or**

A case who stayed at an accommodation site linked to other cases of legionnaires' disease which had occurred **more than two years previously**.

Travel-associated cases may involve travel within Ireland or travel abroad.

*Cluster of travel-associated cases**

A cluster is defined as two or more cases of legionnaires' disease who stayed at or visited the same accommodation site in the ten days before onset of illness and whose onset is within the same two-year period.

If any further cases associated with the cluster site occur more than two years after the last case, they will be reported as new single cases, although the country of infection will receive information on all previous cases regardless of the time period involved.

Source: European Working Group on Legionella Infection guidelines[25]

*A cluster is not the same as an outbreak. It is a EWGLINET definition and refers to two or more cases in a single accommodation site within a specified period

A case must meet the clinical, microbiological and travel history criteria for it to be notified to the European Working Group on Legionella Infection (EWGLI) surveillance scheme for travel-associated legionnaires' disease (EWGLINET) (Appendix A).

Outbreak.

An outbreak is defined as two or more cases associated with the same geographical location or probable source of infection during the preceding six months.

Pontiac fever

A self-limiting influenza-like illness characterised by fever, headache, myalgia and non-productive cough. Patients recover spontaneously without therapy after two to five days. There is no evidence of pneumonia.

1.8 Epidemiology

Studies have estimated that legionnaires' disease accounts for between 0.5% to 10% of community-acquired pneumonia requiring hospitalisation in adults.[4] In a review of nine studies of community-acquired pneumonia in which admission to intensive care was required, *L. pneumophila* was second only to *Streptococcus pneumoniae* as the aetiological agent most frequently identified.[26] Mortality from severe legionnaires' disease in these nine studies ranged from 0-25%. Overall, *Legionella* is probably the second to fourth most common cause of community-acquired pneumonia.

The proportion of hospital-acquired pneumonia due to legionnaires' disease has been reported as ranging from 0-47%.[27] Numerous species and serogroups of *Legionella* can be present in hospital water systems. It has been shown when an active search for *Legionella* infection is initiated, cases are frequently confirmed.[27;28] Although *L. pneumophila* serogroup 1 accounts for the majority of cases, other serogroups have also been associated with infection in healthcare settings.[28;29] This has important clinical implications as the most widely used test for diagnosing legionnaires' disease is the urinary antigen test and this test is specific for *L. pneumophila* serogroup 1 only.

Legionnaires' disease is thought to be rare in children. A review of the medical literature published in 2006, identified 76 cases of *Legionella* infection in children, 78% of whom had an underlying condition such as malignancy.[30] More recently, a large outbreak has been reported in a neonatal unit of a private hospital in Cyprus. Eleven cases were reported and three deaths.[31]

1.8.1 Legionnaires' disease in Ireland

The number of cases of legionnaires' disease notified to the Department of Health and Children (DoHC) and the Health Protection Surveillance Centre (HPSC) from 1994 to 2007 is shown in Table 1. HPSC took over responsibility for the collation of infectious diseases notifications on 1 July 2000.

Table 1. Number of legionnaires' disease cases per million population notified in Ireland, 1994-2007

Year	Number of cases	Crude rate per million population
1994	1	0.3
1995	1	0.3
1996	2	0.6
1997	6	1.7
1998	2	0.6
1999	2	0.6
2000	9	2.3
2001	3	0.8
2002	6	1.5
2003	7	1.8
2004	4	1.0
2005	9	2.3
2006	13	3.1
2007	16	3.8

1996 population: 3,626,087 – (1994-1999)

2002 population: 3,917,203 – (2000-2003)

2006 population: 4,239,848 – (2004-2007)

There were 67 cases of legionnaires' disease reported in Ireland during the period 2000 to 2007. There were six deaths due to legionnaires' disease during this period, giving a case fatality rate (CFR) of 9.0%. Forty-five cases (67.2%) were male, and 22 (32.8%) were female. Forty-one cases (61.2%) were travel-associated; three of these were associated with travel within Ireland. Twenty-one (31.3%) were community-acquired, and five (7.5%) were nosocomial.

Fifty-nine cases (88.1%) were classified as confirmed and eight (11.9%) as probable. *L. pneumophila* serogroup 1 was responsible for 82.1% of cases, *L. pneumophila* serogroup unknown (3.0%), and *Legionella* species unknown (14.9%).

The median age was 48 years, with a range from 18 to 80 years. The median age for females was 45 years and 49 years for males. The cumulative number of cases in each age group is shown in Figure 3.

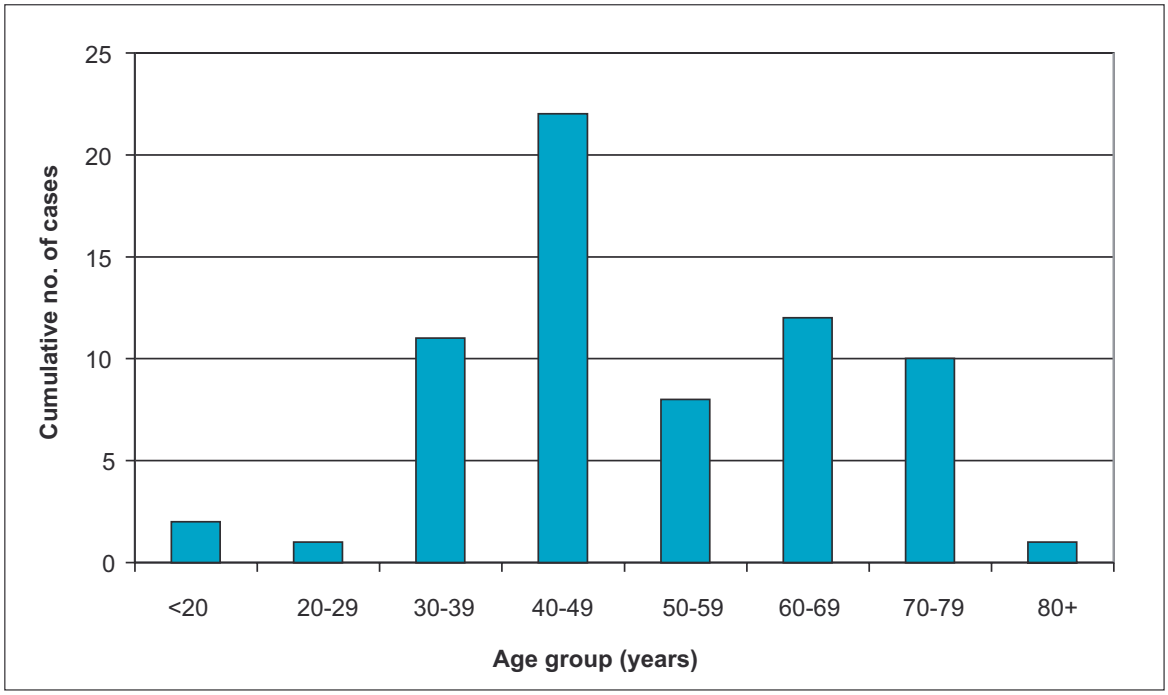

Figure 3. Cumulative number of cases of legionnaires' disease in each age group, 2000 to 2007

The peak month of notification was September (Figure 4). The main method of diagnosis was urinary antigen in fifty cases (74.6%), serology in fifteen (22.4%), culture in one case (1.5%), and the method was unspecified in one case (1.5%).

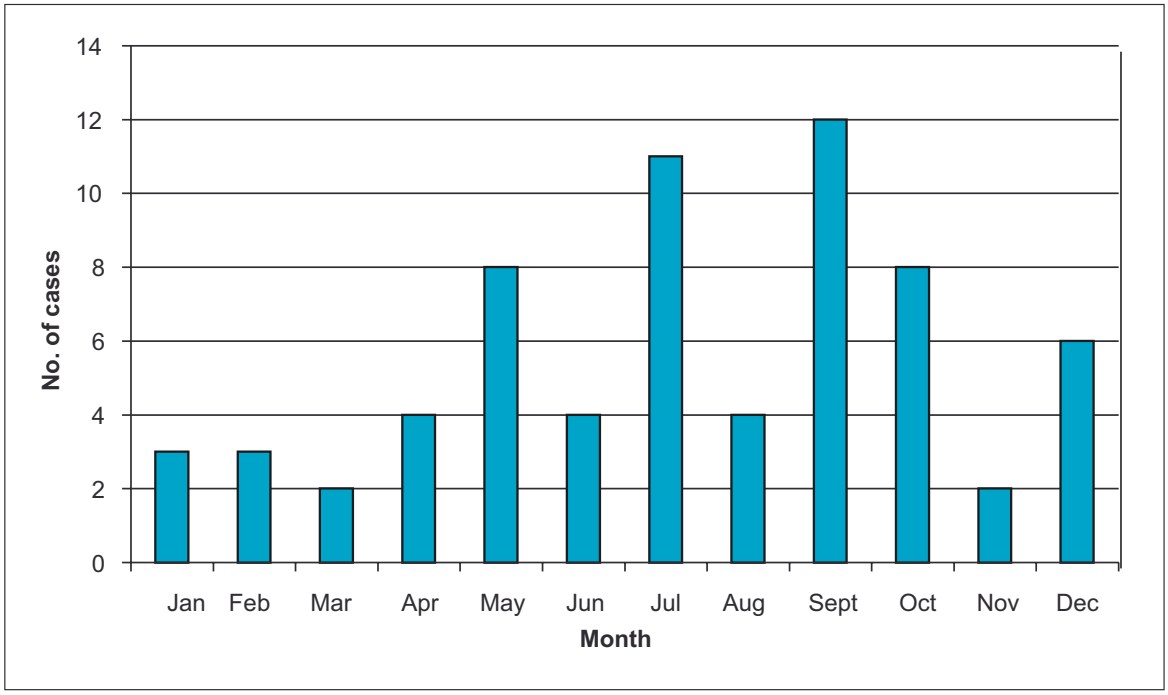

Figure 4. Cumulative number of cases by month, 2000 to 2007

1.8.2 Legionnaires' disease in Europe

Legionnaires' disease is a statutorily notifiable disease in many but not all European countries. In 2007, the overall European rate of infection was 11.4 cases per million population (based on a population of 520.3 million in 33 countries).[32] Table 2 shows the incidence rate in various European countries in 2007.

Table 2. Number of legionnaires' disease cases and rate per million population in various European countries in 2007

Country	Number of cases	Rate per million population
Spain	1,098	24.8
France	1,428	22.8
Denmark	133	24.4
Netherlands	321	19.6
Sweden	130	14.2
Scotland	43	8.4
England & Wales	441	8.2
Northern Ireland	11	6.3
Ireland	**16**	**3.8**
Poland	13	0.3
Norway	35	7.5

There were 391 deaths associated with legionnaires' disease in Europe in 2007, a CFR of 6.6%. The majority of cases were male (71.6%). The number of cases in each age group in Europe is shown in Figure 5.

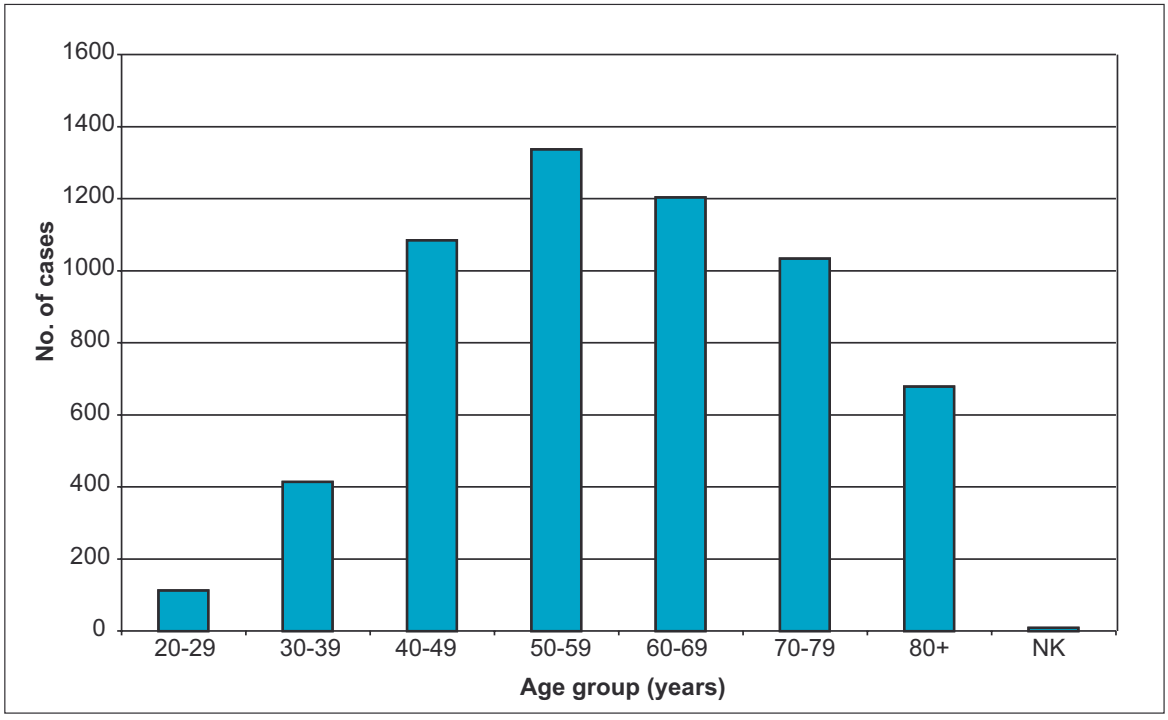

Figure 5. The number of legionnaires' disease cases in each age group in Europe, 2007

The majority of cases were community-acquired (62.1%), 21.7% were travel-associated, 5.6% were nosocomial, 0.9% other, and 9.6% unspecified. The cases were classified as confirmed in 89.8% of cases, 8.9% were presumptive and 1.3% were unknown. The main method of diagnosis was by urinary antigen (80.6%), culture (8.7%), serology (7.1%), PCR (2.2%), other (0.2%), unknown (1.2%).

1.8.3 Under-diagnosis and under-reporting

Under-diagnosis and under-reporting are thought to lead to a significant under-estimation of incidence of legionnaires' disease in many countries. The causes include:

- Pneumonia being treated with antibiotics which cover *Legionella* and patients recovering without the need to establish the cause of pneumonia
- Lack of sensitivity and specificity of diagnostic methods e.g. serology
- Cases not being notified.

Denmark has consistently had a higher rate of infection (around 20/million population) than most other countries. The factors probably associated with this are that it is a small country which carries out high levels of testing for *Legionella* in patients with pneumonia and it has a centralised reference laboratory for diagnosing and reporting cases. In recent years, EWGLI has adopted the rate of 20/million population as the 'gold standard' for countries to reach in order to reflect a truer incidence of infection.

The reported incidence of legionnaires' disease in Ireland has increased from 0.3/million population in 1994 to 3.8/million in 2007. However, the rate is still low compared with many European countries and the rate falls well short of the 'gold standard' as set by EWGLI. This could suggest that a major degree of under-diagnosis and under-reporting currently exists in Ireland or that the rate in Ireland may actually be lower than in some European countries. It is critical to the control of legionnaires' disease that enhanced surveillance is maintained at a high level. Significantly, it has been reported that delay of appropriate therapy results in poor outcome.[33] A rapid urine antigen test is available in Ireland. Consideration should be given for the more widespread use of this test when a patient presents with pneumonia. The importance of specimens for culture should also be considered.

Chapter 2: Laboratory Diagnosis

2.1 Introduction

The clinical features of infection with *Legionella* may be indistinguishable from those of other causes of both community-acquired and nosocomial pneumonia. Accurate diagnostic methods are therefore essential to identify *Legionella* and to provide timely and appropriate therapy.

The information on the current status of the application of laboratory diagnostic tests for the detection of *Legionella* spp. was recently reviewed by Diederen.[15] It was concluded that no currently available test is able to detect all *Legionella* spp. in a timely fashion with a high degree of sensitivity and specificity. Examination of different specimen types with several tests in parallel is recommended. The amount of microbiological workup should be determined by the severity of the pneumonia. Patients with severe pneumonia, all those admitted to an intensive care unit, those with a pneumonia that does not respond to therapy with beta-lactam antibiotics, and patients with severe underlying disease should be tested for evidence of legionnaires' disease. Table 3 summarises the suggested indications for testing for *Legionella* infection.

Table 3. Suggested indications for testing for Legionella infection

- Severe pneumonia including severe CAP as assessed by CURB-65* scoring system, severe nosocomial pneumonia and all patients with pneumonia admitted to an intensive care unit
- Pneumonia which does not respond to beta-lactam antibiotics
- Patients with specific risk factors e.g. recent travel - within 10 days of onset, certain occupations where exposure to *Legionella* may have occurred, recent repair to domestic plumbing systems, immunosuppression and severe underlying disease
- All patients with CAP during a community outbreak of *Legionella* infection
- All patients with nosocomial pneumonia where risk assessment indicates likely exposure to *Legionella* bacteria
- Tests for legionnaires' disease should also be considered in all at-risk patients (see Chapter 1 Section 1.5) who are seriously ill with signs of infection (with or without clinical features of legionellosis) and where no other alternative diagnosis is evident.

2.2 Clinical diagnostic tests

The laboratory methods listed below have all been applied in the laboratory diagnosis of *Legionella* infections:

1. Isolation of *Legionella* bacteria by culture
2. Detection of *Legionella* antigen in urine (current tests detect *L. pneumophila* serogroup 1 only)
3. Antibody detection using paired or single sera
4. Detection of *Legionella* bacteria in clinical material such as tissue or body fluids by immunofluorescence microscopy [e.g. direct fluorescent antibody (DFA) microscopy or indirect fluorescent antibody test (IFAT)]
5. Detection of *Legionella* bacteria DNA using qualitative polymerase chain reaction (PCR) or quantitative real-time PCR methods.

In recent years the application of diagnostic tests for legionellosis has changed significantly. Urinary antigen detection has now largely replaced serology as the primary diagnostic method (see executive summary of laboratory survey Appendix B) but serology remains an important tool for case finding during

* CURB-65 is a simple severity assessment tool for categorising CAP. It has a six part scale (0-5) – one point for each risk factor measured at the initial hospital assessment: confusion; urea > 7mmol/l; respiratory rate ≥ 30/min; low systolic (< 90mm Hg) or diastolic (≤ 60mm Hg) blood pressure; and age ≥ 65 years.

outbreak investigations and for late or retrospective diagnosis. Culture continues to play an important role (see below) and while PCR is not yet available for routine use, it is likely that genus-specific assays based on this technology will be available in the near future.

Culture remains the 'gold standard' for diagnosis of legionnaires' disease and is the most specific diagnostic procedure. However, its relatively low sensitivity and reliance on the availability of lower respiratory tract samples make it inadequate as a sole diagnostic test.[15] *Legionella* culture should be specifically requested by clinicians on laboratory request forms from patients with severe community-acquired pneumonia, or where *Legionella* infection is suspected on epidemiological grounds.[12;13]

Legionella urine antigen tests should be performed for patient groups listed in Table 3. A rapid testing and reporting service for *Legionella* urine antigen should be available to all hospitals admitting patients with community-acquired pneumonia.[12;13]

Despite the availability of immunological and molecular genetic methods for the diagnosis of legionnaires' disease these are generally only effective for detection of *L. pneumophila* serogroup 1. The sensitivity and specificity of methods for diagnosing and identifying other *L. pneumophila* serogroups and species of *Legionella* are far from ideal.[3]

Since many laboratories now rely almost exclusively on urinary antigen testing, the detection of *L. pneumophila* serogroup 1 is increasing and all other serogroups are probably under-diagnosed. The antigen detection test is substantially more sensitive for community-acquired and travel-associated legionnaires' disease than for nosocomial infection because the tests are more sensitive for Pontiac *L. pneumophila* serogroup 1 than for non-Pontiac strains of *Legionella*. Pontiac strains cause the majority of community-acquired and travel-associated legionnaires' disease cases but are significantly less common in nosocomial cases. For this reason culture of sputum (or other respiratory specimens such as bronchial washings, when available) is recommended whenever possible.

It is important that healthcare facilities have policies in place to ensure appropriate testing is carried out for legionnaires' disease in patients with nosocomial pneumonia. Effective diagnosis and evaluation of results are crucial for the adequate and prompt management of incidents and outbreaks, for the control of clusters of infection and for the protection of other patients.

The UK Health Protection Agency guidance note '*Laboratory Diagnosis of Legionella Infections in the HPA*' gives advice on the selection and usefulness of tests on clinical specimens. It also provides a testing algorithm for the diagnosis of legionnaires' disease.[34] This document is available at http://www.hpa-standardmethods.org.uk/documents/qsop/pdf/qsop30.pdf.

Methods used for clinical specimens should be based on recognised reference procedures. In Ireland, the most commonly used reference methods are those issued by the UK HPA or International Organization for Standardization. The HPA National Standard Method for Legionella species is BSOP 47.[35] This document is available at http://www.hpa-standardmethods.org.uk/documents/bsop/pdf/bsop47.pdf.

All medical laboratories performing this testing should be accredited for the methods used and operate to the ISO standard 15189:2007.[36] ISO 15189:2007 specifies requirements for quality and competence particular to medical laboratories. It is based on the ISO 17025:2005[37] which specifies the general requirements for the competence to carry out tests and/or calibrations, including sampling and applies to all laboratories.

All laboratories should participate in an appropriate external proficiency scheme. The subcommittee recommends that an external proficiency scheme is developed for Ireland.

2.3 Water and environmental samples

2.3.1 Introduction

The usefulness and quality of results on water and environmental samples is dependent on the appropriateness and quality of the sampling procedures and plans. It is therefore important that before any samples are taken for either surveying or the investigation of an outbreak the staff involved are appropriately trained and have a thorough knowledge of the guidelines to be followed. The UK Environment Agency booklet '*The determination of Legionella in waters and other environmental samples*

(2005) - Part 1 – rationale of surveying and sampling' gives guidance on the factors to be considered before samples are taken.[38] Further information on environmental sampling is also available in Chapter 6. Considerable laboratory work and resources are required for the laboratory testing of environmental samples so it is important that only appropriate samples are taken and that sampling is carried out in accordance with the above guidelines. The subcommittee recommends that laboratory facilities for environmental testing are available in each Health Service Executive (HSE) area.

2.3.2 Environmental testing laboratory methods

Methods used for testing environmental samples should be based on the International Organization for Standardization (ISO) standard reference methods. ISO 11731:1998 is the appropriate method.[39] This method has been divided into 2 parts: the latest part, Part 2 (ISO 11731 – 2:2004)[40] and the original ISO 11731:1998 which is currently under revision and when revision is complete will subsequently be called ISO 11731 Part 1. All laboratories performing this testing should also be accredited for these methods and participate in an appropriate external proficiency scheme.

2.3.3 Reference laboratory

A national *Legionella* reference laboratory should be established and accredited by the Irish National Accreditation Board (INAB) for both clinical and environmental sample testing (based on ISO 15189:2007 and ISO 11731-2:2004 respectively), to act as a typing centre and to provide expert opinion on the microbiology of the organism. It should also take part in an external quality assessment scheme for the isolation of *Legionella* from water, sediment, sludges and swabs.

2.4 Application of PCR for the detection and enumeration of Legionella species

Culture on solid agar media in the laboratory is currently considered the 'gold standard' for the detection and enumeration of viable legionellae. However, this approach is time-consuming because of the slow growth rates of these organisms and can take up to ten days. Furthermore, standard culture techniques will not detect viable non-culturable legionellae in a somnicell state. This is further complicated by difficulties in isolating legionellae in samples containing high background levels of other microorganisms (some of which can inhibit *Legionella* growth) or in situations where legionellae are protected within amoebae or protozoa. Additionally, some non-*L. pneumophilia* species grow poorly on conventional solid media used for the routine isolation of legionellae.

A brief overview of the application and potential advantages of PCR technology to the detection and enumeration of legionellae is provided below, together with selected references. The reference list is not intended to be exhaustive but provides a good introduction to the subject and relevant literature.

Over the last two decades, the application of PCR technology has revolutionised the diagnosis of infections caused by a wide variety of microorganisms, especially organisms that are slow growing or difficult to grow in the laboratory. Indeed, PCR represents one of the few diagnostic tests with the potential to detect the presence of all known microorganisms, including *Legionella*. PCR involves the highly specific amplification of particular target DNA sequences from the microorganism under investigation. The target sequences are usually species-specific. Thermostable enzymes (e.g. *Taq* polymerase) that can copy DNA sequences are used to generate millions of copies of the target sequence in a matter of a few hours. The highly amplified target sequences can then be visualised in agarose gels or can be detected by a variety of other means. Determining the nucleotide sequence of the amplified target DNA can be used to validate the specificity of amplification. In this way, PCR assays can be developed and validated for the rapid detection of any target DNA sequence and thus any microorganism.

Over the last ten years a wide variety of PCR tests have been developed to detect legionellae in environmental samples (e.g. water samples or samples from cooling towers),[41-46] and from clinical specimens (e.g. broncho-alveolar lavage, respiratory secretions, lung biopsy samples, pharyngeal swabs, nasopharyngeal swabs, peripheral blood mononuclear cells, urine and serum).[41;47-56] Several PCR tests have been developed to detect all *Legionella* species or specifically just *L. pneumophila,* that target DNA sequences from the 16S rRNA gene,[57] the 5S rRNA gene,[58;59] the 23S-5S spacer region,[52] the macrophage infectivity potentiator gene *mip*[42;59-61] and the *dotA* gene.[44] Many PCR tests were found to be highly sensitive and highly specific, but by their very nature qualitative, and provided little information on the

relative risk of legionellosis in the case of environmental samples (i.e. the tests indicated the presence or absence of *Legionella* DNA only, with no information as to the presence of whole cells or whether they were alive or dead). Furthermore, environmental and clinical samples may contain PCR inhibitors that prevent amplification of target sequences and can result in false-negative results. The problem of PCR inhibition, particularly that caused by iron compounds (e.g. rust), fulvic acid (a natural acidic organic polymer found in soil, sediment, or aquatic environments) humic acids (major constituents of soil organic matter that can be found in streams) frequently present in environmental water samples, as well as other inhibitors, can limit the usefulness of PCR-based tests unless effective DNA purification methods are employed and PCR inhibition controls are routinely included (i.e. positive amplification controls) in the PCR tests.[44;46] Qualitative PCR with high sensitivity and high specificity has been used to successfully detect legionellae in environmental and respiratory samples in a matter of hours and has proven to be a valuable adjunct to culture, serology and urinary antigen detection. However, its usefulness with environmental samples is limited by its failure to distinguish between live, viable non-culturable, or dead *Legionella* cells.

Several research groups have described the development of quantitative real-time PCR assays for detecting legionellae in environmental and clinical samples.[41;42;44;45;52;53;57] This approach provides information on the number of *Legionella* genome units in the samples tested but equivalence with the number of colony forming units (CFU) has not yet been established robustly. Usually, the number of genome units is higher than the number of CFU, probably due to the presence of viable non-culturable and dead *Legionella* cells in the samples tested. Nonetheless, recently developed quantitative real-time PCR assays have shown immense potential for the detection and enumeration of *Legionella* in both clinical and water samples with many benefits including speed (results within a few hours), high-specificity, high-sensitivity, stability and cost-effectiveness. Multiplex real-time PCR assays capable of the simultaneous detection of multiple *Legionella* species have also been described.[62] These assays are ideally suited to routine surveillance of water samples and for clinical specimens. However, it is important to emphasise that these assays have to be rigorously validated and controlled to obtain meaningful and informative results. Some researchers have combined real-time PCR *Legionella* detection with immunogenetic separation of *L. pneumophila* from water samples. Immunogenetic separation involves the interaction of *Legionella*-specific antibodies attached to paramagnetic beads and *Legionella* surface antigens, permitting separation of *Legionella* cells from water samples by placing a bead-water suspension in a strong magnetic field.[44] This helps to specifically enrich *Legionella* recovery from water samples contaminated with different bacterial species. The DNA from *Legionella* recovered by immunogenetic separation can then be used as a template for quantitative real-time PCR detection. The development of standardised real-time PCR protocols and reagents for detecting *Legionella* will go a long way to making this technology more accessible and applicable in the clinical laboratory and for the routine surveillance of water supplies and water distribution networks in buildings. One potential approach to standardisation is the use of commercial kits for the identification and enumeration of *Legionella* and for DNA purification from samples. Several such kits are currently available (e.g. AquaScreen, Minerve Biolabs, Germany; iO-Check legionella, BioRad, USA) but large-scale comprehensive independent comparative studies on their sensitivity, specificity and accuracy have yet to be undertaken.

Qualitative PCR and real-time PCR have become important investigative tools in many clinical and environmental microbiology laboratories for a wide variety of applications. The equipment required is expensive to purchase and maintain and requires considerable technical expertise. However, use of PCR technology is cost-effective when applied to microorganisms that are slow growing or difficult to grow in the laboratory, such as *Legionella*, and is ideal when accurate and rapid detection is required. PCR will often detect the presence of a microorganism in a sample when culture results are negative, which may occur in a patient being treated with antibiotics.

Finally, DNA microarrays for detecting *Legionella* in water and clinical samples are very likely to be developed as alternative molecular tools for *Legionella* detection. This technology involves immobilising species-specific oligonucleotides on to the surface of microarrays that hybridise with target DNA in test samples permitting fluorescent signal detection.[63] This technology has the potential for the simultaneous detection of multiple microbial species and is ideally suited to pathogen and opportunistic pathogen detection.

In conclusion, PCR assays (especially real-time PCR) have immense potential for the accurate, rapid and

cost-effective detection and enumeration of legionellae in environmental samples. PCR assays also have immense potential to enhance our ability to rapidly and accurately diagnose *Legionella* infections. The development of standardised and validated PCR protocols and procedures involving the integration of efficient and rapid sample preparation techniques with rapid PCR technologies in coming years should significantly improve the detection, prevention and management of *Legionella* infection. This approach should also be invaluable for evaluating the effectiveness of water treatment regimes. Currently, culture on solid media remains the 'gold standard' for *Legionella* detection and enumeration.

Chapter 3: Legislation

3.1 Health and Safety at Work Legislation

3.1.1 Introduction

This chapter provides an overview of the relevant occupational health and safety legislation in relation to the control of legionellosis in Ireland. It does not purport to be a complete exposition of the health and safety legislation. Further information with regard to this legislation is available from the Irish Health and Safety Authority (HSA) website at www.hsa.ie.

In Ireland, the principal legislative provisions of relevance to the prevention of legionellosis in the workplace include:

- The Safety, Health and Welfare at Work Act 2005 (S.I. No. 10 of 2005)
- The Safety, Health and Welfare at Work (General Application) Regulations 2007 (S.I. No. 299 of 2007)
- The Safety, Health and Welfare at Work (Biological Agents) Regulations, 1994 as amended in 1998 (S.I. No. 146 of 1994 and S.I. No. 248 of 1998)
- The Safety, Health and Welfare at Work (Chemical Agents) Regulations, 2001 (S.I. No. 619 of 2001).

Official copies of the legislation can be purchased from the Government Publications Sales Office, Sun Alliance House, Molesworth Street, Dublin 2, Tel: 01 - 647 6000 or copies can be downloaded from www.irishstatutebook.ie/.

3.1.2 Outline and description of legislation

a) Safety, Health and Welfare at Work Act 2005 (S.I. No. 10 of 2005)

The Safety, Health and Welfare at Work Act 2005 applies to employers, employees in all employments and to the self-employed. It also has implications for persons who control places of work and for those who design, manufacture, import or supply articles or substances for use at work.

It replaced the Safety, Health and Welfare at Work Act 1989 (S.I. No. 7 of 1989). It does not specifically refer to *Legionella* (or, indeed individual biological hazards) but sets out the general principles to be adopted at all workplaces to manage risk. Brief descriptions are given of those provisions of most relevance to *Legionella* control in Appendix C. Section 8 of the 2005 Act sets out the general duties of employers (Appendix C).

It must be borne in mind that, notwithstanding section 12 of the 2005 Act, the intent and purpose of this legislation is protection of the health of employees from hazards arising from work-related activities or workplace conditions. Nevertheless, in any given building, it is clear that *Legionella* exposure risks apply, not only to workers, but also to others present at the workplace who may be affected by virtue of the work activity. Therefore the measures required by law, to manage the risk of *Legionella* exposure for workers, will benefit all building users.

Section 19

The employer and where applicable, any person who has control to any extent of the place of work, are required, by section 19 of the 2005 Act to:

- Carry out a written risk assessment of the place of work, including, assessing the risk to non-employees using the workplace
- Prepare a safety statement (section 20 of the 2005 Act) setting out the way in which risk is managed.

Section 16

Section 16 of the Act places an onus on designers, manufacturers, importers or suppliers of articles for use at work to ensure that:

- The article (which includes appliances, plant and machinery in the definition given in section 2 of the Act) is designed and constructed so as to be without risk to health when properly used at a place of work
- Information is provided about the safe use of the article to any person to whom he or she supplies that article
- This information must relate to the use for which the article has been designed, manufactured or tested and must also include information on safe installation, use, maintenance, cleaning, dismantling or disposal without risk to safety or health.

b) Safety, Health and Welfare at Work (Biological Agents) Regulations, 1994 as amended in 1998 (S.I. No. 146 of 1994 and S.I. No. 248 of 1998)

Despite the revocation of the Safety, Health and Welfare at Work Act 1989, the Safety, Health and Welfare at Work (Biological Agents) Regulations, 1994 as amended in 1998 (S.I. No. 146 of 1994 and S.I. No. 248 of 1998) remain in force. *Legionella* spp. and *L. pneumophila* are listed among biological agents set out in the Fourth Schedule of the regulations and are categorised as a 'group 2 biological agent', that is "one which 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".

Regulation 3

Regulation 3 (Appendix D) sets out the duties of employers to prevent exposure to a biological agent or, if complete prevention is not possible, to minimise exposure. Of particular relevance to *Legionella* control is Regulation 3 (f), which refers to situations where the work activity does not involve a deliberate intention to work with or use a biological agent but may nevertheless result in employees being exposed to a biological agent (e.g. cleaning and maintenance work). This would be the situation pertaining to *Legionella* in most situations.

Regulation 4

Regulation 4 (Appendix D) obliges the employer to:

- Carry out a written risk assessment of exposure of an employee to a biological agent (including *Legionella*)
- Identify appropriate control measures to be taken
- Forward information on the risk assessment to the HSA, should the Authority so request.

Regulation 7

Regulation 7 requires the employer to:

- Provide employees and/or their safety representatives with information and training regarding the risk posed by a biological agent (Appendix D).

Second schedule

The second schedule of the regulations as seen below outlines measures to be taken where exposure to a biological agent cannot be prevented (Regulation 3 (d)):

- The keeping as low as possible of the number of employees exposed or likely to be exposed to a biological agent
- The design of work processes and engineering control measures so as to avoid or minimise the release of a biological agent into the place of work
- The use of both collective protection measures and individual protection measures where exposure cannot be avoided by other means
- The use of hygiene measures compatible with the aim of preventing or reducing the accidental transfer or release of a biological agent from the workplace
- The use of the biohazard sign depicted in the Third Schedule, and other relevant warning signs
- The drawing up of plans to deal with accidents involving a biological agent
- The testing, where it is necessary and technically possible, for the presence, outside the primary physical confinement, of a biological agent used at work
- The use of means for the safe collection, storage and disposal of waste by employees, including the use of secure and identifiable containers, after suitable treatment where appropriate
- The making of arrangements for the safe handling and transport of a biological agent within the workplace.

In summary, therefore where there is the potential for *Legionella* bacteria to be present at the workplace an employer must take the following actions:

- Assess the risk of exposure
- Limit exposure
- Introduce collective and adequate control measures to protect workers from exposure occurring
- Comply with the biological agents regulations as appropriate to the work activities and specific workplace details so as to protect those at risk from exposure.

c) Safety, Health and Welfare at Work (General Application) Regulations 2007 (S.I. No. 299 of 2007)
These regulations are a composite set of regulations. Of relevance to the control of *Legionella* in the workplace is Part 2, Chapter 2 of these regulations which covers the use of work equipment. Work equipment is defined under these regulations as any machinery, appliance, apparatus, tool or installation for use at work.

Regulation 29
Regulation 29 (Appendix E) requires the employer to ensure that:

- Employees have adequate information and where appropriate written instructions on work equipment
- The content of any information or instruction should address as necessary, normal conditions of use of the work equipment and actions to identify and control foreseeable abnormal situations.

Regulation 30
Regulation 30 (Appendix E) requires the employer to ensure that:

- Where the safety of work equipment depends on the installation conditions that an initial inspection is carried out after installation is completed and before it is first put into service
- Where work equipment is exposed to conditions causing deterioration liable to result in a danger to safety or health that the employer must ensure that periodic inspections and where appropriate, testing is carried out
- Special inspections are carried out when exceptional circumstances arise which are liable to make work equipment unsafe e.g. modification work and prolonged inactivity
- Deterioration is detected and remedied in good time
- Inspections must be carried out by a competent person
- Results of the inspections must be recorded and kept for five years
- Records must be available for inspection by a HSA inspector.

Regulations 62-67
Regulations 62-67 of the Act set out the responsibilities of employers in relation to personal protective equipment (PPE) (see also Chapter 7, Section 7.4). These regulations require employers to:

- Provide PPE for their employees' use where risks to the health and safety of employees at the work place cannot be avoided or limited by other means
- Make an assessment of whether the equipment satisfies the regulation requirements
- Determine the conditions of use and compatibility of the equipment
- Ensure use is normally confined to one employee and where it is necessary that equipment is made available to more than one employee, that such use does not create health or hygiene problems for any user
- Ensure that the PPE provided is maintained properly and replaced where necessary
- Provide information, training and instruction on the use of the equipment and the risks against which the wearing of the equipment protects the employee.

d) Safety, Health and Welfare at Work (Chemical Agents) Regulations, 2001 (S.I. No. 619 of 2001)
While not directly related to *Legionella,* employers are obliged to consider the requirements of these regulations to ensure that their workers are not at risk from exposure to chemicals while at work and/or performing a work activity in which chemical agents are being used. In this regard therefore, chemical agents in the form of biocides and disinfectants, etc. are used as a means of controlling aspects relating to the presence of *Legionella* and for cleaning purposes.

A hazardous substance is something which 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 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. The regulations require that employers:

- Determine which chemical agents are present and being used at the workplace
- Prevent and control exposure to these chemical agents
- Introduce specific protection and prevention measures to protect workers
- Make arrangements to deal with accidents, incidents and emergencies
- Inform, train, consult and supervise workers in the safe use of chemical agents.

Regulation 4
Regulation 4 outlines the requirements necessary for employers to perform an adequate risk assessment regarding any hazardous chemical agent present and used at the workplace (Appendix F). 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. Consideration should be given to the availability of a universal chemical antidote (e.g. the hypertonic, polyvalent, amphoteric compound Diphoterine) that can neutralise many hazardous chemicals.

3.2 Infectious Diseases Regulations 1981 (S.I. No. 390 of 1981)

The principal current regulations relating to legionellosis are contained in the Infectious Diseases Regulations (S.I. No. 390 of 1981) as amended by the Infectious Diseases (Amendment) Regulations 1985 (S.I. No. 268 of 1985), Infectious Diseases (Amendment) Regulations 1988 (S.I. No. 288 of 1988) and Infectious Diseases (Amendment) Regulations 1996 (S.I. No. 384 of 1996) and Infectious Diseases (Amendment) Regulations (S.I. No. 707 of 2003). These regulations can be viewed on the Irish Government website at www.irishstatutebook.ie/.

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".

Legionellosis is a statutorily notifiable disease in Ireland as defined by the Infectious Disease Regulations 1981 (S.I. No. 390 of 1981). Under the Infectious Diseases (Amendment) (No. 3) Regulations 2003 (S.I. No. 707 of 2003), which came into effect on 1 January 2004, laboratory and clinical notification of legionellosis is mandatory. Cases should be notified to the MOH in the relevant department of public health.

Under the Infectious Diseases (Amendment) (No. 3) Regulations 2003 (S.I. No. 707 of 2003), it is also mandatory for a medical practitioner and a clinical director of a diagnostic laboratory to notify to the MOH any unusual clusters or changing patterns of any illness, and individual cases thereof, that may be of public health concern. The MOH in turn must notify HPSC.

3.2.1 Recommendation re *Legionella*-specific legislation

There is an urgent need for the DoHC and the Department of the Environment, Heritage and Local Government to consider:

- Legislative controls on standards of maintenance and disinfection of any equipment that poses a risk of producing aerosols contaminated with *Legionella* during both normal and abnormal (e.g. during maintenance) operating conditions
- A system of statutory notification by the owner/occupier of high-risk sites e.g. cooling towers

- The provision of legislative backing to an appropriate statutory authority for the monitoring and control of high-risk sites, including those instances where there is a recognised public health risk e.g. guest accommodation and trade shows with open air fountains/spa pools, etc.
- That provision should be made for adequate resources and training to ensure effective enforcement of existing legislation.

Chapter 4: Risk Assessment

4.1 Introduction

This chapter on risk assessment and Chapter 5 on *Legionella* prevention and control provide an overview of risk management in relation to *Legionella* in water systems. They do not purport to provide definitive guidance for every situation. They should be read in conjunction with the UK, Health and Safety Commission (HSC) document – *Legionnaires' disease: the control of Legionella bacteria in water systems: approved code of practice and guidance (L8)*[64] and the UK, Department of Health technical document – *Health Technical Memorandum 04-01: the control of Legionella, hygiene, 'safe' hot water, cold water and drinking water systems: Part B: operational management*.[6]

The UK Approved Code of Practice (L8) advocates that a systematic risk management approach is adopted to prevent and control the risk of exposure to *Legionella* bacteria from water systems. This approach should be multidisciplinary, involving a team of experts with a thorough understanding of the particular water system. Risk management involves:

- Assessing the risks
- Developing a written scheme for preventing and controlling the risks
- Implementing and auditing the scheme.

This approach also provides a means for ensuring controls are applied which are commensurate with the level of risk and that a process for review and continual improvement is in place. The subcommittee agrees with this approach. Key elements of the risk management process are summarised in Figure 6.

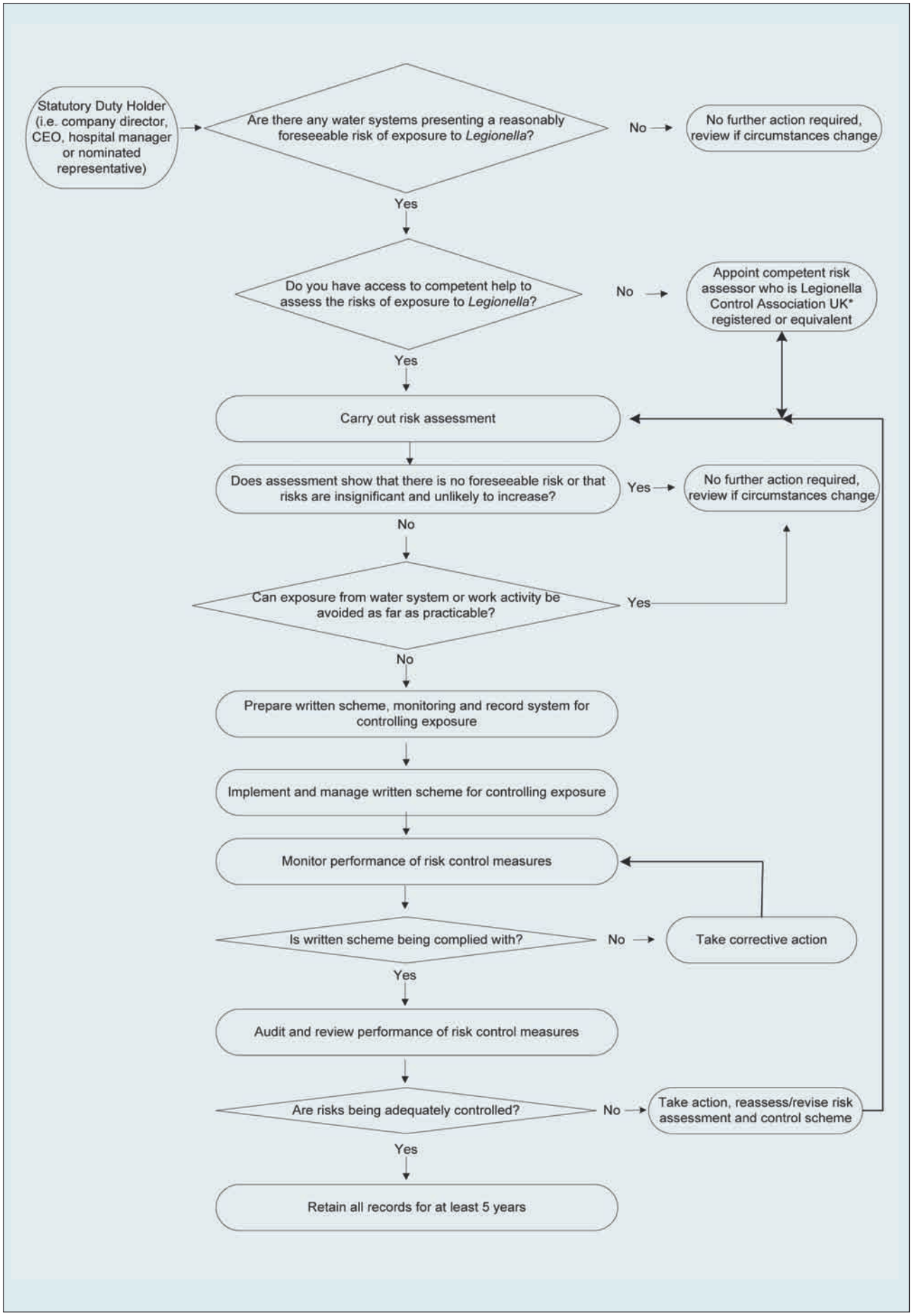

Figure 6. Summary of risk management process

**Legionella Control Association (LCA) (Chapter 4, Section 4.2.1 and Chapter 7, Section 7.3)*

4.2 Risk Assessment

In Ireland, under occupational health and safety legislation (see Chapter 3) there is a legal obligation on employers to carry out a risk assessment in relation to *Legionella* prevention and control in the workplace and where a risk is identified the appropriate control measures should be put in place and a risk management plan adopted.

4.2.1 Responsibilities, training and competence

It is imperative that a competent person (Appendix G) with the relevant skills, knowledge and experience carries out the risk assessment. Organisations and individuals carrying out risk assessments should ideally be members of a recognised professional body or association e.g. the Legionella Control Association in the UK or equivalent (see www.conduct.org.uk and Chapter 7, Section 7.3). If this level of expertise is not available within the organisation, then it should be sourced externally. Sections 8 and 19 of the 2005 Safety, Health and Welfare at Work Act outline in detail the legal duties of the employer in this regard and the legal requirements in relation to hazard identification and risk assessment (see Chapter 3). The person on whom the corporate responsibility for the premises/systems lies should have access to such expertise. In order to prevent any conflicts of interest, it is recommended that ideally, those appointed to carry out the risk assessment are independent of those appointed to implement the control measures and remedial actions, including water treatment and cleaning and disinfection. It is the duty of the employer to ensure that those undertaking the risk assessment are competent and suitably trained and have the necessary equipment to undertake the risk assessment in a safe and proper manner (see Chapter 7 on training).

4.2.2 Undertaking a risk assessment

The purpose of a risk assessment is to:

- Identify and assess the risk of exposure to *Legionella* bacteria from work activities and water systems on a premises i.e. a workplace, healthcare facility or leisure facility
- Establish any necessary preventive and control measures
- Provide direction on prioritising the risks.

A risk assessment is usually undertaken by or on behalf of the employer or person in control of a premises or systems where the risk may be present (e.g. the CEO of the hospital) in order to assess the risk to employees, themselves or to others.

Risk assessments should consider:

- The potential for *Legionella* seeding and growth
- The potential for aerosol generation and exposure
- The presence of susceptible persons
- The adequacy of existing site management arrangements and records
- The efficacy of existing preventive and control measures.

4.2.3 Process of risk assessment

When undertaking a risk assessment, the individual nature of each site must be taken into account. In complex systems or premises, a site survey of all the water systems should be carried out and should include an asset register of all associated plant, pumps, strainers and other relevant items. This should include an up-to-date diagram/drawing showing the layout of the plant or system including parts temporarily out of use. A schematic diagram would be sufficient. It should then be decided which parts of the water system, for example which specific equipment and services, may pose a risk to those at work or to other people.

The following systems present a potential risk of exposure to *Legionella* bacteria:

- Water systems incorporating a cooling tower
- Water systems incorporating an evaporative condenser
- Hot and cold water systems
- Spa pools
- Humidifiers
- Respiratory and other therapy equipment
- Dental chair waterlines
- Natural thermal springs and their distribution systems
- 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.

A water system includes all plant/equipment and components associated with that system e.g. all associated pipework, pumps, feed tanks, valves, showers, heat exchangers, quench tanks, chillers, etc. It is important that the system is considered as a whole and not for example the cooling tower in isolation. Dead legs and parts of the system used intermittently also need to be included as they can create particular problems with microbial growth and go unnoticed. Other systems e.g. humidifiers and air washers, spa pools and baths, car/bus washes, wet scrubbers, industrial water systems, fountains and water features also need to be considered.

The following list contains some of the factors which should be considered when undertaking a risk assessment:

- The source of the system supply water, e.g. whether from the mains supply or not
- Possible sources of contamination of the supply water within the premises before it reaches the cold water storage cistern, calorifier, cooling tower or any other system using water that may present a risk of exposure to *Legionella* bacteria
- The design, location and condition of equipment for example the position of air intakes for buildings in relation to the location of cooling tower exhausts
- Conditions suitable for multiplication of the microorganisms e.g. stagnant water, suitable temperature (20°C-45°C), and a source of nutrients e.g. sludge, scale, rust, algae and other organic matter
- A means of creating and disseminating inhalable droplets e.g. aerosols generated by cooling towers, taps, showers or spa pools
- Normal equipment operating conditions and any unusual but foreseeable conditions e.g. equipment breakdown
- The presence of vulnerable individuals e.g. immunocompromised individuals who may be exposed to infection
- The extent of exposure – the number of people who may be exposed and the length, duration and frequency of exposure.

Not all systems will require elaborate risk assessment and control measures. A simple risk assessment may show that the risks are low e.g. small domestic-type premises where temperature and turnovers are high and where instantaneous water heaters are used. In such cases no further action may be required other than to review the risk assessment on a regular basis.

4.2.4 Written risk assessment

Where a risk is identified, the significant findings of the assessment should be recorded, together with the name of the person and organisation that carried out the assessment. It will also be necessary to record sufficient details of the assessment to be able to show that it has been done. It should be linked to other relevant health and safety records.

Failure to undertake a risk assessment or possession of an inadequate risk assessment may lead to prosecution, especially if a system or premises is implicated in a legionnaires' disease outbreak.

A written risk assessment should include:

- The scope of the assessment
- A description of the site and water systems with details of design, operation and maintenance
- Details of site arrangements for managing and recording control of *Legionella* risks
- Assessment of risk for each system and activity
- Recommendations for preventing (elimination of source of bacteria, aerosols or exposure) or controlling (control bacteria re-growth, aerosol release and exposure) the risks including monitoring, remedial actions, etc.

4.2.5 Frequency of risk assessment

Once the risk assessment is completed and documented, it should be reviewed regularly i.e. at least annually. If there are significant alterations to operational procedures in the institution or significant changes to the water distribution system then the risk assessment should be reviewed and updated. There should be a written record of this review. In addition, it will need to be repeated more frequently in situations where the original assessment is considered to be no longer valid. An indication of when to review the assessment and what needs to be reviewed should be recorded. This may result from:

- Changes in the water system or its use
- Changes in the use of the building in which the water system is installed
- The availability of new information about risk and control measures
- The results of checks indicating that control measures are no longer effective
- A case of legionnaires' disease/legionellosis associated with the system.

4.2.6 Risk rating

The risk rating for exposure to *Legionella* can be categorised as follows:

a. **VERY HIGH** - where it is certain or near certain that exposure will occur

b. **HIGH** - where exposure will often occur

c. **MEDIUM** - where exposure will sometimes occur

d. **LOW** - where exposure will seldom occur

e. **INSIGNIFICANT OR NOT FORESEEABLE.**

Where an assessment determines that there is a potential risk of exposure to *Legionella* bacteria, the use of water systems, parts of water systems or systems of work that lead to exposure have to be avoided as far as is reasonably practicable. Where it is not practicable to do so then control measures should be adopted to minimise exposure.

Guided by the risk ratings outlined above, actions for the prevention or control of exposure to *Legionella* should be prioritised by adopting:

- Urgent corrective actions to prevent or control exposure from water systems or activities categorised as VERY HIGH or HIGH RISK
- Planned corrective actions to meet L8 guidance or equivalent for medium and low risk.[64]

Chapter 5: *Legionella* Prevention and Control

5.1 Implementing a control scheme

If the risk assessment identifies that there is a potential risk and it is practicable to prevent exposure or to control the risk from exposure, the person on whom the corporate/statutory obligation falls e.g. CEO, employer, should appoint a responsible person to take managerial responsibility and provide supervision for the implementation of the precautions and for ensuring that:

- All persons involved in the implementation of the control scheme are properly trained and supervised
- Staff roles, responsibilities and lines of communication are properly defined, clearly documented in writing and understood by all involved
- Management arrangements and communication procedures are audited regularly to ensure that they are effective.

The above also applies to outside companies and consultants who may be responsible for certain parts of the treatment regime. Their contract should clearly state what work they are contracted to do and to whom they are reporting. Also if they become aware, whilst on site, of something that would impact on *Legionella* control that they would transmit this information to the appropriate person even if the piece of equipment, etc. is outside the scope of their contract. The employment of contractors or consultants does not absolve the duty of the holder of responsibility for ensuring that control measures are in place to the highest standard to prevent the proliferation of *Legionella* bacteria.

The responsible person will have day-to-day responsibility for the prevention and control of *Legionella* bacteria in the organisation and is accountable to the manager/CEO who has corporate responsibility for the organisation. The responsible person should be a manager or director, or have similar status with sufficient authority, degree of competence and knowledge of the installation and resources to ensure control measures and systems operations are carried out in a timely, safe and effective manner. The competence required of the responsible person will depend upon the risks they have to manage, i.e. the nature, size, age, use and complexity of the water systems for which they are responsible. For locations with medium- to high-risk water systems the responsible person should have attended specific training courses given by a qualified training provider on the management and control of risks of exposure to *Legionella* bacteria. They should also attend regular refresher courses and attendance at all courses should be recorded. They should have a clear understanding of their duties and of the overall health and safety management structure and policy of the organisation.

Arrangements should be made to ensure appropriate staffing levels are maintained during all hours that water systems are in operation. Appropriate arrangements should be made to ensure that the responsible person or an authorised deputy can be contacted at all times. Details of the contact arrangements for emergency call out personnel should be clearly displayed at access points to all automatically or remotely controlled water systems.

A written scheme detailing measures to prevent or control risks should be implemented and properly managed, including:

- An up-to-date schematic of the plant, building or system, including parts temporarily out of use
- A description of correct and safe operation
- Precautions to be taken and checks to be conducted to ensure the efficacy of the scheme and frequency of such checks
- Remedial action to be taken if the scheme is shown not to be effective.

Based on the above scheme, a programme should be developed for implementation of control measures taking account of risk ratings, site requirements, resources and short-, medium- and long-term options for preventing and reducing risks as far as is reasonably practicable. This will require communication between the risk assessor, service provider and the responsible person.

The risk from exposure will normally be controlled by measures which do not allow the proliferation of *Legionella* bacteria in the system and reduce exposure to water droplets and aerosol. These include

engineering controls, cleaning protocols and other control strategies such as:

- Controlling the release of water sprays
- Avoidance of water temperatures and conditions which favour the proliferation of *Legionella* bacteria and other microorganisms i.e. avoiding water temperatures between 20°C and 50°C. Water temperature is a particularly important factor in controlling the risks and should be either below 20°C or above 50°C
- Avoidance of water stagnation that can encourage the growth of biofilm (slimes that form on surfaces in contact with water) which can harbour *Legionella* bacteria and provide local conditions that encourage growth
- Avoidance of the use of materials which harbour bacteria and other micro-organisms or provide nutrients for microbial growth e.g. natural rubber washers and hoses
- Maintenance of the cleanliness of the system and the water in it in order to avoid the build up of sediments which may harbour bacteria (and also provide a nutrient source for them)
- Use of water treatment regimes/techniques where it is appropriate and safe to do so
- Action to ensure the correct and safe operation and maintenance of the water system.

Decisions should be made about the maintenance procedures and intervals and where relevant on equipment used for carrying out the control measures. *Legionella* bacteria may be present in low numbers in many water systems but careful control will prevent them from multiplying. The scheme should give details on how to use and carry out the various control measures and water treatment regimes including:

- The physical treatment programme e.g. the use of temperature control for hot and cold water systems
- The chemical treatment programme including a description of the manufacturer's data on effectiveness, the concentrations and the contact time required. All disinfectants used must be validated for the purpose for which they are being used and the information available in peer-reviewed literature that has been independently assessed
- Health and safety information for storage, handling, use and disposal of chemicals
- System control parameters (together with allowable tolerables); physical, chemical and biological parameters, together with measurement methods and sampling locations, test frequencies and procedures for maintaining consistency
- Remedial measures to be taken in case the control limits are exceeded including lines of communication
- Cleaning and disinfection procedures.

There should also be a description of the correct operation of the water system plant including:

- Commissioning and recommissioning procedures
- Shutdown procedures
- Checks of warning systems and diagnostic systems in case of system malfunctions
- Maintenance requirements and frequencies
- Operating cycles – including when the system plant is in use or idle.

5.1.2 Monitoring the control scheme

Many outbreaks of legionnaires' disease are caused by poor maintenance and control procedures. The implementation of a control scheme should be regularly monitored and decisions should be made on the frequency and manner of the monitoring procedures. The effectiveness of the programme should also be monitored including the impact of short-term or interim measures. Regular review and updating of risk ratings is crucial to the success of the control scheme and the implementation programme should be updated to take account of any changes in priorities and timescales. This should be the responsibility of the responsible person or where appropriate an external contractor or an independent third party should be involved.

This will involve:

- Checking the performance of the system and its component parts
- Inspecting the accessible parts of the system for damage and signs of contamination
- Monitoring to ensure that the treatment regime continues to control to the required standard.

The operating characteristics of the water distribution network e.g. pumps **should be monitored at least once weekly**. The results of monitoring and testing should be interpreted by a suitably experienced and competent person and any remedial measures where necessary should be carried out promptly.

Testing of water quality is an essential part of monitoring of the treatment regime, particularly in cooling towers. A service provider e.g. a water treatment company or consultant may undertake it provided that they are trained to do so and properly supervised (see Chapter 7, Section 7.3). The type of tests required will depend on the nature of the system.

The routine monitoring of the general aerobic heterotrophic bacterial count (total viable count) is a very important indicator of whether microbiological control is being achieved. This should be routinely undertaken for cooling towers (see Section 5.2.2 and Chapter 6, Section 6.9.2) and spa pools (see Chapter 8, Section 8.5.9).

In relation to hot and cold water systems, there is no need for routine microbiological monitoring as systems should be supplied with water that is fit to drink and the system should be totally enclosed and not open to significant external contamination. However, if maintenance or control measures have been inadequate and there is a risk of microorganisms proliferating in the system then microbiological investigations should be undertaken.[64] Sampling and testing for the presence of *Legionella* bacteria may also be appropriate as an indication that adequate control is being achieved. More details on sampling for *Legionella* in the various systems are outlined in Sections 5.2.2 and 5.2.3, and Chapter 6, Section 6.9.

In order to ensure effective implementation of the control programme, a compliance checklist should be compiled which includes:

- Responsibilities allocated
- Risk assessments up-to-date
- Written control scheme implemented
- Written control scheme working
- Satisfactory closure of non-compliances
- Emergency action procedures
- Process of management review
- Records complete and up-to-date.

5.1.3 Record keeping

The responsible person(s) appointed must ensure that appropriate up-to-date records relating to the control scheme are kept. These records should include the following details:

- Names and positions of person(s) responsible for carrying out the various tasks under the written scheme i.e. responsible for risk assessment, managing and implementation of the control scheme
- Plans and schematic drawings of the systems
- Details showing the current state of operation of the system e.g. when the system or plant is in use and if not in use whether it was drained down or not
- The significant findings of the risk assessment
- The written scheme of actions and control measures required and details of their implementation
- The results of any monitoring, inspection, test or check carried out, and the dates
- A log detailing visits by contractors, consultants, and other personnel. The remedial work required and carried out and the date of completion
- The signature of the person carrying out the work or other form of authentication where appropriate i.e. contract specification
- Copies of contractor's method statements

- Cleaning and disinfection procedures and associated reports and certificates
- Results of the chemical and microbiological analysis of the water
- Information on other hazards e.g. treatment chemicals
- Personnel training records
- Review meeting notes and actions
- Product information and chemical/biocide safety data sheets.

Records kept in accordance with the above should be retained throughout the period for which they remain current. All test and inspection records must be kept for five years from the date of the test or inspection. All records should be signed by those persons performing the various tasks assigned to them.

5.1.4 Audit

A competent person should audit the implementation and performance of the risk management programme periodically (at least every two years). This person should be completely independent of the personnel responsible for the implementation of the risk control regime and should have no interest in the provision of such services.

5.1.5 Responsibilities of suppliers and service providers

Outbreaks of legionnaires' disease have been associated with faulty installation of equipment[65] and inadequate application of water treatment and risk control regimes. As outlined in Chapter 3 on legislation, suppliers and service providers have duties and responsibilities under occupational health and safety legislation and must ensure that:

- Equipment is designed and constructed to be safe and without risks to health when used at work
- Adequate information is provided to the user about risk and measures necessary to ensure that water systems will be safe and without risk to health when used. This should be updated in the light of any new information about significant health and safety risks that becomes available
- Products and services are fit for purpose and that any limitations are clearly defined and made known to responsible persons
- Staff have the necessary ability, experience, instruction, training and resources to carry out tasks competently and safely
- A written risk assessment is undertaken and a plan of work/method statement for their work activities is prepared so that such activities are planned, organised and controlled.

5.1.6 Reducing *Legionella* risks in new and refurbished buildings

Water systems should be designed, installed and commissioned to ensure risks from *Legionella* bacteria are eliminated wherever possible, or reduced as far as is reasonably practicable. Designs should also ensure that adequate provisions are made to facilitate safe system operation and maintenance since a poorly designed system can be both difficult and expensive to operate and maintain.

The 'designing out' of features that will increase the potential for seeding, growth and aerosolisation of *Legionella* should be regarded as an integral component of an effective risk control strategy, e.g. cold and hot water systems should be designed to preserve supply water quality, prevent microbial growth, eliminate or reduce formation of aerosols, minimise corrosion and maintain internal surfaces in a clean condition. This can be achieved by, for example:

- Using cold water storage tanks that optimise the maintenance of potable water quality with a storage capacity of no more than 24 hours average water demand
- Utilising unvented direct mains supplied hot water systems
- Avoiding water storage tanks supplying calorifiers
- Using point of use water heaters rather than centralised hot water systems
- Designing hot water storage vessels, direct fired hot water service boilers and calorifiers to ensure adequate control of water temperatures in storage and distribution, and with sufficient heating capacity to enable periodic pasteurisation of their contents
- Minimising the distance between the source of the water supply and point of use. Zoning should be

used where appropriate in more complex systems

- Designing distribution systems to ensure regular throughput of water by eliminating 'dead legs' and long pipework runs
- Hot and cold water distribution pipework should be installed to minimise the transfer of heat between both. Appropriate insulation of pipes is essential
- Ensuring that fittings, materials and components are corrosion-resistant and are constructed of approved materials which do not release nutrients into the water to support microbiological growth
- Avoiding use of equipment such as spray taps which generate aerosols where suitable alternatives are available. Where it is essential (e.g. showers) then equipment should be selected to facilitate routine cleaning and disinfection
- Thermostatic mixing valves, when used, should be sited as close as possible to the point of use. Ideally, a single TMV should not serve multiple tap outlets but if they are used the mixed pipework should be kept as short as possible.[64] Self-disinfecting TMVs are now available but their effectiveness may be compromised by the presence of extensive sludge, scale and biofilm in the water distribution network
- Sources of aerosols or droplets should be sited away from direct intake sites such as air vents and open windows.

It is important that the total requirements for water supply and quality are assessed in the planning stages and water systems appropriate to areas of accommodation are allocated. Where a building project is completed and commissioned in phases or it is anticipated that areas of the building are likely to have different levels of occupancy and usage then careful consideration should be given to **zoning** of the water services to enable floors and areas of the building to be isolated and operated independently.

Installation and commissioning also require careful planning and execution to ensure designs are properly implemented and the necessary pre-commissioning cleaning and disinfection are carried out in accordance with industry standards and completed in time for hand-over. Long delays between completing the system disinfection and operating the water system will result in a deterioration in water quality and should be avoided. It is essential to minimise the development of biofilms. This can be done by emptying water limbs that are not in service and by preventing water stagnation in the distribution system. Disinfection systems should be in place from the first moment the water flows through the system. Once established, biofilms are extremely difficult to eliminate. In new hot and cold water systems, if more than seven days has elapsed before the system is put into regular use, every outlet should be flushed until the water temperature stabilises.[66]

Only competent service providers should be appointed to design, install or modify water systems. For those installations or modifications which could significantly affect the risk of legionellosis from the system, the appointed service provider should submit the following to the appropriate responsible person:

- A detailed description of the proposed new system, including a schematic drawing showing the layout of all component parts and identifying changes to existing systems
- Confirmation that its design and construction complies with relevant legislation, guidance and standards
- A risk assessment which considers the risk of legionellosis arising during the installation, including from any changes to existing systems, and identifies the precautions required to mitigate against these risks.

This information should be submitted to the responsible person at a reasonable period in advance of commencement of the work. The work should not proceed until it has been approved by the responsible person or by a nominated deputy in their absence.

On receipt of the information specified in the section above, the responsible person, or their nominated deputy should review the submission within 20 working days to consider whether:

- The system design allows it to be subsequently adequately maintained
- The assessment of risk is suitable and sufficient, with precautions adequate to minimise the risks, for example, from creation of dead legs and blind ends, from possible contamination of the system, etc.
- Arrangements are in place to monitor the work and ensure adequate commissioning of the system

- Necessary contingency measures will be put in place to minimise potential disruption to business operations and welfare facilities, for example, by provision of alternative water supplies, communicating changes, etc.
- The site can be cleared of other work and properly prepared
- Adequate and appropriate records will be provided, including sufficiently detailed 'as-fitted' plan or schematic drawings, operations and maintenance manuals, etc.

Once satisfied that all necessary safety arrangements are in place, the responsible person should approve the work and notify the designer/installer. Larger and more complex projects will often benefit from a multidisciplinary approach involving, for example, designers, architects, manufacturers, installers, risk assessors, water quality specialists, microbiologists, operatives and users.

5.1.7 Materials for construction of water distribution networks

As *Legionella* bacteria are usually associated with bacterial biofilms and biofouling in water systems, consideration should be given to the materials used in the construction of water distribution networks. Previous studies with a range of materials commonly used in the construction of water systems showed that some materials were very good at limiting colonisation and biofilm formation by a wide range of bacterial species, whereas other materials were very poor. Copper was the best at limiting colonisation and biofilm formation, followed by polybutylene and stainless steel, whereas biofilm formed more readily on polyethylene, chlorinated polyvinyl chloride (PVCc), unplasticised polyvinyl chloride (PVCu), steel and ethylene-propylene.[67;68] Distributing hot and cold water using copper pipes may significantly improve the microbial quality of water in water distribution networks as copper has been shown to possess significant antimicrobial advantages over water pipework of other composition.

5.2 Technical guidelines for prevention and control

An effective water treatment regime is essential for *Legionella* control. In addition to controlling legionellae, water treatment must also address the control of general microbial activity, biofilm development, corrosion, scale deposition and the retention of particulate solids. A cooling tower for example, with an inadequate or poorly controlled water treatment programme will be more vulnerable to contamination with legionellae and, therefore, present a much higher risk of exposure. Similarly, a distribution system which is fed with water containing sediment, minerals, organic matter and biofilm seed will always present a high risk. Removal or control of these elements does much to reduce the risk and also reduces the requirements for residual disinfection.

In assessing the adequacy of water treatment, cleaning, disinfection and maintenance regimes particular attention should be paid to:

- Biocide type, dosage rate and frequency, and half-life
- Efficacy of corrosion/scale control
- Operation and calibration of dosing/control equipment
- Maintenance of pre-treatment and ancillary plant
- Adequacy of cleaning and disinfection.

5.2.1 Hot and cold water systems

Temperature control

Temperature control is the preferred strategy for reducing the risk of *Legionella* in water systems. Cold water systems should be maintained at a temperature <20°C, while hot water should be stored at 60°C and distributed so that it reaches a temperature of 50°C within one minute at the outlets. Care is needed to avoid much higher temperatures because of the risk of scalding. At 50°C the risk of scalding is small for most people. However, the risk particularly to young children, people who are disabled or elderly and to those with sensory loss will be greater. The risk of scalding also increases rapidly with higher temperatures and for longer exposure times. Where a significant scalding risk has been identified the use of TMVs on baths and showers should be considered to reduce temperature. These need to be placed as close to the point of use as possible.[64] Where buildings cannot be retrofitted with TMVs, periodically increasing the temperature to at least 66°C at the point of use or chlorination followed by flushing should be considered.[69]

Thermal disinfection of hot water systems in emergency situations is detailed in Chapter 9, Section 9.4.1.

Monitoring the temperature control regime

Table 4 outlines the recommended inspection frequency for the temperature control regime.

Table 4. Monitoring the temperature control regime in hot and cold water systems

Frequency	Check	Standard to meet		Notes
		Cold water	Hot water	
Monthly	Sentinel taps[1]	The water temperature should be below 20°C after running the tap for up to two minutes	The water temperature should be at least 50°C within one minute of running the water	This check makes sure that the supply and return temperatures on each loop are unchanged i.e. the loop is functioning as required
	If fitted, input to TMVs on a sentinel basis		The water supply to the TMV should be at least 50°C within one minute of running the water	One way of measuring this is to use a surface temperature probe
	Water leaving and returning to calorifier		Outgoing water should be at least 60°C and return water at least 50°C	If fitted, the thermometer pocket at the top of the calorifier and on the return leg are useful points for accurate temperature measurement. If installed these measurements could be carried out and logged by a building management system
Six monthly	Incoming cold water inlet (at least once in the winter and once in the summer)	The water temperature should preferably be below 20°C at all times		The most convenient place to measure is usually at the ball valve outlet to the cold water storage tank
Annually	Representative number of taps on a rotational basis	The water temperature should be below 20°C after running the water for two minutes	The water temperature should be at least 50°C within one minute of running the water	This check makes sure that the whole system is reaching satisfactory temperatures for *Legionella* control

Source: HSC UK – Legionnaires' disease: the control of Legionella bacteria in water systems: approved code of practice and guidance[64]

Chemical control

Although temperature control is the recommended strategy for reducing risks from *Legionella* bacteria in water systems, in some buildings, such as large healthcare facilities, chemical control (e.g. chlorine dioxide

[1] Sentinel taps: For a hot water system: the first and last taps on the recirculating system. For cold water systems (or non-recirculating hot water systems), the nearest and furthest tap from the storage tank. The choice of sentinel taps may also include other taps which are considered to represent a particular risk.

or silver/copper ionisation treatment) is often used as an additional means of control.

It is important to note that chlorine dioxide and its breakdown products chlorite and chlorate can be deleterious to certain high-risk groups, e.g. renal dialysis patients, and should be removed from the water supply to units where these patients are being treated. They are also a potential problem for neonates if ingested. It is important to ensure that the water used to make up feeds in neonatal units is from the potable water supply (drinking water) and not from the chlorine dioxide treated water. Where chlorine dioxide and other potentially hazardous chemicals (e.g. hydrogen peroxide) are used, water disinfection procedures should be reviewed and liaison should take place with units treating at-risk patients. For further information please consult the UK DoH documents HTM 04-01[6] and Estates and Facilities Alert, DH 2008/08, Gateway ref.10618.[70]

Backflow prevention is required if chemicals are injected into a pipe connected to the mains supply.[6] **Chloramines are increasingly being used to disinfect drinking water supplies but can also present problems for dialysis water systems.**[6]

In hot water systems, chlorine is rapidly lost and maintaining temperature control of the system is essential. Ionisation is pH-sensitive and there have been reports of a reaction between silver and dissolved calcium minerals in water, resulting in staining of sanitary ware. Ultraviolet light and ozone treatment are available but are of limited use as they are only effective at or close to the point of application.

Monitoring of chemical regime
Routine inspection and maintenance will usually be sufficient to ensure control in most systems provided the following parameters are monitored at regular intervals and remedial action taken when necessary:[64]

Chlorine dioxide regime

- The quantity of chemicals in the reservoir
- The rate of addition of chlorine dioxide to the water supply
- The concentration of chlorine dioxide at sentinel taps should be measured monthly and should be at least 0.1mg/l
- The concentration of chlorine dioxide at a representative number of outlets should be measured annually and should be at least 0.1mg/l.

Ionisation

- The rate of release of copper and silver ions into the water supply
- The concentration of silver ions at sentinel outlets should be measured monthly and should be at least 20µg/l
- The concentration of silver ions at representative taps selected on a rotational basis should be measured annually and should be at least 20µg/l
- The condition and cleanliness of the electrodes
- The pH of the water supply.

Additional monitoring of hot and cold water systems
Checklist 1 outlines additional monitoring that is required in hot and cold water systems. Monitoring in relation to *Legionella* is dealt with in Chapter 6, Section 6.9.

Checklist 1. Hot and cold water systems

Service	Task	Frequency
Hot water services	Visual check on internal surfaces of calorifiers for scale and sludge.	**Annually**
Cold water services	Visually inspect the cold water storage tanks and carry out remedial work where necessary	**Annually**

Source: Adapted from Checklist 2 in HSC UK – Legionnaires' disease: the control of Legionella bacteria in water systems: approved code of practice and guidance[64]

Flushing
The extent of water use is one of the most important factors affecting water quality.[6] Where stagnation occurs or water use is low, cold water temperatures can increase significantly and there is the potential for *Legionella* growth. Showers are very important in this regard because of their capacity to generate aerosols and their potential to be under-utilised. Management needs to ensure that water services are sufficiently used. All unnecessary showers should be removed and the supply pipework should be cut back as far as the mains connection.

The risk of legionellosis attributed to the colonisation of hot and cold water systems by *Legionella* bacteria is well established. In a study of ten hospitals that were colonised by *Legionella* and ten that were not colonised, legionnaires' disease was found significantly more often in colonised than non-colonised hospitals ($p = 0.054$).[71] In a study of 20 Spanish hospitals, nosocomial legionnaires' disease was found in 64.7% of the hospitals with water cultures positive for *Legionella*, whereas no nosocomial cases were found in hospitals with *Legionella*-negative water cultures.[72]

Exner *et al* in their review of the literature on nosocomial infections cite a German study which investigated hospitals and residential units and other buildings that could be affected by the colonisation of the water system with *Legionella* bacteria.[73] In the study, local colonisation of the water system was defined as colonisation of isolated parts of the plumbing system (taps or showerheads). Systemic colonisation was defined as colonisation of the whole system, including the central parts of the water supply. In the case of local colonisation it was possible to flush out *Legionella* bacteria from the distal water sites e.g. taps, showers. However, with systemic colonisation even intensive system flushing had no effect on the reduction of *Legionella* bacteria in the system. If regular flushing is having no effect on the levels of *Legionella* then all of the existing control procedures need to be reviewed and amended if necessary.

Hot and cold water systems should be designed to aid safe operation by preventing or controlling conditions which permit the growth of *Legionella*. Flushing procedures should be based on a risk assessment of the water systems in the building/institution concerned. A flushing protocol is only effective where the water system is adequate and the water supply is not contaminated. This particularly applies where there are water storage tanks.

The following are risk factors that should be considered in the risk assessment:

Institutional risk factors

- *Age and condition of the pipes*
  Older pipes are more prone to the growth of *Legionella* because of corrosion, scaling, biofilms and sediment. *Legionella* bacteria require a supply of nutrients to multiply. Sources of these nutrients include commonly encountered organisms within the water system such as algae, amoebae and other bacteria. The presence of sediment, sludge, scale and other material within the system, together with biofilms, facilitate the growth of *Legionella* and may provide protection for the *Legionella* bacteria from temperatures and disinfectants that might otherwise kill or inhibit the growth of these organisms.[64]
- *Redundant pipework and fittings*
  Hospitals are frequently constructed over a long period of time and as a result often contain a considerable amount of redundant pipework/deadlegs in which water can stagnate which also facilitates the growth of *Legionella*.[74] Studies have shown that flushing of outlets whilst reducing stagnation has little effect on biofilm, particularly when applied to outlets supplied from extensive pipework distribution systems. Therefore, before the procedures are carried out, consideration should be given to the removal of infrequently used sanitary fixtures such as showers and taps, etc. If they are removed then the redundant supply pipework should be cut back as far as the main connection.[64] Showers (excluding safety showers used for decontamination purposes) should not be fitted where they are likely to be used less than once per week.
- *Complexity of the system*
  Complex, lengthy pipe systems are more at risk than simpler, short systems.

Population at risk
In the hospital setting, patients with predisposing risk factors are not only at higher risk of infection but also have a higher mortality rate when infected with *Legionella*. Consequently, hospitals and residential institutions must pay particular attention to the prevention of legionellosis.[74] Those at higher risk include:

- Immunocompromised organ transplant patients, patients with HIV/AIDS, and those receiving systemic steroids
- Patients with underlying chronic disease such as diabetes mellitus, congestive heart failure, chronic obstructive pulmonary disease, and chronic renal disease
- People over 40 years of age
- Smokers
- Those with excessive alcohol intake.

Prior history of building

- History of legionellosis associated with the building
- History of positive water cultures from the potable water system and outlets or cooling towers.

Flushing procedure

The risk from *Legionella* bacteria growing in peripheral parts of the water system such as deadlegs off the recirculating hot water system may be minimised by regular use of these outlets. Water within the system may stagnate because a particular outlet is not used for more than a week.[74] In most hospitals, there are areas which may have water outlets such as showers that are not used for significant periods of time. These areas may change from time to time, as wards or patient bathroom areas are disused and reopened. Showers in such areas are more likely to harbour *Legionella* than those in areas where outlets are in regular use. Hotel accommodation may present the same problem with bedrooms unused during the off-peak periods.[74]

Showers and water outlets that are in daily use do not require flushing.

How to flush

The frequency and duration of flushing procedures should be based on a risk assessment. Only run showers that are intermittently used. All outlets should be flushed at least once per week at full flow (the water flow should be increased gradually to minimise the production of aerosols). However, risk assessment may indicate the need for more frequent flushing where there is a more susceptible population present, e.g. in hospitals, nursing homes, etc.[64] High-risk areas in hospitals e.g. wards with immunocompromised patients, renal transplant units, may require flushing on a daily basis and this should become part of the daily cleaning process. The local multidisciplinary infection prevention and control team should make these decisions.

Healthcare facilities

The duration of flushing should be based on a risk assessment but at a minimum the procedure below should be followed:

Showers

Run showers for six minutes weekly as follows:

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

Taps

Run individual hot and cold taps weekly as follows:

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

Mixer taps

- Run with the lever in the coldest position for three minutes weekly
- Run with the lever in the hottest position for three minutes weekly
- Ensure that hot water comes out hot when in the hot position and cold when in the cold position.

Cold water should be used to flush the cold water system and hot water to flush the hot water system. The period of flushing must be sufficient to remove all stagnant water leading to the outlet. The number of outlets that can be flushed simultaneously will depend on the capacity of the water heater and the flow capability of the system.[75]

Where it is difficult to carry out weekly flushing, the stagnant and potentially contaminated water from within the shower/tap and associated deadlegs needs to be purged to drain before the appliance is used. It is important that this procedure is carried out with minimum production of aerosols, e.g. additional piping may be used to purge contaminated water to drain. Automatic drain valves fitted to showers to drain the mixer valve and shower hose after use can produce conditions within the shower that support the growth of *Legionella* and are not recommended as a method for controlling the risk of exposure to *Legionella*.[64]

Where a single TMV serves several multiple showerheads, it is important to ensure that these showers are flushed frequently. Where an outlet is not used for more than a week it must be flushed until the temperature of the water at the outlet has reached the pre-determined temperature set by the thermostatic mixing valve. A surface probe can be used to measure the temperature of the water going into the TMV. Every thermostatic mixing valve must be cleaned and maintained at least once in every calendar year.[74]

The flushing procedures for hot and cold water services are shown in Table 5.

Table 5. Flushing procedures for hot and cold water services

Service	Task	Frequency
Intermittently used outlets	Flush for several minutes Where there is difficulty with weekly flushing, flush through and purge to drain immediately before use. Avoid the production of aerosols.	Weekly Before use
Hotels/accommodation	Run all taps and showers in every bedroom whether occupied or unoccupied for several minutes Flush cisterns once	Weekly Weekly
Emergency showers and eye wash sprays. Eye wash sprays should be on an independent water reservoir	Flush through and purge to drain	Quarterly or more frequently if recommended by manufacturers
Dental unit waterlines. Dental handpieces, ultrasonic scalers and air/water syringes	Flush for a minimum of 2-3 minutes Flush for a minimum of 20-30 seconds Flush for a minimum of 30 seconds	At the beginning of each working day After each patient After each patient

Source: Adapted from Checklists 2 and 3 in HSC UK – Legionnaires' disease: the control of Legionella bacteria in water systems: approved code of practice and guidance[64]

Monitoring

Once started, the flushing procedure has to be sustained and logged as lapses can result in a critical increase in *Legionella* bacteria density at the outlet. A flushing protocol should be introduced in each

institution. The protocol should be incorporated into the institution's regular cleaning contract. A monitoring system must be put in place to monitor compliance with the flushing protocol. Records of compliance should be maintained and a nominated person should be accountable for implementing the protocol and for maintaining records.

Audit
A regular audit of control and monitoring procedures should take place.

Precautions
Maintenance, cleaning, and operating procedures should be designed to control the risks to staff and others who may be affected. Personnel involved in flushing procedures should be adequately trained in safety procedures including the use and maintenance of PPE.

Cleaning and disinfection of showerheads
Consider replacing showerheads and hoses as an alternative to cleaning and disinfection.

Dismantle, clean and descale showerheads and hoses quarterly or more frequently as required based on a risk assessment. In high-risk areas this should be done on a monthly basis.[75] Disinfectants containing chlorine can be used to disinfect showerheads.[76] However, chlorine concentrations vary in different products.[77] Proprietary bleach can lose some of the chlorine over time so newly manufactured bleach should be used if possible. Thick bleach solutions should never be used for disinfection purposes as they contain potentially poisonous additives.

A solution of **1,000 parts per million (ppm)** of free available chlorine (Table 6) for 10-15 minutes should be used to disinfect showerheads.

Table 6. Preparation of chlorine disinfectants used for disinfecting showerheads

Proprietary bleach (4% free available chlorine)	
Volume of water to which chlorine is added	**1,000 ppm**
5 litres water	Add 125 ml bleach
10 litres water	Add 250 ml bleach
50 litres water	Add 1,250 ml bleach
Liquid pool chlorine (with 12.5% free available chlorine – concentrations are based on 10% free available chlorine)	
5 litres water	Add 50 ml bleach
10 litres water	Add 100 ml bleach
50 litres water	Add 500 ml bleach
Granular chlorine (with 65% free available chlorine)	
5 litres water	Add 8 g bleach
10 litres water	Add 15 g bleach
50 litres water	Add 77 g bleach

Source: Adapted from Victorian Government Department of Human Services[78]
***Note:** It is safer to add chlorine to water – do not add water to chlorine. Always use cold water to make up chlorine solutions.*

Procedure

a. Set up hazard warning signs at access points to the washroom area if the work site is open to the public or general staff. If possible showerheads should be removed from the area for cleaning at a designated point

b. The following PPE is required: standard overalls, gloves and goggles/face shield. In areas where there is a significant risk, PPE and respiratory filter masks should be worn
c. Transfer only small quantities of the required treatment chemicals to the area
d. Routine

- Remove the showerheads to be cleaned. If flexible hoses are used they should be included in the cleaning routine
- Dismantle the heads as far as possible
- Place the fittings into the cleaning product*, physically clean as required to remove scale and any other deposits
- Rinse seals and fittings thoroughly with fresh water (this is important to avoid potentially dangerous fumes from reactions with the disinfecting solution)
- Place the fittings in a disinfecting solution* (hypochlorite at 1,000 ppm for 10-15 minutes)
- Rinse seals and fittings thoroughly with fresh water
- Reassemble the showerhead
- Re-fit the showerhead
- Flush the whole showerhead assembly

e. Complete the showerhead cleaning record.

** Some showerhead materials require specific cleaning and disinfecting chemicals to avoid damage of the fitting, examples include gold plated and thin chrome plated fittings (see manufacturer's advice).*

5.2.2 Cooling towers and evaporative condensers

Evaporative cooling is a physical phenomenon by which evaporation of a liquid into the surrounding air cools the remaining liquid. In the case of water this phase change can be used as part of a cooling system.[75] Evaporative cooling is an energy efficient means to reject unwanted heat from an air conditioning, refrigeration or process cooling system using an open or closed circuit cooling tower. Evaporative condensers (Figure 7) which directly condense refrigerant use the same principle.

To optimise the evaporation process in evaporative cooling equipment there needs to be a large area of contact between the water and the airstream flowing through the unit. In an open circuit cooling tower this is achieved by filming the water to be cooled over a fill pack that has a large surface area to maximise the air and water interface. In a closed circuit cooling tower or evaporative condenser the fluid to be cooled or refrigerant to be condensed is in a closed loop heat exchanger within the unit. The evaporative cooling effect is achieved by a secondary re-circulating system which distributes water continuously over the heat exchanger.

Evaporative cooling equipment operates at temperatures which can provide an environment for the growth of microorganisms in the water, including *Legionella*. If the water is allowed to become heavily contaminated and to escape from the unit in aerosol form and then inhaled by susceptible persons in the vicinity, cases of legionellosis may result. However, this can be avoided completely by close attention to the design of the equipment, by using water treatment to maintain good water quality control, and by system cleanliness. An important element of the design is the need for high efficiency drift eliminators to minimise the water droplets and aerosols discharged into the atmosphere.

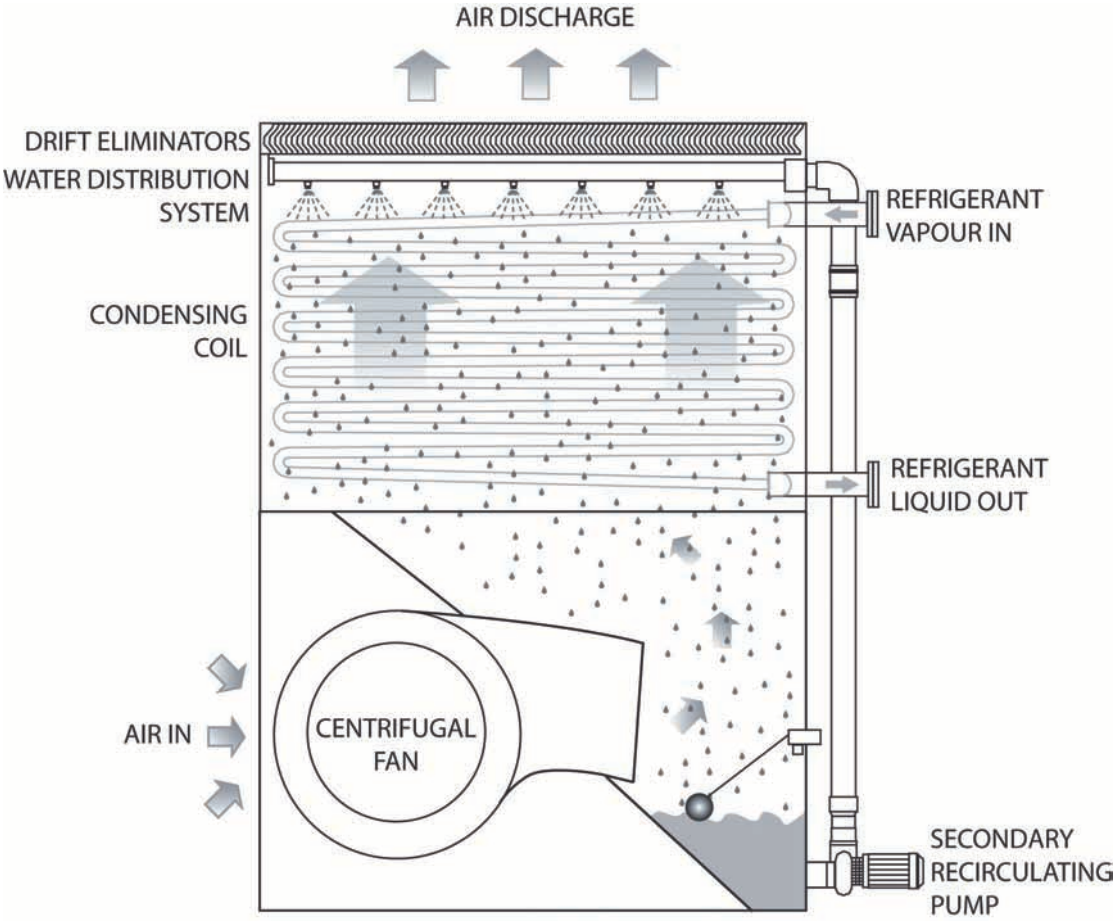

Figure 7. Evaporative condenser

Monitoring of cooling towers
Checklist 2 and Table 7 outline the inspection frequency for cooling towers and evaporative condensers.

Checklist 2. Cooling tower installations

System/service	Task	Frequency
Cooling towers and evaporative condensers	Monitor water quality, water use and biocide/ chemical use to assess and ensure effectiveness of water treatment regime, including key chemical and microbiological parameters, and observation of internal conditions of pond, pack and water	**See table 7 and 8**
	Central control function, conductivity sensor calibration, blowdown function, uniformity of water distribution, condition of sprays/troughs, eliminators, pack, pond, immersion heater, fans and sound attenuators	**Monthly to three monthly, according to risk (table 7)**
	Clean and disinfect cooling towers/evaporative condensers, make-up tanks and associated systems, including all wetted surfaces, descaling as necessary. Packs should be removed and cleaned where practicable (see the Health and Safety Executive guidelines on the removal of pack from cooling towers at www.hse.gov.uk/legionnaires/coolingtowers.htm)[79]	**Six monthly**

Source: HSC UK – Legionnaires' disease: the control of Legionella bacteria in water systems: approved code of practice and guidance[64]

Table 7. Typical on-site monitoring checks recommended for good operating practice of cooling towers

Parameter	Timing	
	Make-up water	Cooling water
Calcium hardness as mg/l $CaCO_3$	**Monthly**	**Monthly**
Magnesium hardness as mg/l $CaCO_3$	**Monthly**	**Monthly**
Total hardness as mg/l $CaCO_3$	**Monthly**	**Monthly**
Total alkalinity as mg/l $CaCO_3$	**Quarterly**	**Quarterly**
Chloride as mg/l Cl	**Monthly**	**Monthly**
Sulphate as mg/l SO_4	**Quarterly**	**Quarterly**
Conductivity µs (Total dissolved solids)	**Monthly**	**Weekly**
Suspended solids mg/l	**Quarterly**	**Quarterly**
Inhibitor(s) level mg/l	**Not applicable**	**Monthly**
Oxidising biocide mg/l	**Not applicable**	**Weekly**
Temperature °C	**Not applicable**	**Quarterly**
pH	**Quarterly**	**Weekly**
Soluble iron as mg/l Fe	**Quarterly**	**Quarterly**
Total iron as mg/l Fe	**Quarterly**	**Quarterly**
Concentration factor	**Not applicable**	**Monthly**
Microbiological activity	**Quarterly**	**Weekly**
Legionella	**Not applicable**	**Quarterly**

Source: HSC UK – Legionnaires' disease: the control of Legionella bacteria in water systems: approved code of practice and guidance[64]

Table 8. Outlines the action levels following microbial monitoring of cooling towers.

Table 8. Action levels following microbial monitoring of cooling towers

Aerobic count cfu/ml at 30°C (minimum 48 hours incubation)	*Legionella* bacteria cfu/litre	Action required
10,000 or less	100 or less	**System under control**
More than 10,000 and up to 100,000	More than 100 and up to 1,000	**Review programme operation** A review of the control measures and risk assessment should be carried out to identify any remedial actions and the count should be confirmed by immediate re-sampling
More than 100,000	More than 1,000	**Implement corrective action** The system should be immediately re-sampled. It should then be 'shot dosed' with an appropriate biocide as a precaution. The risk assessment and control measures should be reviewed to identify remedial actions

Source: HSC UK – Legionnaires' disease: the control of Legionella bacteria in water systems: approved code of practice and guidance[64]

5.2.3 Other risk systems

The monitoring frequency for various tasks in other risk systems is detailed in Checklist 3.

Checklist 3. Other risk systems

System/service	Task	Frequency
Ultrasonic humidifiers/foggers and water misting systems	If equipment fitted with UV lights, check to ensure effectiveness of lamp (check to see if within working life) and clean filters	**Six monthly or according to manufacturer's instructions**
	Ensure automatic purge of residual water is functioning	**As part of machinery shut down**
	Clean and disinfect all wetted parts	**As indicated by risk assessment**
	Sampling for *Legionella*	**As indicated by risk assessment**
Spray humidifiers, air washers and wet scrubbers	Clean and disinfect spray humidifiers/air washers and make-up tanks including all wetted surfaces, descaling as necessary	**Six monthly**
	Confirm the operation of non-chemical water treatment (if present)	**Weekly**
Water softeners	Clean and disinfect resin and brine tank - check with manufacturer what chemicals can be used to disinfect resin bed	**As recommended by manufacturer**

Lathe and machine tool coolant systems	Clean and disinfect storage and distribution system	**Six monthly**
Spa baths	***See Chapter 8, Section 8.5***	
Horticultural misting systems	Clean and disinfect distribution pipework, spray heads and make-up tanks including all wetted surfaces, descaling as necessary	**Annually**
Dental chair unit waterlines	***See Chapter 8, Section 8.3***	
Car/bus washes	Check filtration and treatment system, clean and disinfect system	**See manufacturer's instructions**
Indoor fountains and water features	***See Chapter 8, Section 8.4***	

Source: Adapted from Checklist 3 in HSC UK – Legionnaires' disease: the control of Legionella bacteria in water systems: approved code of practice and guidance[64]

Chapter 6: Environmental Sampling

6.1 Introduction

Examination of water samples can be a useful method for identifying potential sources of *Legionella* infection. The objectives of environmental water sampling are as follows:

- Confirmation or exclusion of the implicated site as a source of infection
- Risk assessment of the site's water system(s)
- Distinguishing between local or system-wide colonisation of water system(s)
- Identifying critical sites
- Checking the regulation of the temperature, pressure and flows in the plumbing system
- Selecting the right strategy for short-term control of *Legionella*
- Facilitating a proposal for the long-term control strategy for the whole facility.

Sampling for the purposes of routinely monitoring the effectiveness of control measures should only be undertaken on the basis of a comprehensive risk assessment. Whilst sampling for the routine monitoring of *Legionella* represents only one aspect of monitoring the effect of a water treatment programme, it can be useful for auditing control measures, and also to validate new disinfection regimes.[38] In addition, sampling and culturing for *Legionella* may be carried out for the purpose of tracing the source of an outbreak.

Sampling is not a substitute for good maintenance practices and water treatment.[75]

6.2 Sampling criteria

A successful examination for *Legionella* depends on several factors:

- The quality of the sample(s)
- The location of sampling points in terms of being representative of the water system being tested
- The timing of the sampling in relation to the normal operating conditions and control measures of the system, including the timing and levels of biocide dosing
- Proper transportation and storage of the sample(s) to ensure that the sample(s) should undergo as little change as possible before the analysis begins.[38]

6.3 Safety

Environmental samples for *Legionella* should be collected by people with knowledge of *Legionella* ecology and general risk assessment. People taking environmental samples require training to ensure that they select samples containing the highest numbers of bacteria and that they are aware of the risk to themselves and to others from potentially positive sites. Based on a written risk assessment, in some circumstances, it may be necessary to use respiratory protective equipment (see Chapter 7, Section 7.4 on PPE).[3] Individual staff 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.[38]

6.4 Site assessment

The number and types of sites that should be tested to detect *Legionella* must be determined on an individual system basis because of the diversity of plumbing, heating, ventilation and air-conditioning systems in the various institutions that may be sampled.[3] Samples should be representative of each separate water system. They should be taken from the proximal and distal end of the water system and a number of sentinel points in between, the number and location being based on a comprehensive risk assessment (Table 9). Selection of sampling sites also depends on whether the sampling is for routine monitoring or to investigate an outbreak.

Table 9. Sentinel points for sampling

System	Sample points
Cold water system	Storage tank Furthest outlet from the storage tank Other outlets in areas considered to represent a particular risk e.g. hospital wards with 'at risk' patients
Hot water system	Calorifier outlet or nearest tap to the calorifier outlet Return supply or nearest outlet to the return supply Base of calorifier where drain valves have been fitted Furthest outlet from the calorifier Other outlets in areas considered to represent a particular risk e.g. hospital wards with 'at risk' patients

It is essential to undertake a survey of the site to be investigated prior to taking any sample.[38] All surveys follow a basic pattern. The source and the quality of the water should be determined and the site should be examined to establish the location of all systems using water. These systems should then be reviewed and assessed to determine which systems contain water at temperatures likely to support the growth of *Legionella* bacteria. In addition, areas within the systems where growth of *Legionella* bacteria may be expected to be greatest should be reviewed, as should locations where potentially contaminated water might produce aerosols or where aerosols might be released into the environment. The route or pathway of the water through the system should be followed from its entry into the site to the point where it is used or discharged. If a schematic diagram does not exist or is not available, or is known to be or is suspected of being out-of-date, then an up-to-date diagram should be prepared indicating, for example locations of:

- The in-coming water supply, whether of mains or private source
- Storage tanks, expansion or pressure vessels, filters, booster vessel pumps and strainers
- Water softening filters or other storage or treatment facilities
- Calorifiers or water heaters
- The type and nature of materials and fittings, for example taps, showers, water closet cisterns, valves, thermostatic mixer valves, pressure release valves, bathroom radiators and towel rails connected to the domestic water supply (and associated pipework) and the presence of metals, plastics, jointing compounds
- Evaporative cooling towers and condensers or heating circuits
- Air conditioning systems or humidifiers within the building which are supplied with, and store water and which may produce aerosols
- Other equipment that contains water and which might be a potential risk, such as spa pools, humidified display cabinets, machine tools, fountains, etc.
- Equipment that is used infrequently or might not normally be of concern but presents a risk only when the system undergoes maintenance or repair
- The presence of dead-legs or blind-ends.[38]

When all risk sites have been identified the appropriate samples can be collected. There should be discussion with the laboratory which will analyse the samples on the number and type of samples required.[38] Arrangements should also be made for the transportation of the samples to the laboratory.

Aseptic precautions during sampling
It is important to take appropriate precautions to eliminate cross-contamination occurring between sampling sites, especially when collecting dip samples from storage tanks, cisterns and cooling towers.[38]

6.5 Sample types

Two primary sample types should be collected when sampling for *Legionella* - water samples and swabs of biofilm.[3]

Water samples capture the planktonic form of *Legionella* or any disturbed biofilm. Generally, a minimum

of one litre must be collected.[39] Samples should be collected in new, unused, capped or pre-sterilised polyethylene or similar containers containing sufficient sodium thiosulphate to neutralise any chlorine or other oxidising biocide. Temperatures should be measured using a calibrated thermometer, placed in the middle of the water stream.

Swab samples capture the sessile form of *Legionella* that is associated with biofilms.[80] Swab samples must be taken before water samples when collecting both sample types from the same outlet. Swab samples must be kept moistened with sterile water. Multiple samples can be collected from the same site. Sterile absorbent cotton wool swabs should be used.[38]

6.5.1 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.[38]

6.5.2 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.[38]

A pre-and post-flush sample should be taken at all outlets sampled.

6.6 Additional information

Information should be gathered to help interpret the results. As 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.[3]

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, and the presence of various rubber and plastic attachments.

6.7 Sample transport and storage

All samples should be transported to the laboratory in dark, insulated containers to protect them from extreme temperatures and from light.[3] Analysis should begin as soon as possible after the sample has been taken, preferably on the same day. If analysis is delayed, samples should be stored so that concentration and incubation procedures can be commenced within 48 hours of collection. The maximum time from sample collection to culture of the concentrate is 14 days. Samples should be transported and stored at less than 18°C but not less than 6°C.[39] Storing the sample in a refrigerator at temperatures below 6°C may reduce subsequent recovery of *Legionella* bacteria since the bacteria may be induced into a non-culturable state. Although *Legionella* will not multiply significantly during this period, the organism may be adversely affected by the presence of biocides remaining in the sample. If biocides are likely to be present in the sample and cannot be neutralised prior to storage this information should be recorded, and the transport and storage times kept to a minimum.[38]

6.8 Laboratory analysis

Analysis of water samples and swabs for *Legionella* should be carried out by an accredited laboratory which takes part in an external quality assessment scheme for the isolation of *Legionella* from water and is operating in accordance with the international standard ISO 17025:2005. Laboratory facilities for environmental testing should be available in each HSE area.

To meet international best practice requirements a national *Legionella* reference laboratory should be established for clinical and environmental sample testing, to act as a typing centre and to provide expert opinion on the microbiology of the organism.

For more detailed information on sampling procedures see '*The determination of Legionella bacteria in waters and other environmental samples (2005) – Part 1 – rationale of surveying and sampling*' produced by the UK Environment Agency.[38]

6.9 When to take an environmental water sample

It is essential that before a *Legionella* control programme is commenced that a risk assessment is undertaken on site (Chapter 4) and that a written control plan is developed to cover the actions required if sampling for *Legionella* is positive. The UK HSC guidelines on the control of *Legionella* bacteria in water systems outline when sampling should be performed and provide guidance on the appropriate action that should be taken.[64] A summary of its recommendations in relation to hot and cold water systems and cooling towers is outlined below.

6.9.1 Hot and cold water systems

Routine monitoring for *Legionella* in hot and cold water systems is not normally required unless problems arise in the system, for example:

- In water systems treated with biocides where hot water storage temperature is <60°C and distribution temperature is <50°C. Sampling should be carried out monthly initially. The frequency of testing can be reviewed after a year and may be reduced when confidence in the efficacy of the biocide regimen has been established
- In systems where control levels of the treatment regimen (e.g. temperature, biocide levels) are not being consistently achieved. As well as carrying out a thorough review of the system and treatment regimen, more frequent samples should be taken to determine the efficacy of control measures
- When an outbreak is suspected or has been identified.

Table 10 outlines the action level for *Legionella* sampling in hot and cold water systems.

Table 10. Action level following Legionella sampling in hot and cold water systems

***Legionella* bacteria** cfu/litre	**Action required**
>100 but <1,000	**Re-sample and review control programme** - if only one or two samples are positive the water 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, albeit at a low level, with *Legionella*. Disinfection of the system should be considered but an immediate review of control measures and risk assessment should be carried out to identify any other remedial action required
>1,000	**Re-sample, review programme, disinfect system -** the system should be re-sampled and an immediate review of the control measures and risk assessment carried out to identify any remedial actions, including possible disinfection of the system If the identified control measures including disinfection fail to achieve reduced levels of *Legionella* bacteria, the water distribution system should be examined in more detail. If the structure and fabric of the water distribution system is found to be the cause of continued failure to control the level of *Legionella* bacteria, the water distribution system or part of the system should be replaced as deemed appropriate to ensure control

Source: Adapted from Table 4 in HSC UK – Legionnaires' disease: the control of Legionella bacteria in water systems: approved code of practice and guidance[64]

6.9.2 Cooling systems

In cooling tower systems, in addition to routine sampling for aerobic bacteria, a routine monitoring scheme should include periodic sampling for the presence of *Legionella* bacteria. This should be undertaken at least quarterly unless sampling is necessary for other reasons such as to help identify possible sources of the bacteria during outbreaks. More frequent sampling should be carried out when commissioning a system and establishing a treatment programme or when conducting a review of the system/risk assessment to help establish when the system is back under control.

Sampling methods should be in accordance with the international standard ISO 11731 – *Water quality – detection and enumeration of Legionella*.[39] This standard provides advice on best practice for the collection, transportation and storage of samples. It can be purchased from the National Standards Authority of Ireland, Glasnevin, Dublin 9 (Phone: +353 1 8073874). Samples should be taken from the cooling tower water reservoir.

Table 8 in Chapter 5 outlines the action levels following microbial monitoring of cooling towers. Failure to detect *Legionella* bacteria should not lead to the relaxation of control measures and monitoring. Neither should monitoring be used as a substitute in any way for vigilance with control strategies and those measures identified in a risk assessment.

6.9.3 Healthcare facilities

Routine environmental sampling and culture for *Legionella* in healthcare facilities should be based on a comprehensive risk assessment and should be part of an overall management strategy.

The subcommittee recommends that routine water sampling should be done six monthly in healthcare facilities, including nursing homes and long-stay care institutions. In patient care areas for persons at high risk for *Legionella* infection i.e. transplant units,[69] monthly culturing for *Legionella* in water samples is recommended as part of a comprehensive strategy to prevent legionnaires' disease in transplant recipients. The addition of filter-heads to showers in transplant units should be considered.

The subcommittee also recommends that the Dutch guidelines be followed and the number of samples taken should be based on the number of outlets in the water system as shown in Table 11.[81] This will require additional resources.

Table 11. Number of water samples recommended for healthcare institutions

Number of outlets	Number of samples
<50	2 samples
51-100	4 samples
101-200	6 samples
201-400	8 samples
401-800	10 samples
801-1,600	12 samples
>1,600	14 samples

6.9.4 Domestic premises when a case has possible domestic exposure

Health Protection Scotland (HPS) published their advice on water sampling for *Legionella* in domestic premises, based on a study carried out between 1994 and 1998 by the UK Building Research Establishment (BRE).[82]

The study found that it was not unusual to isolate *L. pneumophila* from domestic water systems and its presence per se did not present an unacceptable risk to occupants. Host factors played a significant part in determining if exposure resulted in symptomatic illness. It is likely that most if not all of the population is periodically and even regularly exposed but that only in special circumstances do host factors, level of exposure and infectivity of the particular *Legionella* strain result in a clear case of disease. **Immunocompromised patients should be advised on the avoidance of risk.**

HPS concluded that, as there is a possibility of identifying *Legionella* in any domestic system, sampling of an individual's home should not be a routine response to a notification of a sporadic case unless there are other factors which can be taken into account. Such sampling may lead to isolation of the organism

with consequent pressure for its elimination, a process that is technically problematic and may well be unsuccessful. If domestic water sampling is contemplated there must be a clear rationale for doing so which considers in advance what action, if any, will be taken in the event of identifying the organism in the supply. Possible valid reasons for considering testing a domestic water supply include:

- Eliminating the house as a source of infection in an individual case for epidemiological purposes only
- Identifying a continuing risk of exposure in situations where there is reason to believe that another occupant of the property might be at increased risk (as opposed to a normal level of risk) of developing illness.

HPS also proposed that at least one of the following additional criteria should be fulfilled:

- Evidence that a *Legionella*-like illness, though not necessarily clinically or microbiologically confirmed, has occurred previously amongst occupants of the same house
- Evidence that sampling of the water system would contribute information to inform prevention and control of legionellosis in general terms and which could not otherwise be obtained.

6.9.5 Spa pools

Spa pools will also require regular monitoring for *Legionella,* as other routine microbiological parameters are not good indicators of the risk from *Legionella* (see Chapter 8, Section 8.5.9).[38]

Chapter 7: Training

7.1 Introduction

Without adequate knowledge on the part of all stakeholders, prevention and management of legionellosis is simply not possible, hence the provision of training and/or raising of awareness for all concerned must form a key component of legionellosis risk management. Clearly, training/awareness needs may vary considerably depending on an individual's role or responsibilities. Groups with differing roles in *Legionella* control are outlined below:

- Those involved in risk assessment and risk management activities at a particular location (whether an employee of the organisation or an external consultant)
- Those with a role in investigating cases of legionellosis and managing outbreaks
- The person(s) in an organisation who have been assigned specific responsibility for the supervision of, and implementation of, *Legionella* control measures (these will often, though not always, be the same people as in the first category above)
- Personnel in those workplace environments more favourable to the growth and aerosolisation of *Legionella* bacteria e.g. healthcare facilities, leisure centres, hotels.

Reference to training and competency is made in Chapter 4. The aforementioned chapter deals exclusively with the training/competency requirements for those carrying out risk assessments and for the responsible person designated for *Legionella* control within an organisation.

Those involved in environmental investigations of cases of legionellosis and in assessment of control measures should have, in addition to knowledge of the epidemiology of legionellosis, prior training in both theoretical (e.g. desktop studies) and practical *Legionella* risk assessments (i.e. site visits). They should also have a basic knowledge of building services and have received training in appropriate sampling procedures.

It is highly desirable that all staff working in higher risk locations such as hospitals, hotels, leisure centres, etc. have an awareness of the *Legionella* hazards associated with their work environment and knowledge of appropriate control measures. Training workshops should be undertaken which are tailored to institutions/operatives following a training needs assessment. Basic information sheets on *Legionella* hazards and control should be developed for distribution to workplaces (e.g. Appendix H 'Minimising the Risk' could be used/adapted for this purpose). The information sheets should also have details of relevant websites e.g. UK - HPA, and HSC; Ireland - HPSC, and HSA. The designated responsible person for *Legionella* control in each organisation should carry out awareness sessions with the staff at regular intervals and keep records of these.

7.2 'Competent person' and assessment of competency

The definition of 'competent person' given in Section 2 of the Safety, Health and Welfare at Work Act 2005 is outlined in Appendix G. It relates to the possession of 'sufficient training, experience and knowledge appropriate to the nature of the work to be undertaken'. Assessment of competency therefore falls into two broad areas:

1. **Formal qualification(s)**, if any, possessed by the person. In this regard, Section 2.(2)(b) refers to the 'framework of qualifications referred to in the Qualifications (Education and Training) Act 1999. This, in practice, relates to training or qualifications which have formal validation and recognition in the State through validating bodies, established under the aforementioned Act such as the Higher Education and Training Awards Council (HETAC) (subsequently established by the Minister of Education and Science in 2001). This body is responsible for validation of higher education and training awards and recognition of institutions (e.g. universities, institutes of technology) to which authority to make awards may be delegated. Any third level institution offering further education or training can apply to the HETAC for formal recognition. The Minister also established the Further Education and Training Awards Council (FETAC) under the 1999 Act. The Council recognises and validates shorter courses e.g. those run by FÁS, CERT, vocational educational committees, Teagasc. The formal qualification would also be expected to address the area of the knowledge criterion of the 'competent person' definition.

2. **Experience** would relate to evidence of the practical application of knowledge and training in carrying out the duties assigned. This criterion is necessarily more difficult to assess than that of qualifications as it will generally be a more subjective process and, of course, the person assessing the experience will have to be competent in order to do so.

It is suggested that a person responsible for *Legionella* control in a building or facility should have the following competencies as a minimum:

- Have a basic knowledge of the source, means of transmission and symptoms of legionellosis
- Be aware of the safety, health and welfare at work statutory provisions relating to *Legionella*
- Be able to identify and assess sources of risk
- Have the ability to make suitable and appropriate recommendations on how *Legionella* risk can be managed
- Be able to monitor the effect of any control measures implemented or to identify the appropriate outside expertise where necessary
- Be able to maintain records of all risk assessments, control plans, monitoring, reviews and all other activities associated with *Legionella* control.

7.3 Training matrix

The training matrix (Table 12) is based on the recommendations of the Legionella Control Association in the UK (www.conduct.org.uk) and is provided as guidance to assist statutory duty holders and site responsible persons in identifying the training requirements for managers, supervisors and operatives involved in administration of water management control programmes. Where these posts do not exist in-house, it applies to experts who are brought in.

Table 12. The training matrix for technical aspects

Module	Activity						
		Statutory duty holder	Responsible person	Site safety officer	Site engineer supervisor or equivalent	Mechanical maintenance officer/technical services	Cleaning / chlorination technician
01	*Legionella* general awareness	X	X	X	X	X	X
02	*Legionella* legislation	X	X	X	X	X	X
03	Risk assessment: general principles	X	X	X	X	X	X
04	Water management: general principles	X	X	X	X	X	X
05	Record keeping	X	X	X	X	X	X
06	Data interpretation and reporting	X	X	X	X	X	X
07	Training and competence	X	X	X	X	X	X
08	Programme monitoring and review	X	X	X	X		
09	Contract management	X	X				
10	Water treatment principles		X	X	X	X	X
11	Cleaning and disinfection principles		X	X	X	X	X
12	Sampling and on-site testing principles		X	X	X	X	X
13	Plant and equipment maintenance		X	X	X	X	X
14	Cleaning and disinfection practice					X	X
15	Sampling and on-site testing practice					X	X

X - Training required if client staff directly involved in carrying out cleaning/disinfection, on-site testing, etc.

7.4 Personal Protective Equipment

There are legal requirements under the Safety, Health and Welfare at Work Act 2005 that require employers to protect the health and safety of employees, and of other people associated with their institution, company or business (see Chapter 3). All personnel/contractors must wear suitable PPE identified by a works-specific risk assessment. PPE is any clothing, equipment or substance designed to protect the user from injury or illness. PPE is the very last line of defence in protecting a person's health and safety.

7.4.1 PPE and *Legionella*

Legionellosis is transmitted primarily by inhalation of contaminated aerosols from aqueous sources or from aspiration of contaminated water. Personnel involved in the inspection and maintenance of air-handling and water systems are at risk of contracting legionellosis and should wear appropriate PPE while performing these tasks. Water impermeable gloves should be worn when working with contaminated water or where there is a possibility that the water may be contaminated, (e.g. when taking water samples). **Cuts or abrasions should be covered with waterproof dressings at all times where there is a risk of infection from a variety of bacteria that can be present in contaminated water (e.g. *Pseudomonas aeruginosa*). It should be noted that legionnaires' disease is a respiratory illness and CANNOT be contracted through cuts or abrasions.** Table 13 below lists the minimum PPE required to protect personnel against *Legionella* during routine maintenance or inspection operations in risk situations.

Table 13. Recommended minimum PPE required during maintenance/inspection of water systems and air-handling units

Task	*Legionella* hazard	PPE
Maintenance/inspection	Aerosol/spray	Ordinary site clothing (e.g. full length protective overalls, safety boots, and if necessary, a site hat). The wearing of a half-face mask with a high efficiency particulate air filter of Class P2* (FFP2 or N95) is not required but is optional based on a risk assessment
High pressure spraying	Aerosol/spray	Half-face mask with a high efficiency particulate air filter of Class P2*, full-length waterproof overalls, water impervious gloves, safety boots, goggles or face shield, waterproof hair covering (e.g. site hat)
Chemical disinfection and mechanical cleaning of cooling towers	Aerosol/spray	Half-face piece mask with a high efficiency particulate air filter of Class P2* and additional filters to provide protection against biocides (e.g. chlorine), organic vapours, and acidic gases. Full-length waterproof overalls, water impervious gloves, safety boots, goggles or face shield, waterproof hair covering (e.g. site hat)

**European Standard for filters EN 149 (2001): Particulate Filters*

7.4.2 Provision, training, use and maintenance of PPE

Employers must provide suitable PPE to each employee who may be exposed to risks. It is imperative to consider the following aspects in relation to PPE:

- Ensure that all PPE provided is compatible, and where appropriate can be used together
- Ensure that all PPE is used and maintained in accordance with the manufacturer's instructions
- Ensure that all PPE provided fits correctly and is used in the proper manner at all times. Respiratory protection equipment should be fit tested initially using a qualitative method. The employee should be trained to check the fit of the mask each time it is used
- Maintain, replace and/or clean all PPE as necessary and provide appropriate accommodation for employees to store PPE
- Provide adequate and appropriate training to enable employees using the PPE to be aware of the risk(s) the PPE will avoid or limit, and the actions required by the employee to maintain the PPE in a fit state

- Training should be provided to all new employees who may be exposed to risks when they start work
- Training should be provided to all employees who may be exposed to risks when new PPE is obtained or protocols are altered
- Training should be provided periodically to refresh employees' knowledge of the correct use and maintenance of PPE
- Written information and protocols for PPE use should be available in relevant languages, where appropriate
- Ensure that written or electronic records of all PPE training provided to employees are maintained.

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

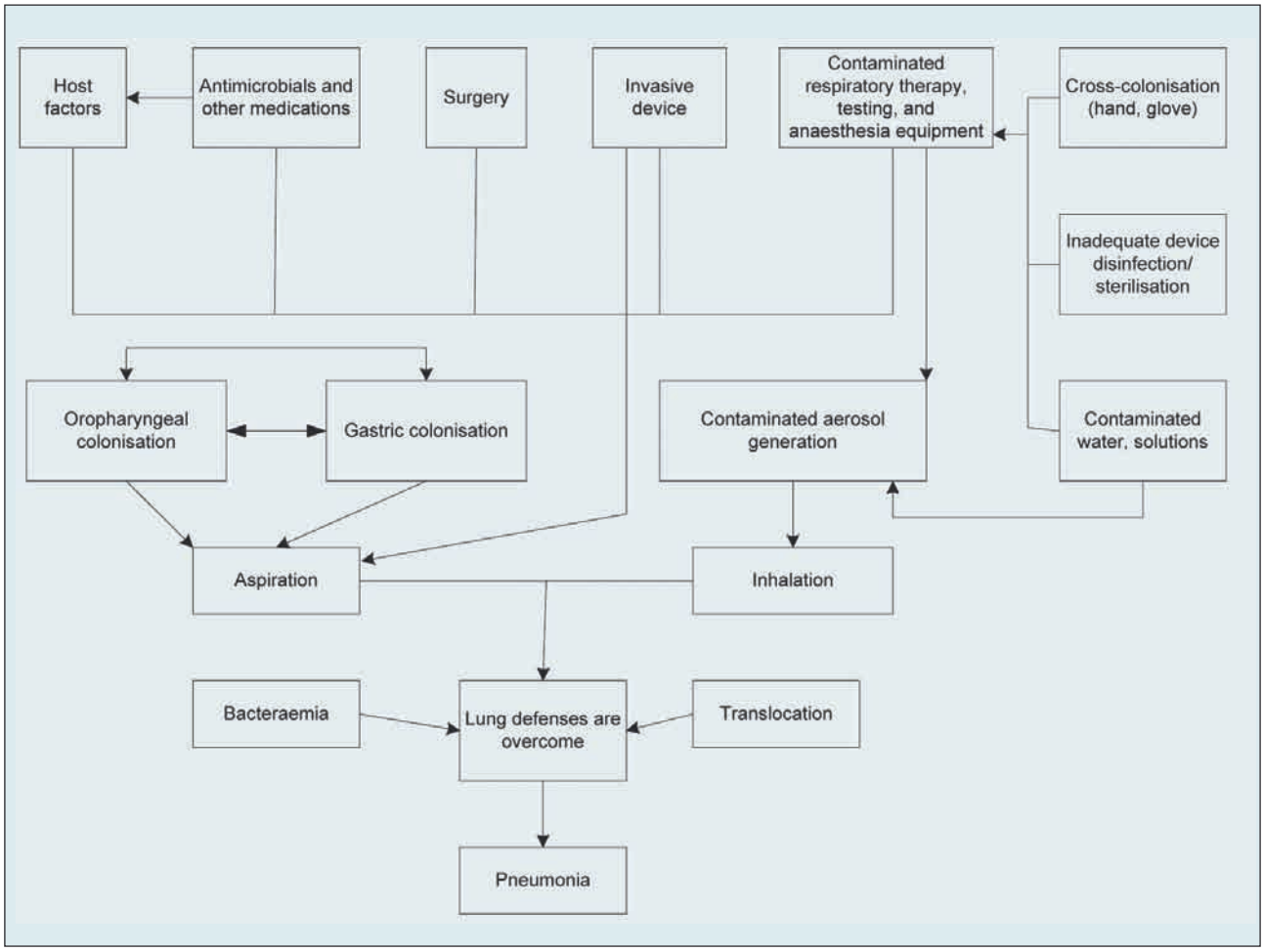

Figure 8. The pathogenesis of nosocomial bacterial pneumonia[88]

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 groups[84]
- 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/EC[99] and 2000/96/EC[100] 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 scalers, 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 ≥ 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 bioflim, 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, gymnasia, 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 *Legionella* 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 Pools[148]

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*

Chapter 9: Investigation of Legionellosis Cases

9.1 Introduction

Incidents of legionnaires' disease are classified for purposes of surveillance as:

- **Sporadic:** a single case not associated with any other cases
- **Outbreak:** two or more cases associated with a single source with dates of onset within six months of each other.

Each case of legionellosis should be reported immediately to the nominated MOH of the relevant HSE area (director of public health).

Each case warrants full investigation in order to identify and eliminate possible sources of infection. Investigation should include confirmation of the diagnosis, tracing the patient's movements during the incubation period and onward reporting of the case by the MOH to HPSC using both the specific legionellosis surveillance form (Appendix J) and where relevant the Computerised Infectious Disease Reporting System (CIDR). The HSA should also be informed by the MOH when a workplace is a possible source of infection (contact number 1 890 289 389).

9.2 Response to a single (sporadic) case of legionnaires' disease

As part of the epidemiological investigation, five key steps should be taken following the diagnosis (clinically and microbiologically) of a single case of probable or confirmed legionnaires' disease including:

- **Confirm the diagnosis**
- **Report the case to the appropriate MOH who in turn reports to HPSC**
- **Identify potential sources of infection**
- **Search for links with other cases**
- **Investigate possible sources of infection.**

Confirm the diagnosis

For the purposes of surveillance and public health action, the clinical diagnosis of legionnaires' disease should be supported by confirmed or probable microbiological evidence of recent *Legionella* infection (see Chapter 1, Section 1.7). When the clinical and microbiological evidence are consistent with a diagnosis of legionnaires' disease both the attending physician and director of the microbiology laboratory should notify details immediately to the relevant department of public health (MOH). The department of public health should then liaise with the environmental health department and other relevant agencies to ensure timely, appropriate and thorough investigation.

Report the case

On receipt of the notification the MOH should report the case to HPSC using the specific legionellosis surveillance form (Appendix J) and CIDR where relevant. Even where details are incomplete, cases should be reported. The completed details should be provided as they become available. Where travel-associated, HPSC will inform EWGLINET as appropriate (see Appendix A).

Where a place of work is a potential source of infection for a case, this should be brought to the attention of the HSA as a matter of priority by the department of public health/MOH in the relevant area.

Identify potential sources of infection

For each confirmed or probable case of legionnaires' disease, the patient's movements during the incubation period should be recorded. It is essential to detail the patient's movement accurately to facilitate identification of possible sources of infection. Although the incubation period in legionnaires' disease is between two to ten days, given that the exact onset of an illness is not always certain, enquiries should be made for the two weeks before the onset of illness.

Patient risk factors for legionnaires' disease e.g. immunosupression treatment, diseases associated with impaired immune response should be specifically enquired about and recorded.

Details of the patient's movement in the two week period prior to the onset of illness including full

address of places of residence/overnight stays, places of work, places of leisure and travel details should be obtained. Exposure to any recognised potential environmental sources of *Legionella* should also be specifically asked about and recorded including:

- 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 and which may release a spray or aerosol (i.e. a spray of droplets and/or droplet nuclei) during operation or when being maintained.

A diary (Checklist 4) of every place the patient has visited for the two weeks prior to onset of illness should be filled out by the patient (or surrogate if too ill). The list of potential environmental sources and locations in Checklist 5 can be used to maximise the likelihood of identifying possible risk sources.

Checklist 4. Diary of patient's movements in the 14 days prior to onset of symptoms

Date (count back 14 days from onset of symptoms)	Morning	Afternoon	Evening	Night

Checklist 5. Patient's exposures in the 14 days prior to onset of symptoms

Did the patient	Details	Dates
Visit a sports centre or club that had a whirlpool spa		
Use a whirlpool spa anywhere else		
Use a shower (at home or elsewhere)		
Attend a dentist or dental hygienist		
Use a nebuliser (not an inhaler)		
Spend any time near building works		
Spend any time near fountains (indoors or outdoors)		
Attend a garden show/DIY show		
Visit a public building, e.g. attend a seminar, cinema, theatre, hotel, hospital		
Visit a commercial car wash		
Work near/involving cooling towers		
Work with water/water storage systems		
Spend time aboard a ship		
Use pressure water spraying equipment e.g. home car wash pressure cleaner		

Is the patient aware of anyone else with legionnaires' disease, now or in the past?
If yes, give details _____

Is the patient aware of anyone with similar symptoms to themselves?
If yes, give details _____

Based on the HSE South Eastern area checklists

Search for link with other cases
The MOH and HPSC will check for links with other cases based on infectious disease notifications to the area, HPSC, local hospitals, and neighbouring HSE areas or EWGLINET for linked cases in other countries.

Investigate possible sources of infection
The key to the investigation of legionnaires' disease is in the detailed enquiry of the case's exposure to potential environmental sources of *Legionella* in the two weeks prior to the onset of symptoms.

9.2.1 Community-acquired case – single case

Legionella are widespread in the environment. Aerosols containing the organism can be dispersed into the atmosphere and travel distances of up to several hundred metres from their source.[161] A recent outbreak in France would suggest a much greater distance of airborne transmission of at least 6 km.[162]

If the patient has a history of exposure to a recognised potential source of *Legionella* infection outside of hospital or a domestic premises, examination of the maintenance records of these systems including water systems should be requested.

With the diagnosis of a confirmed/probable case sampling of potential environmental sources to which the patient was exposed should be carried out based on a risk assessment. Pending results of the sampling, and subsequently when sample results are available, steps may need to be taken to prevent risk to others and to identify other cases – possibly undiagnosed.

For all locations where water is the potential source, the water system risk assessment should be reviewed, maintenance records checked and a search made for other cases. Any deficiencies identified by the risk assessment should be remedied as soon as possible. Interim measures may need to be put in place until these remedial measures are fully in place. If precautionary disinfection of parts of the water systems is considered necessary this should only be undertaken after taking relevant samples. The latter should be done as a matter of urgency.

In addition, if the patient's place of work is a potential source of infection, the co-operation of management or the relevant occupational health department, if appropriate, should be sought to identify recent levels of sick leave or respiratory symptoms among the workforce to identify other potential cases.

If the patient lives in a nursing home/residential home/institutional setting, the water systems should be assessed as above. As part of the search to identify other cases, checks should be made about unexplained respiratory symptoms among other residents, current and past. The time period to review should be informed by the likely duration of any identified potential source of infection including water system deficiency.

Water under pressure as found in spa pools, fountains, sprinklers, etc. is a recognised source of legionnaires' disease. Large outbreaks have been associated with pools on display as well as in use.[163] If a patient reports exposure to such sources, as part of the control measures the maintenance requirements and records for that source should be reviewed to ensure they comply with published guidelines e.g. those for spa pools.[148]

Internationally, potting compost is a recognised source of *L. longbeachae* and has been associated with cases of legionnaires' disease, particularly in Australia.

Domestic premises
A proportion of sporadic cases of legionnaires' disease may be residentially acquired.[164] This is more likely to occur if a patient uses for example a shower after it has been out of use for some time e.g. a week or more. In general, sampling of domestic premises is not required (see Chapter 6, Section 6.9.4). However, testing for *Legionella* in domestic water systems can be of value when more than one environmental source is identified. The facility to discriminate isolates using molecular typing can be informative in such a situation.[165]

9.2.2 Travel-associated cases
A case is considered to be travel-associated if the patient stayed at or visited an accommodation site used for leisure purposes e.g. hotels, holiday apartments, ships, campsites in the ten days prior to the onset of illness. Where such stays were abroad, HPSC should forward the details to EWGLINET to facilitate the identification of clusters and risk locations.

Where the travel or leisure premises is in Ireland, arrangements should be made to sample potential environmental sources. At a minimum, arrangements should be made to assess the premises, inspect maintenance records, sample as indicated and initiate/recommend protective measures. Checklist 6 outlines the actions to be taken at the implicated site. The relevant department of public health should ensure that the accommodation site receives the checklist from the EWGLI guidelines on travel-associated legionnaires' disease that outlines good practice for minimising the risk of *Legionella* infection (Appendix H).[25]

Legionnaires' disease can occur up to ten days after the patient returns to their own home. Exposure could be linked to this domestic source rather than the leisure/commercial accommodation. A travel history is not sufficient to imply causation. Isolation of *Legionella* from the patient's home of the same type as that isolated from the patient suggests infection at home rather than travel related.

Checklist 6. Implicated site visit

Action	Completed (yes/no)	Comment
1. Obtain water system plans showing • The incoming water supply (mains or private source) • All tanks/cisterns, expansion/pressure vessels, booster vessels and pumps • Any water softeners or other treatments • Any calorifiers/water heaters • The type and nature of materials and fittings (e.g. taps, showers, water closet cisterns, pressure release valves, and pipework) and the kinds of metals, plastics, jointing compounds, etc. present • Cooling towers or heating circuits • Air conditioning systems or humidifiers within the building which are supplied with, and store water and which may produce aerosols • Any other equipment that contains water and could be a potential risk such as spa pools, humidified display cabinets, machine tools, fountains, etc.		
2. Identify all systems using water • Systems which contain water at temperatures likely to support the growth of legionellae • Areas where growth of legionellae may be expected to be greatest • Cross-contamination between free-flowing and stagnant water • Locations at which the potentially contaminated water can be aerosolised • Locations where the aerosol might be released into the environment		
3. Examine inspection and maintenance protocols		
4. Examine logbooks recording water system maintenance and treatment		
5. Interview management and staff involved in maintenance programmes • Role and function • Rosters/training • Recent illness history • Staff absenteeism		
6. Environmental water sampling • Cooling tower • Hot and cold water systems • Water closet cisterns • Spa pools • Decorative fountains • Humidifiers • Air washers • Other (specify) **NB.** Sampling should be conducted in accordance with ISO 11731-2:2004		

7. Emergency control measures implemented • Hyperchlorination • Shock heating • Cleaning of tanks/heaters • Shut down of non-essential equipment • Exclusion of persons from areas of risk • Closure of high-risk items		
8. Selection of long-term remedial measures in consultation with on-site staff		
9. Establish in consultation with on-site staff protocol for "post outbreak" routine monitoring		

Form completed by: *Date:*

***NB**. A checklist is a guide. There may be extra issues that require additional attention depending on individual sites and circumstances*

Source: European Working Group for Legionella Infection (EWGLI)

9.2.3 Nosocomial infection

Investigation is essential for every case or suspect case of nosocomial legionnaires' disease. This is particularly urgent, given the vulnerability of other patients, where it cannot be excluded as having been acquired in hospital (see definitions Chapter 1, Section 1.7).

When a confirmed or probable case of nosocomial legionnaires' disease is identified an investigation team should convene with the relevant consultant microbiologist as chair, or if relevant a CPHM. The team should consist of infection prevention and control personnel from the hospital, at least one senior physician, senior hospital engineer, senior hospital management representative, a CPHM, PEHO and others as appropriate e.g. occupational health staff.

The team should identify and address investigation, control and prevention measures.

The risk assessment for control of *Legionella* in water systems, including water supplies for general use and display, water therapies and respiratory therapy equipment, and maintenance records should be reviewed. Samples should be taken.

Potential environmental sources are listed above in Section 9.2. Of particular relevance in the hospital setting are the hot and cold water distribution system, wet spray cooling water systems, showers or spray washing equipment, drainage systems and taps, spa pools, whirl pool baths or therapy pools, respiratory therapy equipment, clinical humidifiers, humidifiers in ventilation systems, cooling coils in air conditioning systems, fountains, ornamental water features and sprinklers.

Any deficiencies identified by the risk assessment should be remedied as soon as possible. Interim measures may need to be put in place to protect patients until these remedial measures are in place. If precautionary disinfection of parts of the water systems is considered justified, this must only be undertaken after any sampling. This latter should be done as a matter of urgency.

Simultaneous to the risk assessment an active case search should be conducted for other nosocomial cases including unexplained pneumonia and respiratory illness among patients or hospital staff. The GPs of in-patients discharged from the suspect units/wards/institution should be contacted to enquire about patients' attendance with pneumonia and respiratory illness since hospital discharge. Similarly, for those transferred to other institutions. Occupational health staff should review records of staff absence due to respiratory illness. The investigation team will determine the time period for inclusion.

As with travel-associated and community-acquired cases, where the patient did not spend all of the incubation period in the hospital other possible sources of infection must also be investigated. As mentioned earlier in the chapter where more than one environmental source is identified it is important to the investigation that all sources are identified and tested so as to inform control, remedial and preventive actions.[165]

9.2.4 Summary

The investigation of single cases of legionnaires' disease should always be carried out in a systematic and methodical way (Figure 10). Single cases may be the first reported case in an outbreak or may be truly sporadic. Examination of the potential environmental sources of infection for these single cases can highlight problems that might otherwise remain undetected and possibly contribute to the occurrences of further cases.

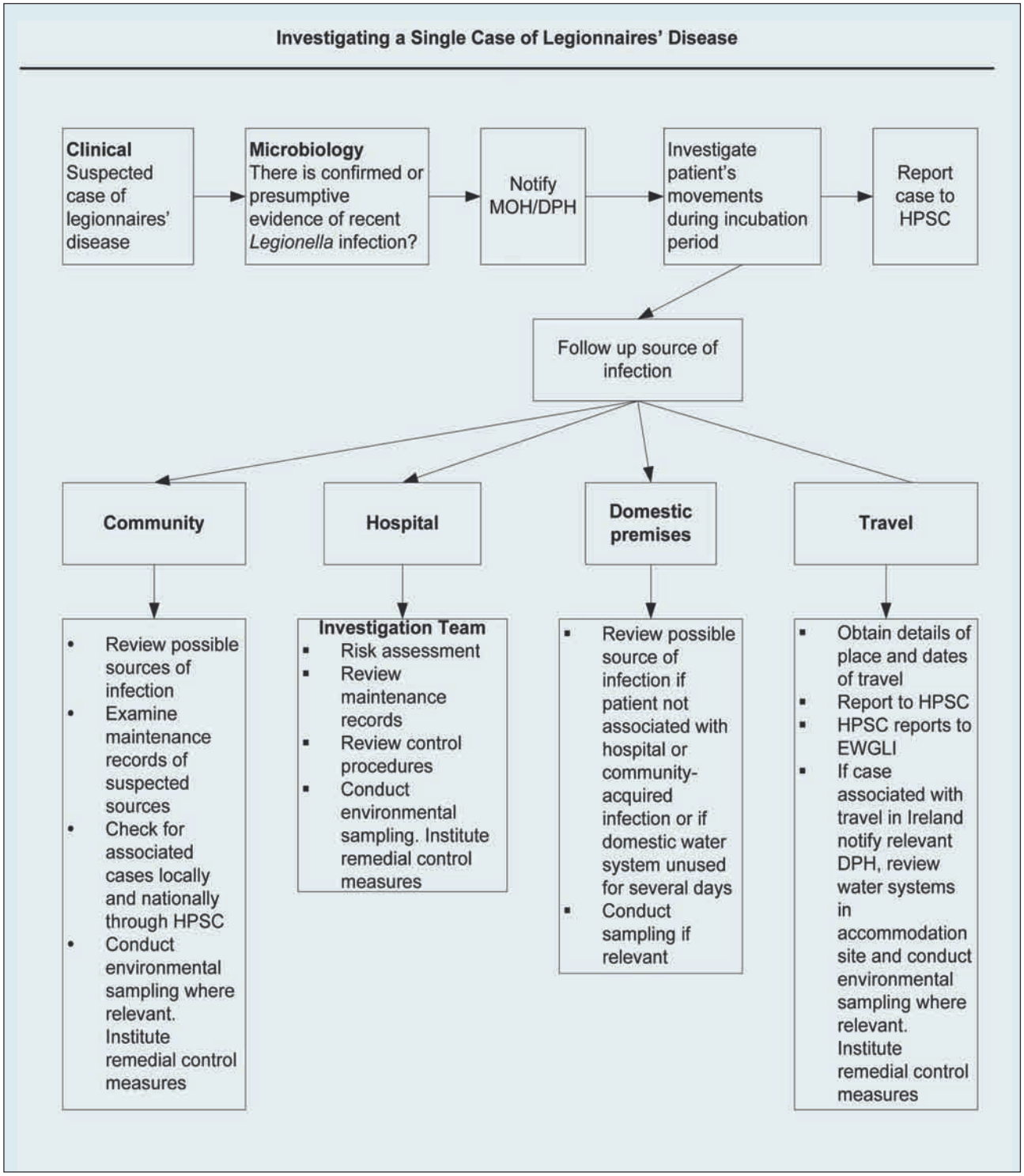

Figure 10. Investigation of a single case of legionnaires' disease[166]

9.3 Investigating an outbreak of legionnaires' disease

An outbreak can be defined as two or more cases of legionnaires' disease associated with the same geographical location or probable source during the preceding six months. An outline of the outbreak investigation procedure is shown in Figure 11.

A multidisciplinary outbreak control team (OCT) should be convened by the relevant director of public health. The team should include representatives from the following groups:

- Microbiologist
- Physician
- PEHO
- CPHM
- Representative of senior management where appropriate
- Infection prevention and control nurse specialist where appropriate
- HPSC where appropriate
- Internal health and safety personnel where appropriate
- Engineer where appropriate
- Press officer where appropriate
- Occupational health where appropriate
- Other personnel considered appropriate.

As for any outbreak advance arrangements should be in place for:

- Contact numbers of all OCT personnel (and designates)
- Logistical backup - clerical/administrative, communications, headquarters, etc.
- Sampling equipment
- Meteorological data acquisition
- On-call provision for staff (this will have resource implications)
- Appropriate laboratory facilities should be available
- Liaison with other authorities - local authorities, HSA, etc.
- Liaison with GPs, hospital clinicians, adjacent HSE areas if appropriate.

9.3.1 Epidemiological investigation

The CPHM should ensure that the appropriate epidemiological investigations are carried out which will include interviewing cases (or their proxies), case finding (active and passive) and appropriate epidemiological studies.

When a potential source(s) is identified in particular settings, the check for additional cases by the CPHM will include interviews with relevant management and staff about recent illness history and staff absenteeism.

When the potential source is in a geographical location rather than setting, the CPHM will use a variety of sources e.g. GPs, A&E in the search for additional cases.

9.3.2 Microbiological investigation

Clinical samples for microbiological confirmation of infection in suspected cases should be obtained, likewise for environmental samples. Sampling should be carried out by a competent person and microbiological analysis should be carried out by a laboratory that is accredited for the detection of *Legionella* species from clinical and environmental samples and capable of recognition of *Legionella* species and serogroups. A microbiologist experienced in the microbiology of, detection of, and ecology of *Legionella* species should interpret the clinical and environmental laboratory findings.

9.3.3 Environmental investigation

The PEHO or accredited commercial company should ensure that the appropriate environmental investigations are carried out including identification of potential sites, early visiting of any identified implicated site and sampling as appropriate.

9.3.4 Public relations

Arrangements should be made by the press officer to keep members of the press informed as appropriate. The OCT should agree press releases.

9.3.5 Overview of the activities of the OCT

The OCT has responsibility for overseeing the investigation of potential sources of infection, including site surveys and environmental sampling, emergency control measures, recommending long-term control

measures and ensuring a system for post-outbreak routine monitoring.

9.3.6 Investigation of sources

The initial aim in any outbreak investigation must be to identify quickly the potential sources, to sample them and then render them safe either by precautionary disinfection and cleaning or by disabling the equipment until it has been shown to be safe.

All relevant information should be passed to the OCT as soon as possible and continuous contact should be maintained between investigating personnel and the OCT during the outbreak.

All potential sites of infection should be identified. Pending identification of potential sources, it may be necessary for environmental health officers to carry out a door-to-door survey of non-domestic property (likely to have 'high-risk' plant) in the suspect areas to ensure against the possibility of 'high-risk' plant being in operation without the knowledge of the OCT. A survey of local cooling towers should be carried out. High-risk plants should be visited, inspected visually and water samples obtained. Owners or occupiers having responsibility for the plant should be requested to provide relevant documentation and take appropriate steps to ensure that their plant is not likely to be a source of legionnaires' disease.

An early visit to any implicated site(s) is essential. The investigation should include the engineering, microbiological and environmental aspects of implicated sources.

9.3.7 Site survey

This should consist of an analysis of the operational, structural and facility elements. Survey of the design and maintenance of any water system must be detailed enough to enable valid decisions to be made about the risk to health and control measures to be taken. It should identify sources of *Legionella* on the premises, points of entry of *Legionella* and any necessary precautionary measures. The site is first examined to establish all systems using water i.e.

- Systems which contain water at temperatures likely to support the growth of *Legionella*
- Areas where growth of *Legionella* may be expected to be greatest
- Cross contamination between free-flowing and stagnant water
- Locations at which the potentially contaminated water can be aerosolised
- Locations where the aerosol might be released into the environment.

It should be noted that temperatures and disinfection particularly influence the ecology of the water supply. The possibility of alternative sources of *Legionella* should also be kept in mind.

The route of the water should be followed from its entry into the site to the point where it is used or discharged. If a plan of the system does not exist or is out-of-date one should be prepared showing the locations of:

- The incoming water supply (mains or private source)
- All tanks/cisterns, expansion/pressure vessels, booster vessels and pumps
- Any water softeners, filters or other treatments
- Any calorifiers/water heaters
- The type and nature of materials and fittings (e.g. taps, showers, water closet cisterns, pressure release valves, and pipework) and the kinds of metals, plastics, jointing compounds, etc. present
- Cooling towers or heating circuits
- Air conditioning systems or humidifiers within the building which are supplied with, and store water and which may produce aerosols
- Any other equipment that contains water and could be a potential risk such as spa pools, humidified display cabinets, machine tools, fountains, etc.

The adequacy of management control systems and site documentation including written procedures should be assessed. Inspection and maintenance protocols, and plant shut-down and start-up procedures should be examined.

Any examination of logbooks of the factory/hotel/hospital water maintenance programme or other maintenance/operation records should include:

- Dates and times of equipment changes
- Dates and times of changes in water sources
- Dates and times of significant changes in routine (intensification in cooling tower use should have been matched by increased disinfection)
- Sudden water pressure drops
- Disinfection and dosing history (any water treatment company contacted and questioned).

Interviews of management and staff actually involved in maintenance, etc. and taking of statements on:

- Role and function
- Rosters
- Recent illness history
- Staff absenteeism
- Training.

9.4 Emergency control measures

In addition to the normal operating procedures for *Legionella* control, there should be a written emergency action plan which identifies responsibilities, contact details, materials to be available, and control measures to be undertaken. This may include identification of persons possibly having been exposed or having visited the risk areas and communication with and notification of relevant parties.

The emergency control measures should be implemented as soon as possible after the outbreak has been recognised. It should include the collection of appropriate samples from pre-selected sampling points **before** any other actions affecting the water distribution system are undertaken. The next priority is the exclusion of persons from areas of risk (identified by prior risk assessment) and the closure of high-risk items (showers, cooling towers, humidifiers or other as appropriate to the case). Non-essential equipment such as spa pools, fountains and other ornamental features should be shut down until remedial measures are implemented.

Any risk assessment prepared earlier should be reviewed or if none exists, should be undertaken at this stage. This should identify any further emergency control measures to be implemented. The exact choice of measures will depend on the risk assessment and any available epidemiological evidence. The measures will usually involve disinfection of potential sources by high levels of chlorine, chlorine dioxide or other effective oxidising biocides with biofilm-penetrating and anti-protozoan properties, flushing out the distribution system, cleaning of tanks, water heaters, water softeners, etc. and raising the circulating hot water temperature if this is below 60°C.

9.4.1 Thermal disinfection

Hot water systems

Thermal shock treatment for relatively short periods of time has been used effectively as an emergency disinfection procedure for hot water systems that can be implemented quickly without the requirement for particular equipment. Thermal disinfection is carried out by raising the temperature of the water in the calorifier (hot water storage heater) sufficiently (70-80°C) so that water at each outlet does not fall below 65°C (this should be measured) and circulating this water throughout the system. Each outlet should be flushed sequentially for a minimum of five minutes at 65°C or above. The optimal flush time is unknown and may depend on the characteristics of individual water systems and longer flush times may be necessary. Thus the process may be repeated on successive occasions. Appropriate safety procedures should be employed to avoid scalding and generation of aerosols.

It is important to emphasise that for effective thermal disinfection:

- The water system must be well insulated
- The entire system must be exposed to a temperature of 65°C for at least five minutes
- Dead legs or unflushed spurs will cause recontamination and will necessitate repeat of the thermal treatment at intervals
- The procedure requires sufficient heat capacity in the system and requires considerable energy and manpower resources and is not usually practical for large buildings but may be suitable for smaller systems
- Thermal disinfection will not disinfect downstream of thermostatic mixer valves and so is of limited

value where such valves are installed. Where thermostatic mixer valves are installed to reduce scalding risks, they must be subjected to a programme of planned maintenance and monitoring.

Following heat shock treatment, tanks and calorifiers should be drained and should be subject to physical cleaning and descaling if necessary. Following cleaning, the water system should be disinfected with high levels of free available chlorine (20-50 mg/litre) or other oxidising biocide. It is important to note that the bactericidal action of free available chlorine is pH sensitive and decreases rapidly at pH values > 7. Thus the pH of the water in the system being treated should be monitored and may need adjustment. At the end of the procedure, samples of water and sediment should be collected at distal outlets of the water system and examined for the presence and density of *Legionella* bacteria. If the result is unsatisfactory, the procedure must be repeated until documented decontamination is achieved. Following decontamination, microbiological checks must be repeated periodically.

9.4.2 Chemical disinfection

Cold water systems

Emergency control measures for cold water systems include disinfection of tanks and pipework with high levels of free available chlorine (10-50 mg/litre) or other oxidising biocide. This may not be effective if significant amounts of sludge, scale and sediment are present in the system and these may have to be removed by effective cleaning before effective disinfection can be achieved.

Chemical disinfection requires a good working knowledge of both the chemical's performance characteristics and that of biofilms. For example, chemical disinfection may corrode or damage sensitive equipment attached to the water system e.g. reverse osmosis units; it may not be effective at high temperatures in the hot water system or it may lack biofilm penetration capability. All disinfection is more effective if performed in conjunction with physical cleaning, usually prior to disinfection. In this case, having disinfectant present during cleaning is necessary to reduce the risk of exposure to disturbed biofilm and legionellae. Areas requiring special attention include the high water mark and ballcock assemblies in storage tanks and water softeners or other similar reservoirs.

Cooling towers

Hyperchlorination (>10 ppm) of cooling towers usually requires three treatments plus mechanical cleaning. Higher doses may cause oxidation problems. For distribution systems, circulation of 5 ppm free chlorine for a minimum of three hours is necessary to inactivate free legionellae and the outer layers of biofilm in the system. This will achieve a suitable temporary risk reduction in the system.

The operating temperatures of most cooling towers fall within the optimum range for the rapid proliferation of legionellae, namely 20°C to 45°C. However, the risk can be mitigated by ensuring that the water temperatures of the water supplying these systems, including storage tanks and pipework, are maintained below 20°C. Where water is required to be held hot for *Legionnella* control, all outlets should be clearly labelled very hot to avoid accidents.

NOTE

It must be emphasised that these are only interim measures to reduce risk and buy time during which long-term remedial measures should be formulated and implemented. The selection of the long-term remedial measures must be based on a thorough risk assessment combined with any epidemiological information available. Effective long-term control depends on the rigorous adherence to the control measures. The measures will probably be a combination of those described elsewhere in this document. They are likely to require engineering modifications to the existing water systems as well as improvements in monitoring controls, management and staff training.

9.5 Outbreak report

A detailed report on the investigation, its findings and any recommendations should be completed and delivered to relevant people/organisations.

9.6 Post-outbreak routine monitoring

When a source has been identified following an outbreak there is a clear need for monitoring for *Legionella* thereafter to confirm the long-term effectiveness of the control measures and for monitoring of temperatures, colony counts (aerobic heterotrophs), water volumes, and disinfection. Sampling frequency after an outbreak should be site-specific and based on the risk assessment and remedial measures enacted. It may initially be as high as weekly then can be gradually reduced to monthly and then perhaps quarterly

and so on. Experience shows that buildings that have had a problem frequently have a recurrence if there is a lapse in control measures. Sampling for *Legionella* should back up other more immediate measures of effectiveness such as the monitoring of temperature or chlorine concentrations. There is no guarantee that *Legionella* will be eradicated from a water system. A temporary eradication or a reduction in numbers may only be possible.

The selection of long-term remedial measures should also be based on a thorough risk assessment combined with any epidemiological information available. Such measures may require engineering modifications to the existing water systems as well as improvements in monitoring controls, management and staff training. Effective long-term control depends on the rigorous adherence to such control measures. A proper programme of planned maintenance and operational management of all water systems must be instituted. This should include routine checks to ensure work is done in accordance with specifications and to a satisfactory standard. Any programme should be reviewed routinely or when significant changes to routines occur. Maintenance and operational staff must be adequately trained to understand and carry out their responsibilities.

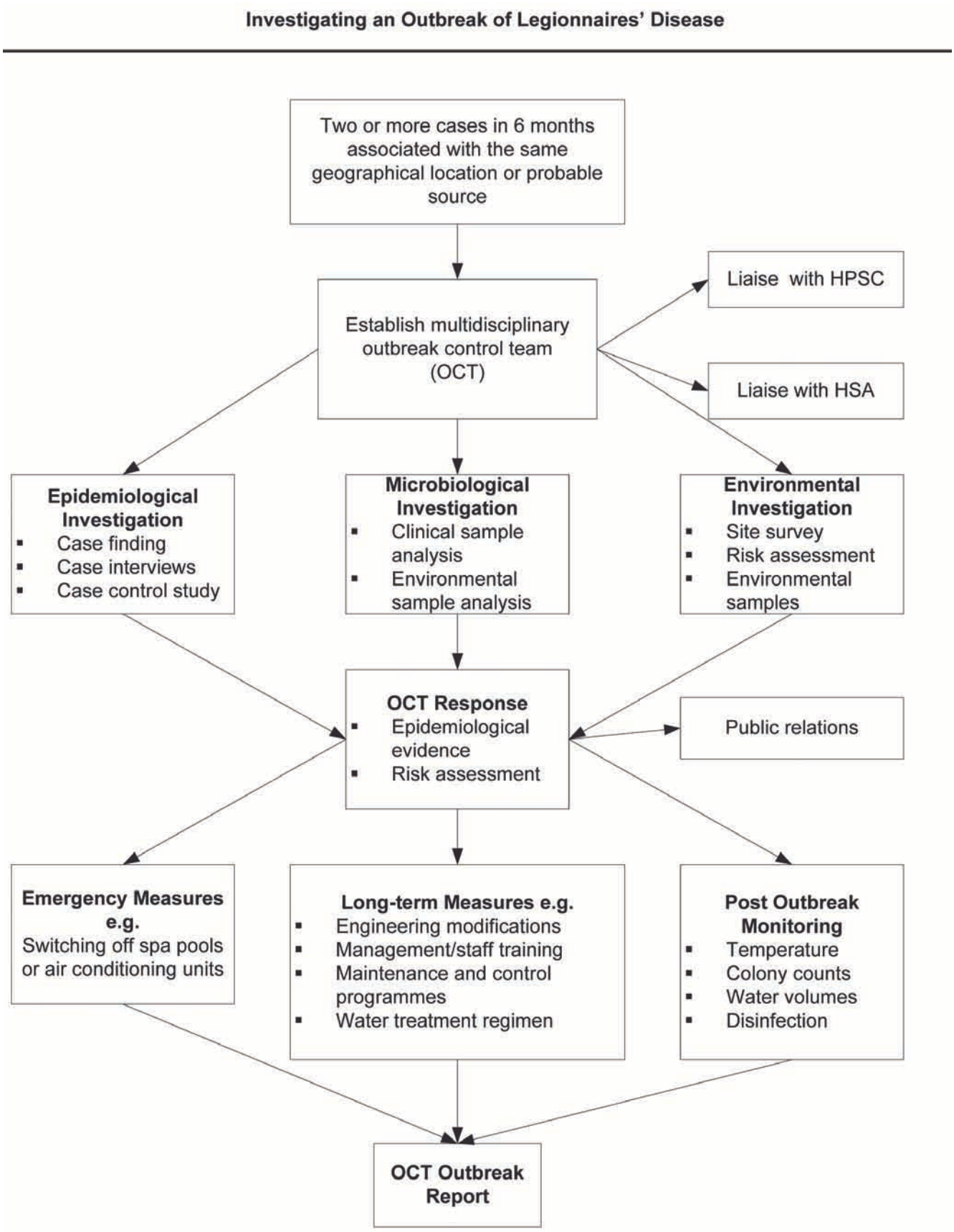

Figure 11. Investigating an outbreak of legionnaires' disease

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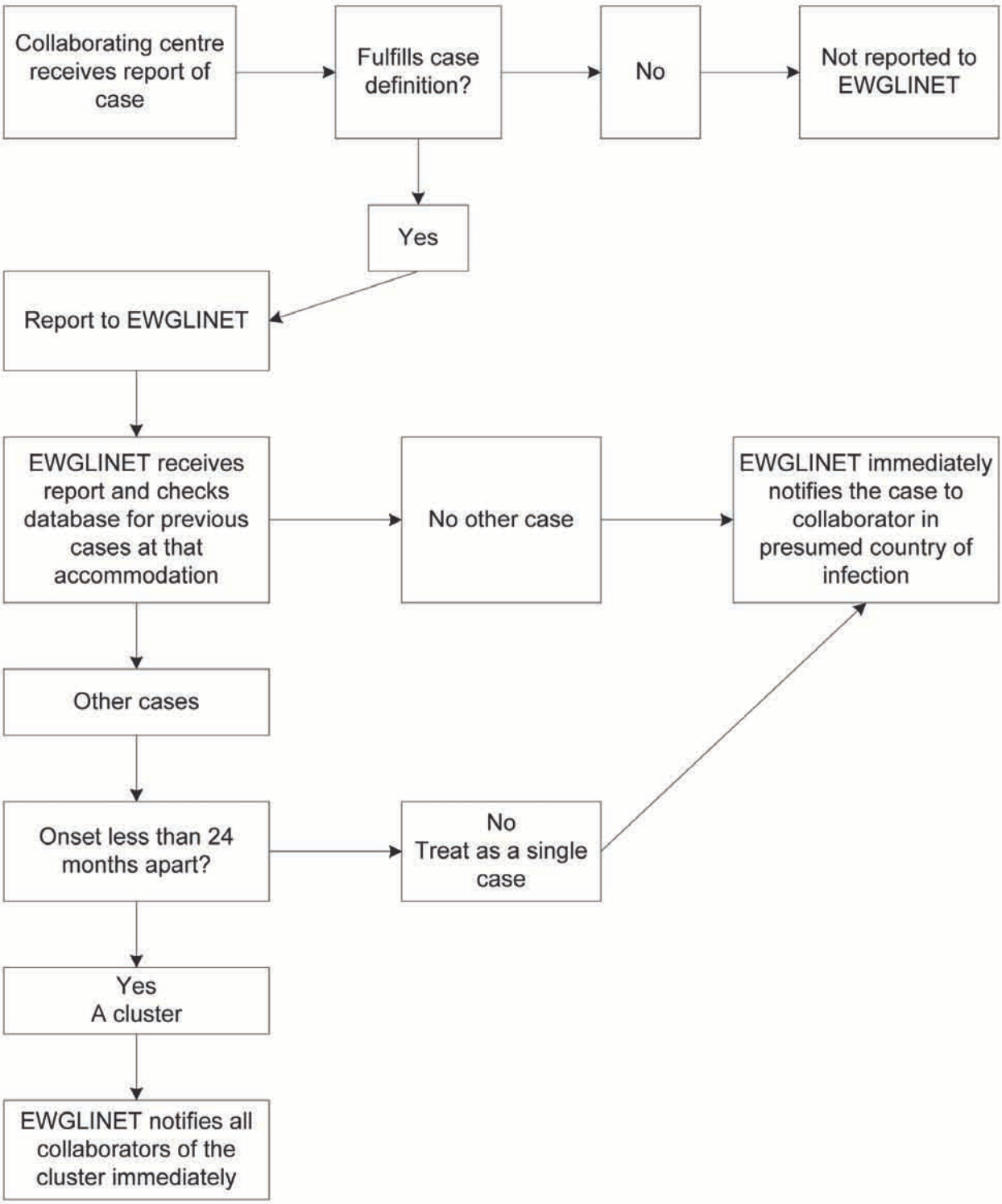
Appendix A
European Working Group on Legionella Infection (EWGLI)

The surveillance scheme
The European Surveillance Scheme for Travel Associated Legionnaires' Disease (EWGLINET) is run by the European Working Group on Legionella Infections (EWGLI). The scheme was established in 1987 and since 1993 the scheme has been based at the HPA, Centre for Infections, London and is funded by the European Centre for Disease Prevention and Control (ECDC). ECDC will take over and operate this network in 2010. Currently 35 countries (24 EU and 11 non-EU) collaborate in the surveillance scheme.

Aims
- To reduce the incidence of travel-associated legionnaires' disease
- To prevent further cases through enhancing the identification and control of known sources of *Legionella*
- To provide an early warning system to all collaborators and other public health officials.

Objectives
- To continue to develop and maintain the European surveillance scheme for travel-associated legionnaires' disease (EWGLINET)
- To enhance the capability within the EU to detect common source outbreaks early, enabling member states to implement timely preventive action
- To inform all those who need to know about travel-associated legionnaires' disease to promote primary preventive action and collaborative investigations
- To provide a dedicated website for enhancing EWGLI's information resource.

Flow of Information in EWGLINET Surveillance System



Appendix B
Executive Summary of Survey of Laboratory Practices for Legionella Infection in Ireland, 2005

Background
The reported incidence rate of legionnaires' diseases in Ireland increased from 0.3 per million in 1994 to 3.8 in 2007. In 2007, the overall European rate for legionellosis was 11.4 per million (based on a population of 520.3 million in 33 countries). Under-diagnosis and under-reporting are thought to lead to a significant under-estimation of incidence in many countries.

In January 2005, the Legionnaires' Disease Subcommittee of the Scientific Advisory Committee of HPSC decided to undertake a laboratory survey to estimate the current level of provision of diagnostic and environmental laboratory services for *Legionella* infection in Ireland.

Methods
A cross-sectional survey of laboratories in Ireland was conducted in April 2005 to assess the extent and type of *Legionella* infection testing being undertaken. An eight-page questionnaire was posted to all microbiological laboratories in the country.

Results
The response rate was 77% (37/48). Thirty-eight percent (38%) of responding laboratories undertook testing for *Legionella* infection. Of these laboratories, 86% tested clinical specimens only, 7% environmental only and 7% both clinical and environmental specimens. Thirty-nine percent (39%) of laboratories who tested clinical specimens used the urinary antigen test (UAT) only; 23% UAT and serology; 15% UAT and culture method; and 23% used all three diagnostic methods. Ninety-two percent (92%) of environmental samples were obtained from hospital sites.

In 2005, one laboratory was accredited for clinical testing and five were seeking accreditation. One laboratory was accredited for environmental testing and two were seeking accreditation. In 2007, four laboratories are accredited for *Legionella* testing: two for clinical testing and two for environmental testing. Sixteen percent (16%) of all laboratories surveyed send isolates to a reference laboratory outside the country for further testing. Nineteen percent of responding laboratories had agreed protocols with clinicians for undertaking *Legionella* testing on all cases of community-acquired pneumonia.

Conclusions/recommendations
The results of this survey highlight that over one-third of laboratories surveyed undertook *Legionella* testing and that in 2005, there were only two laboratories accredited nationally for this, one for clinical testing and one for environmental testing. In 2007, four laboratories were accredited, two for clinical testing and two for environmental testing. As there is no designated national reference laboratory for *Legionella* testing approximately one-fifth of laboratories sent specimens abroad for typing. In countries where detection of *Legionella* reaches the 'gold standard' e.g. Denmark, the national reference facility plays a pivotal role. In 2005, only two laboratories undertook environmental testing indicating a requirement to improve facilities for environmental sample testing at a regional/local level. Protocols between clinicians and consultant microbiologists for testing for legionnaires' disease in cases of community-acquired pneumonia and for consideration of the diagnosis in cases of nosocomial pneumonia need to be developed. Lack of resources and the need for a national reference laboratory were identified by respondents as the main issues to be addressed for future development of services for *Legionella* testing in Ireland.

Appendix C
Safety, Health and Welfare at Work Act 2005 (No. 10 of 2005)

Section 8
Section 8 of the 2005 Act sets out the general duties of employers including:

(1) Every employer shall ensure, so far as is reasonably practicable, the safety, health and welfare at work of his or her employees.
(2) Without prejudice to the generality of subsection (1), the employer's duty extends, in particular, to the following:

(a) managing and conducting work activities in such a way as to ensure, so far as is reasonably practicable, the safety, health and welfare at work of his or her employees;
(b) managing and conducting work activities in such a way as to prevent, so far as is reasonably practicable, any improper conduct or behaviour likely to put the safety, health or welfare at work of his or her employees at risk;
(c) as regards the place of work concerned, ensuring, so far as is reasonably practicable -
(i) the design, provision and maintenance of it in a condition that is safe and without risk to health,
(iii) the design, provision and maintenance of plant and machinery or any other articles that are safe and without risk to health;
(d) ensuring, so far as it is reasonably practicable, the safety and the prevention of risk to health at work of his or her employees relating to the use of any article or substance
(e) providing systems of work that are planned, organised, performed, maintained and revised as appropriate so as to be, so far as is reasonably practicable, safe and without risk to health;
(g) providing the information, instruction, training and supervision necessary to ensure, so far as is reasonably practicable, the safety, health, and welfare at work of his or her employees;
(h) determining and implementing the safety, health and welfare measures necessary for the protection of the safety, health and welfare of his or her employees when identifying hazards and carrying out a risk assessment under section 19 or when preparing a safety statement under section 20 and ensuring that the measures take account of changing circumstances and the general principles of prevention specified in Schedule 3;
(i) having regard to the general principles of prevention in Schedule 3, where risks cannot be eliminated or adequately controlled or in such circumstances as may be prescribed, providing and maintaining such suitable protective clothing and equipment as is necessary to ensure, so far as is reasonably practicable, the safety, health and welfare at work of his or her employees;

Schedule 3
Schedule 3 of the Act outlines the general principles of prevention to be followed in complying with section 8:

1. The avoidance of risks.
2. The evaluation of unavoidable risks.
3. The combating of risks at source.
5. The adaptation of the place of work to technical progress.
6. The replacement of dangerous articles, substances or systems of work by safe or less dangerous articles, substances or systems of work.
7. The giving of priority to collective protective measures over individual protective measures.
8. The development of an adequate prevention policy in relation to safety, health and welfare at work, which takes account of technology, organisation of work, working conditions, social factors and the influence of factors related to the working environment.
9. The giving of appropriate training and instructions to employees.

Section 12
In addition to the employer's obligation towards the workforce, section 12 of the Act requires that the employer ensure that other persons (not being employees) present at the place of work are not exposed to risks to their health

Every employer shall manage and conduct his or her undertaking in such a way as to ensure, so far as is reasonably practicable, that in the course of the work being carried on, individuals at the place of work (not being his or her employees) are not exposed to risks to their safety, health or welfare.

Section 16
Section 16 of the Act outlines the requirements for designers, manufacturers, importers and suppliers of articles for use at work.

(1) A person who designs, manufactures, imports or supplies any article for use at work shall —
(a) ensure, so far as is reasonably practicable, that the article is designed and constructed so as —
(i) to be safe and without risk to health when properly used by a person at a place of work.

Section 19
Section 19 of the Act outlines 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.

(1) Every employer shall identify the hazards in the place of work under his or her control, assess the risks presented by those hazards and be in possession of a written assessment (to be known and referred to in this Act as a "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.
(2) For the purposes of carrying out a risk assessment under subsection (1), the employer shall, taking account of the work being carried on at the place of work, have regard to the duties imposed by the relevant statutory provisions.
(3) The risk assessment shall be reviewed by the employer where -
(a) there has been a significant change in the matters to which it relates, or
(b) there is another reason to believe that it is no longer valid and, following the review, the employer shall amend the risk assessment as appropriate.
(4) In relation to the most recent risk assessment carried out by an employer, he or she shall take steps to implement any improvement considered necessary relating to the safety, health and welfare at work of employees and to ensure that any such improvement is implemented in respect of all activities and levels of the place of work.
(5) Every person to whom sections 12 or 15 applies shall carry out a risk assessment in accordance with this section to the extent that his or her duties under those sections may apply to persons other than his or her employees.

Note: Sections 8 and 16 are abridged.

Appendix D
Safety, Health and Welfare at Work (Biological Agents) Regulations, 1994 as amended in 1998 (S.I. No. 146 of 1994 and S.I. No. 248 of 1998)

Regulation 3
It shall be the duty of every employer -

(a) to avoid the use of a harmful biological agent, if the nature of the activity so permits, by replacing it with a biological agent which, under its conditions of use, eliminates or reduces the risk to the health of employees,
(b) to prevent the exposure of employees to a biological agent at a place of work where the results of the risk assessment under Regulation 4 reveal a risk to employees' health and safety,
(c) 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,
(d) to apply the measures specified in the Second Schedule where the results of the risk assessment under Regulation 4 reveal that it is not technically possible to prevent exposure,
(e) where the results of the risk assessment under Regulation 4 show that the exposure or potential exposure (or both) is to a group 1 biological agent, including live attenuated vaccines, with no identifiable health risk to employees to provide that where a biological agent is being handled as part of an industrial process, to ensure that the principles of good occupational safety and hygiene are applied,
(f) where the results of the assessment under Regulation 4 show that the activity does not involve a deliberate intention to work with or use a biological agent but may result in employees being exposed to a biological agent, as in the course of the activities for which an indicative list is given in the First Schedule, to comply with Regulations 3 (a), 5, 6, 7 (iii), 7 (iv), 8, 9 and 10, unless the results of such assessment show such compliance to be unnecessary,
(g) to apply these Regulations to activities in which employees are likely to be exposed to biological agents as a result of their work.

Regulation 4
It shall be the duty of every employer -

(a) 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,
(b) to keep the risk assessment referred to in paragraph (a) in written form as required by Regulation 10 of the Principal Regulations,
(c) when carrying out the risk assessment required by paragraph (a), to assess the risk, 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,
(d) to renew the risk assessment required by paragraph (a) 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
(e) to conduct the risk assessment referred to in paragraph (a) 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 the Fourth Schedule,
(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,
(iv) knowledge of a disease from which an employee is found to be suffering and which has a direct connection with his work, and

Regulation 5
It shall be the duty of every employer –

(a) to provide the Authority when requested with the information used for making any risk assessment carried out under Regulation 4 and with the findings of any such assessment,

Regulation 7
It shall be the duty of every employer in the case of any activity in relation to which there is a risk to the health or safety of employees due to work with a biological agent:

(i) without prejudice to the provisions of Regulations 11 and 13 of the Principal Regulations, to take appropriate steps to ensure that employees or their safety representative (or both) receive sufficient and appropriate training and information concerning -
(a) potential risks to health,
(b) precautions to be taken to prevent exposure,
(c) hygiene requirements,
(d) the wearing and use of personal protective equipment,
(e) The steps to be taken by employees in the case of incidents and to prevent incidents,

Note: Regulations 4, 5, and 7 are abridged

Appendix E
Safety, Health and Welfare at Work (General Application) Regulations 2007 (S.I. No. 299 of 2007)

Regulation 29
Information and instruction
An employer shall ensure that:

(a) *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, and
(iii) the conclusions to be drawn from experience, where appropriate, in using such work equipment, and

(b) employees are made aware of safety and health risks relevant to them associated with work equipment located at or near their workstation or to any changes relating to that work equipment, even if they do not use the equipment.

Regulation 30
Inspection of work equipment
An employer shall ensure that:

(a) where the safety of work equipment depends on the installation conditions -
(i) an initial inspection is carried out after installation is completed and before it is first put into service, and
(ii) an inspection is carried out after assembly at any new site or in any new location, and that the work equipment is installed correctly and is operating properly,

(b) in the case of work equipment which is exposed to conditions causing deterioration liable to result in a danger to safety or health -
(i) periodic inspections and, where appropriate, testing is carried out,
(ii) special inspections are carried out when exceptional circumstances arise which are liable to make the work equipment unsafe, including modification work, accidents, natural phenomena or prolonged inactivity, and
(iii) deterioration is detected and remedied in good time,

(c) inspections carried out under paragraphs (a) and (b) are carried out by a competent person and are appropriate to the nature, location and use of the work equipment,

(d) the results of inspections carried out under paragraphs (a) and (b) are recorded and kept available for 5 years from the date of inspection, for inspection by an inspector, and access to these records is made available to users of the work equipment upon request, and

(e) when work equipment is used in another place of work, it is accompanied by evidence of the last inspection carried out under paragraphs (a) and (b).

Appendix F
Safety, Health and Welfare at Work (Chemical Agents) Regulations, 2001 (S.I. No. 619 of 2001)

Regulation 4

(1) Without prejudice to the Principal Regulations, it shall be the duty of every employer to determine whether any hazardous chemical agents are present at the workplace and to assess any risk to the safety and health of employees arising from the presence of those chemical agents, taking into consideration the following -

- *(a) their hazardous properties,*
- *(b) information provided by the supplier of the hazardous chemical agents including information contained in the relevant safety data sheet and any additional information as may reasonably be required to complete the assessment,*
- *(c) the level, type and duration of exposure,*
- *(d) the circumstances of work involving such agents and the quantities stored and in use in the workplace,*
- *(e) any occupational exposure limit value or biological limit value contained in an approved code of practice,*
- *(f) the effect of prevention measures taken,*
- *(g) where available, the conclusions from health surveillance already undertaken, and*
- *(h) any activity including maintenance and accidental release in respect of which it is foreseeable that there is a potential for significant exposures.*

(2) In the case of activities involving exposure to several hazardous chemical agents, the risk shall be assessed on the basis of the risk presented by all such chemical agents in combination.

(3) Any risk assessment made under this regulation shall be recorded in writing.

(4) Where, as a result of such risk assessment, a further detailed risk assessment is deemed to be unnecessary the employers may include a justification for this decision.

(5) Any risk assessment made under these regulations shall be reviewed regularly and shall be reviewed immediately if –

- *(b) there is reason to suspect that the assessment is no longer valid,*
- *(c) there has been a significant change in the work to which the assessment relates,*
- *(d) where the results of health surveillance show it to be necessary, or*
- *(e) where as a result of exposure monitoring an occupational exposure limit value is found to have been exceeded.*

(6) A risk assessment made pursuant to this regulation must identify the measures that have been taken or that are to be taken in relation to the requirements of these regulations.

(7) In the case of a new activity involving hazardous chemical agents, work shall not commence until after an assessment of the risk of that activity has been made and the preventive measures identified in the risk assessment have been implemented.

Appendix G

Definition of 'COMPETENT PERSON'

The legal definition for 'competent person' as defined under Section 2 of the Safety, Health and Welfare at Work Act, 2005.

Section 2.- (1) In this Act, unless the context otherwise requires-

"competent person" shall be read in accordance with *subsection (2);*

[whereby subsection (2) states:…….

(2) (a) For the purposes of the relevant statutory provisions, a person is deemed to be a competent person where, having regard to the task he or she is required to perform and taking account of the size or hazards (or both of them) of the undertaking or establishment in which he or she undertakes work, the person possesses sufficient training, experience and knowledge appropriate to the nature of the work to be undertaken.

(b) Account shall be taken, as appropriate, for the purposes of *paragraph (a)* of the framework of qualifications referred to in the Qualifications (Education and Training) Act 1999.

Appendix H

Check List for Hotels and other Accommodation Sites

Legionnaires' Disease: - Minimising the Risk

Legal claims for legionnaires' disease can be a significant cost and cases associated with hotels often receive extensive media coverage and can harm the hotel business. In 2007, 1,283 cases of legionnaires' disease reported to EWGLINET were associated with staying in hotels or other holiday accommodation.

The risk from legionnaires' disease can be reduced by careful attention to a number of simple measures.

1. What is legionnaires' disease

A form of pneumonia which kills about 13% of those infected and is caused by *Legionella* bacteria. *Legionella* bacteria can also cause less serious illness. Illness usually develops 3-6 days after infection but may take longer. Most legionnaires' disease cases are sporadic, while 10-20% of cases can be linked to outbreaks. Any client exhibiting ill-health should be referred immediately to a doctor.

2. Symptoms

The illness usually starts with a fever, chills, headache and muscle pain. This is followed by a dry cough and breathing difficulties that may progress to severe pneumonia. About 30% of those infected will also have diarrhoea or vomiting and about 50% become confused or delirious.

Accurate diagnosis requires specific laboratory tests which often will not be done until the guests have returned home.

3. How is legionnaires' disease caught?

Breathing in air containing the *Legionella* bacteria in an aerosol that may not be visible. Aerosols can be formed from fine droplets generated from water containing the bacteria by, for example, running a tap or shower, flushing a toilet, or from bubbles rising through water in a spa pool. The bacteria can live and multiply in water at temperatures of 20°C to 45°C. They can be found in the natural environment such as rivers, lakes and moist soil but usually in low numbers. High numbers occur in inadequately maintained man-made water systems.

Legionella bacteria do not appear to multiply below 20°C and are killed within a few minutes at temperatures above 60°C. They may, however, remain dormant in cool water and multiply when temperatures reach a suitable level. Chlorination of water supplies does not guarantee elimination of *Legionella* bacteria.

Person-to-person transmission has never been documented.

4. Where are the potential risk areas in hotels?

Wherever water droplets can be created there is a risk of infection e.g:

- Showers and taps
- Spa baths and whirlpool baths
- Turkish baths and saunas
- Cooling towers and evaporative condensers, even if situated on the roof or in the grounds
- Ornamental fountains, particularly indoors
- Humidified food displays.

5. Where can *Legionella* bacteria multiply?

- Hot and cold water tanks/cisterns
- Warm water between 20°C and 45°C
- Pipes with little or no water flow (this includes unoccupied rooms)
- Slime (biofilm) and dirt on pipes feeding showers and taps and tank surfaces
- Rubber and natural fibres in washers and seals
- Water heaters and hot water storage tanks
- Scale in pipes, showers and taps.

These situations and conditions encourage the growth of *Legionella* bacteria and increase the risk of infection to hotel guests and staff.

6. Reducing the risk

The risk of legionnaires' disease can be avoided. Any organisation or premises (work-related or leisure-related) that do not have an active programme to control the growth of legionellae are negligent in ensuring the safety of its workers, visitors, guests and others. The programme should comprise the following:[25]

- Have one person responsible for *Legionella* control
- Ensure that the named person is trained in the control of *Legionella* and other staff are trained to be aware of the importance of their role in controlling *Legionella*
- Keep hot water circulating at all times at 50°C-60°C* (too hot to put hands into or under for more than a few seconds)
- Keep cold water cold at all times. It should be maintained at temperatures below 20°C
- Run all taps and showers in rooms for several minutes at least once a week whether occupied or unoccupied (see Chapter 5, Section 5.2.1)
- Keep showerheads and taps clean and free from scale
- Clean and disinfect cooling towers and associated pipes used in air conditioning systems regularly - at least twice a year
- Clean and disinfect water heaters (calorifiers) once a year
- Disinfect the hot water system with high level (50mg/l) chlorine for 2-4 hours after work on water heaters and before the beginning of a season
- Clean and disinfect all water filters regularly - every one to three months
- Inspect water storage tanks, cooling towers and visible pipework monthly. Ensure that all coverings are intact and firmly in place.
- Inspect the outside of the cold water tanks at least once a year and disinfect with 50mg/l chlorine and clean if containing a deposit or otherwise dirty
- Ensure that the system modifications or new installations do not create pipework with intermittent or no water flow.
- If there is a spa pool, ensure that:
    - Free chlorine residual of 3-5 mg/l is maintained in the spa pool water or if bromine is used, 4-6 mgs/l of total active bromine. The levels should be monitored each day before the spa pool is used and thereafter at least every two hours
    - Replace at least half of the water each day
    - Backwash sand filters daily
    - Clean and disinfect the whole system weekly
    - Keep daily records of all water treatment readings such as temperature and chlorine concentrations and ensure that the manager checks them regularly.[148]

Further advice about specific controls should be sought from experts in this field who can carry out a full risk assessment of the hotel site (see also Chapter 8, Section 8.5).

7. *Legionella* testing

Testing for *Legionella* (which is not compulsory) can be misleading. Samples should only be collected by trained personnel and examined by laboratories accredited for testing water for *Legionella* bacteria. A negative test does not necessarily mean that the hotel is clear of *Legionella* or that there is no risk.

8. Water treatment systems

There are a number of effective water treatment systems known to be beneficial in controlling water quality and safety. The type of system best suited to your site will depend on a number of different factors relating to the size and type of your operation. Independent advice should always be sought from reputable and qualified people before choosing a system and it is important to remember that no system will work if not maintained and checked regularly.

Further information

Further information can be obtained from the European Guidelines for Control and Prevention of Travel Associated Legionnaires' Disease at www.ewgli.org/ and the Irish guidelines for control of legionellosis at www.hpsc.ie/hpsc/.

*** Where these temperatures cannot be achieved due to local conditions, suitable alternative residual disinfection procedures must be used and supported by regular (at least quarterly) testing for *Legionella*. Residual disinfection procedures that have been used include chlorine dioxide and copper/silver ionization**

Appendix I

ISO 15223-1:2007(E)

5 Symbols

When appropriate, information essential for proper use shall be indicated on the medical device, on its package or in the associated documentation by using the corresponding symbols given in Table 1.

Examples can be found in Annex A.

Table 1 — Symbols to convey information essential for proper use

No.	Symbol	Title	ISO 7000 or IEC 60417 registration number
5.1		Biological risks	ISO 7000-0659 (DB 2004-01)
5.2		Do not re-use	ISO 7000-1051 (DB 2004-01)
5.3		Consult instructions for use NOTE This symbol advises the reader to consult the operating instructions for information needed for the proper use of the device. See also symbol 5.4.	ISO 7000-1641 (DB 2004-01)
5.4		Caution, consult accompanying documents NOTE 1 This symbol advises the reader to consult the accompanying documents for important safety-related information such as warnings and precautions that cannot, for a variety of reasons, be presented on the device itself. See also symbol 5.3. NOTE 2 The symbol A or B in ISO 7000-0434 ("Caution") may also be used.	ISO 7000-0434 (DB 2004-01)
5.5		Fragile, handle with care	ISO 7000-0621 (DB 2004-01)
5.6		Keep away from sunlight NOTE The symbol may also mean "Keep away from heat" as referenced in ISO 7000:1989.	ISO 7000-0624 (DB 2004-01)

Source: ISO 15223-1 Medical devices – symbols to be used with medical device labels, labelling and information to be supplied – Part 1: general requirements

Appendix J

Health Protection Surveillance Centre

SURVEILLANCE SCHEME FOR LEGIONNAIRES' DISEASE

Objectives:

- To detect clusters or outbreaks of legionella infection in the Republic of Ireland through the surveillance of all reported cases.
- To identify sources of infection so that control measures can be applied to prevent further cases.
- To disseminate legionella surveillance information to all those who need to know.

REPORT OF A CASE OF

Legionnaires' Disease ☐ **or Pontiac Fever** ☐ **or Asymptomatic Legionella Infection** ☐

PERSONAL DETAILS

Initials of patient _____ Sex: Male ☐ Female ☐

Date of birth ____/____/____ **Age** _____ **Occupation** _____

Home address *(please give postcode if known)* **Work address**

_____

_____

CLINICAL HISTORY OF CASE

06/11/2007

Date of onset of symptoms of legionnellosis ____/____/____

Did this patient have pneumonia? **Yes** ☐ **No** ☐ **Not sure** ☐

What were the other main clinical features? _____

Has the patient had a recent organ transplant? **Yes** ☐ **No** ☐ **Not sure** ☐

Was the patient immunosuppressed for other reasons? **Yes** ☐ **No** ☐ **Not sure** ☐

If YES please give details

_____

Please give details of any other underlying condition _____

_____

Hospital for patient admission _____ **Date of admission** __/__/__

Outcome Death ☐ (date of death __/__/__) Still ill ☐ Recovered ☐ Not known ☐

SUSPECTED HOSPITAL ACQUIRED CASE

If the patient was in hospital for any time in the 14 days BEFORE the date of onset of symptoms of legionnellosis:

Diagnosis on admission _____ Date of admission __/__/__

Type of ward or unit in which patient was resident _____

If the patient was transferred from another hospital, please give details:

Name of hospital before transfer Date of stay __/__/__ to __/__/__

SUSPECTED COMMUNITY ACQUIRED CASE

Sporadic ☐ Cluster ☐ please specify _____

SUSPECTED TRAVEL ASSOCIATED CASE

If the patient spent any nights away from home in the 14 days before onset, please give details:

County	Town or Resort	Hotel/other accommodation* (including room number if known)	Dates of stay From	To

*apartments/composites/cruise ships etc.

Tour operator (if known) _____

Did the patient bathe in a whirlpool/spa? Yes ☐ No ☐ Not sure ☐ Details _____

LEGIONELLA MICROBIOLOGY RESULTS

A Culture Not done ☐

	Date	Specimen	Species	Serogroup
1				
2				

Result:
Positive ☐ Negative ☐
Positive ☐ Negative ☐

B Urine ELISA

Date	Kit used	Result:
		Positive ☐ Negative ☐

C Serology Not done ☐

	IFAT (Immunofluorescent antibody test)			RMAT (rapid microagglutination antibody test)		
Date collected						
Titre						

D Immunofluorescent demonstration of antigen

	Date	Specimen	Species	Serogroup
1				
2				

Result:
Positive ☐ Negative ☐
Positive ☐ Negative ☐

E Other Method (specify) _____

Date	Specimen

Result:
Positive ☐ Negative ☐

CASE DEFINITIONS FOR LEGIONNAIRES' DISEASE

(i) Confirmed case:

A clinical diagnosis of pneumonia with laboratory evidence of one or more of the following:

- Isolation of any legionella organism from respiratory secretions, lung tissue or blood
- Demonstration of a specific antibody response (fourfold or greater rise) to *L. pneumophila* serogroup 1 or other serogroups or other *Legionella* species by the indirect immunufluorescent antibody test or by microagglutination
- The detection of specific legionella antigen in urine using validated reagents.

(ii) Probable case:

A clinically compatible case, or a clinically compatible case with an epidemiological link, and one of the following:

- A single high titre in specific serum antibody to *L. pneumophila* serogroup 1, other serogroups or other *Legionella* species
- Detection of specific legionella antigen in respiratory secretions or direct fluorescent antibody (DFA) staining of the organism in respiratory secretions or lung tissue using evaluated monoclonal reagents.

Laboratory where microbiology carried out _____

Laboratory confirmation at:

Name of reporting doctor(s) (please print) _____

Position Held _____ Signature _____ Date _____

Please return this form to:
Director, Health Protection Surveillance Centre, 25 – 27 Middle Gardiner Street, Dublin 1
01 - 8561299

06/11/2007

Appendix K
List of Submissions and acknowledgements

A draft of the document was sent to the following for consultation and was also available on the HPSC website. We would like to thank those who made submissions for their considered and helpful responses to this document.

Directors of Public Health

Public Health Medicine Communicable Disease Group

Dr Colette Bonner, Deputy Chief Medical Officer, Department of Health and Children

Dr Pat Doorley, National Director of Population Health, HSE

Dr Kevin Kelleher, Assistant National Director of Population Health – Health Protection, HSE

Dr Jim Kiely, Chief Medical Officer, Department of Health and Children

Engineers Ireland

Environmental Health Officers Association

Royal College of Surgeons of Ireland, Faculty of Radiology

Irish Society of Clinical Microbiologists

Royal College of Physicians of Ireland, Faculty of Public Health Medicine

Royal College of Physicians of Ireland, Faculty of Occupational Medicine

Royal College of Physicians of Ireland, Faculty of Pathology

Surveillance Scientists Association

The Federation of Irish Nursing Homes

Irish Dental Association

Irish Thoracic Society

Irish Infection Society

Irish Society of Physicians in Geriatric Medicine

Intensive Care Society of Ireland

Academy of Medical Laboratory Sciences

Royal College of Physicians of Ireland

Infection Prevention Society

Health and Safety Authority

Emergency Medicine Association

Irish College of General Practitioners

Dr Ronnie Russell, Senior Lecturer in Environmental Microbiology, The Moyne Institute, Department of Microbiology, Trinity College, Dublin

Mr Thomas Farren, Registrar, The Dental Council, Merrion Square, Dublin

Mr Brian Murray, Chief Executive Officer, Dublin Dental School and Hospital, Lincoln Place, Dublin

Pure Air Technologies, USA

Irish Tour Operators Federation

Irish Hotels Federation

Health Service Executive, Hospital Managers

Dr Carol Joseph, Consultant Clinical Scientist, EWGLINET Project Leader, Centre for Infections, Colindale, London

Dr Susanne Surman-Lee, LFWEM Laboratory, Regional Microbiology Network, Health Protection Agency, Centre for Infections, Colindale, London

Glossary of Terms

Algae	Small, usually aquatic, plants which require light to grow, often found in exposed areas of cooling towers
Amoeba	A unicellular organism that moves by means of pseudopods. When their living environment becomes unfavourable they become dormant by encysting (see below)
Antibody	A specific substance produced by the body's immune system in response to a particular infection
Antigen	Any substance foreign to the body that evokes an immune response
Backwash	Cleaning water treatment filters by reversing the water flow
Biocide	A chemical substance which destroys microorganisms
Biofilm	A structured community of microorganisms encapsulated within a polysaccharide matrix which forms on wet or damp surfaces such as water pipes. The matrix contains microorganisms, predominantly bacteria, and inorganic compounds. Microorganisms in biofilms are especially difficult to destroy using biocides or disinfectants, because the latter penetrate poorly into biofilms
Blowdown	Water discharged from the system to control the concentration of salts or other impurities in the circulating water
Calorifiers	An apparatus used for the transfer of heat to water in a vessel by indirect means, the source of heat being contained within a pipe or coil immersed in the water
CERT	The national training body for the tourism and hospitality industries in Ireland
Chiller	A machine that removes heat from a liquid, usually water, via a vapour-compression or absorption refrigeration cycle. They are used to cool and dehumidify air in mid-to-large-size commercial, industrial and institutional facilities
Deadlegs	Any area in a piping system where water can be stagnant and where water is not exchanged during flushing
Drift eliminator	Equipment containing a complex system of baffles designed to remove water droplets from cooling tower air passing through it
Encyst	To form or become enclosed in a cyst (protozoans encyst in order to resist drying out)
Evaporative condenser	A heat exchanger in which refrigerant is condensed by a combination of air movement and water sprays over its surface
Excystment	To emerge from a cyst
FÁS	The national employment authority which promotes job opportunities and training courses for school leavers, post-graduates and professionals in Ireland
Pack/packing	The portion of a cooling tower which constitutes its primary heat transfer surface
Plantonic	Free-floating microorganisms in an aquatic environment
Protozoa	Single-celled microorganisms, larger and more complex than bacteria. They are ubiquitous in aquatic environments and soil. A few are important parasites that cause disease
Quench tanks	A water-filled tank used to cool incinerator residue or hot materials from industrial processes
Sessile	Aquatic microorganisms adhering to a surface, normally part of a biofilm
Somnicell	Encompasses bacteria in a viable but non-culturable state which exhibit living attributes other than the ability to reproduce in culture media
Teagasc	The national body providing integrated research, advisory and training services to the agriculture and food industries in Ireland
Thermostatic mixing valve	A device that mixes two streams of hot and cold water so that the temperature at the outlet is pre-selected and controlled automatically by the valve