# The Management of Legionnaires' Disease in Ireland

Scientific Advisory Committee
Legionnaires' Disease Sub-committee
National Disease Surveillance Centre

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# Table of Contents

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# Acknowledgements

This document should be read with particular reference to the following documents:

Approved Code of Practice (AcoP) and Guidance – *Legionnaires'disease: The control of legionella bacteria in water systems*, published in 2000 by the Health and Safety Commission in the UK. ISBN 0 7176 1772 6

*European Guidelines for Control and Prevention of Travel associated Legionnaires' Disease*, awaiting publication by members of the European Working Group for Legionella Infections (www.ewgli.org)

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# Summary of Recommendations

Legionnaires' disease is a notifiable disease in Ireland as defined by the Infectious Disease Regulations 1981, revised in 1985, 1988 and 1996. When compared with other European countries Ireland's notification rates are noticeably lower, particularly so in comparison with Northern Ireland, Scotland, England and Wales with whom we share similar ecological factors including climate, geography and water quality. This would suggest that a major degree of under diagnosis and under reporting of legionnaires' disease currently exists in Ireland. With this in mind the objectives of these guidelines are to enhance the care of patients with suspected or diagnosed legionnaires' disease, improve the notification of such cases, and to safeguard the health of the general public by reducing the risk of exposure to legionella bacteria.

**1.** These guidelines should be read in conjunction with the UK Health and Safety Commission publication : The Control Of Legionella Bacteria In Water Systems: Approved Code of Practice and Guidance, ISBN 0 7176 1772 6.

**2.** 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

**3.** Clinical staff, Microbiologists, Infection Control Teams, Maintenance and Engineering staff of hospitals should be familiar with the recommendations described in this document for the control of nosocomial legionnaires' disease

**4.** Investigation of an outbreak of legionnaires' disease should be conducted by a multidisciplinary Outbreak Management Team in a manner consistent with best practice

**5.** Environmental health officers should receive appropriate training and accreditation in (a) environmental water sampling in accordance with ISO 11731 and (b) conducting a risk assessment for the control and prevention of legionella in water systems according to the UK Health and Safety Commission publication : The Control Of Legionella Bacteria In Water Systems: Approved Code of Practice and Guidance, ISBN 0 7176 1772 6.

**6.** A National Legionella Reference laboratory should be established and accredited by the National Accreditation Board (NAB) for clinical and environmental sample testing, to act as a typing centre and to provide expert opinion on the microbiology of the organism. It should take part in an external quality assessment scheme for the isolation of legionella from water

**7.** Dental unit water lines are a potential risk factor. Methods for monitoring the microbial quality of water used during dental care should be researched and developed by the dental profession that are simple, reliable and cost-effective

**8.** Employers should ensure, in accordance with the Safety, Health and Welfare at Work Act 1989, that possible exposure to legionella bacteria has been considered and addressed in the drafting of a Safety Statement

**9.** Legionella specific legislation is by-and-large absent in Ireland. There is an urgent need for the Department of Health and Children, the Department of the Environment and the Department of Enterprise and Employment to consider (a) legislative controls on standards of maintenance and disinfection of vulnerable plant & equipment at high-risk sites and businesses (b) a system of statutory notification by the owner/occupier of high-risk sites

**10.** Legislative backing should be provided by an appropriate statutory authority such as the Health Board for the monitoring and control of high-risk sites including those instances where there is a recognised public health risk e.g. trade shows with open air fountains/jacuzzis etc.

**11.** Health Boards should establish local implementation committees to plan the introduction of these guidelines and should include identifying training requirements

**12.** Formal out-of-hours on-call arrangements should be put in place for Departments of Public Health & NDSC for surveillance and control of infectious diseases

**13.** These guidelines should be reviewed in 2005 or sooner should new developments demand.

# Epidemiology of Legionnaires' Disease

## 1. 1 Introduction

Infection with Legionella bacteria can cause 2 distinct clinical syndromes, grouped together under the name legionellosis. The first is Pontiac fever, a self-limiting influenza like illness. It usually occurs in explosive outbreaks. Incubation period is usually 24-48 hours. Patients recover spontaneously in 2-5 days. The second and the subject of these guidelines is legionnaires' disease a severe and potentially fatal form of pneumonia. Symptoms include a flu-like illness, followed by a dry cough and frequently progress to pneumonia. Approximately 30% of people infected may also present with diarrhoea and vomiting and around 50% may show signs of mental confusion.

Legionnaires' disease was first recognised during the 1976 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[1]. Legionella bacteria was the organism isolated. 43 Legionella species and 65 serotypes have been described[2 3] of which Legionella pneumophila was responsible for the majority of cases. Legionella pneumophila serogroup 1 was found in 71% of fully identified clinical isolates of cases reported from 1980 to 1989 to the Centres of Disease Control and Prevention (CDC) [4].

## 1.2 Legionella – natural history of the organism

Legionella is a ubiquitous organism that lives as an intracellular parasite of amoebae in aquatic environments [5 6]. Legionella bacteria can be found naturally in environmental water sources such as rivers, lakes and reservoirs, usually in low numbers. From the natural source, the organism passes into sites that constitute an artificial reservoir (channelled water in towns, water systems in individual buildings, etc). Water temperatures in the range 20°C to 45°C favour growth of the organism. The organisms do not appear to multiply below 20°C and will not survive above 60°C. They may, however remain dormant in cool water and multiply when temperatures reach a suitable level. Legionella bacteria also require nutrients to multiply, and sources include commonly encountered organisms within the water system itself such as algae, amoebae and other bacteria. The presence of sediment, sludge, scale and other material within the system, together with biofilms, are also thought to play an important role in the harbouring and providing favourable conditions in which the legionella bacteria may grow. Drinking water disinfectants such as free chlorine penetrate poorly into the biofilm[7] and legionella is further shielded by the amoebae that it parasitises[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 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 and are often removed during water filtering such as occurs in spapools.

Legionnaires' disease may present in the epidemic form following a limited temporal and spatial exposure to a single source, in a series of independent cases in an area in which it is highly endemic or in sporadic cases without any obvious temporal or geographical grouping. Epidemic outbreaks have occurred repeatedly in buildings such as hotels and hospitals. Incidents of legionnaires' disease are classified for purposes of surveillance as

1. Sporadic: a single case not associated with any other cases
2. Cluster/outbreak: two or more cases associated with a single source with dates of onset within 24 months of each other

## 1.3 Recognised and potential sources of Legionella infection

The following are all sources or potential sources of legionnaires' disease:

- Hot and cold water systems
- Cooling towers and evaporative condensers
- Respiratory and other therapy equipment

- Spa pools/natural pools/thermal springs
- Fountains/sprinklers
- Humidifiers for food display cabinets
- Water cooling machine tools
- Potting compost/soil in warmer climates
- Vehicle washes

Additional anecdotal reports suggest that other aerosol producing devices such as medication nebulisers, an ultrasonic misting machine, an electrical sump pump and a carpet cleaner can transmit disease[9 10 11 12]. What they have in common is a combination of high temperature and potential for aerosol formation.

### 1.4 Methods of transmission

Legionnaires disease is normally acquired through the respiratory tract, by inhalation of an aerosol. An aerosol is formed from droplets that can be generated by spraying the water or by bubbling the air into it, or by it impacting on solid surfaces. The smaller the droplets, the more dangerous they are. 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[13]. Person to person transmission has never been documented.

### 1.5 Risk of infection

Recognised risk factors for legionnaires' disease include being of an older age group (>50 years), male, cigarette smoker, and having a chronic underlying disease with or without an associated immunodeficiency[14]. The incubation period is usually between 2 days and 10 days although longer periods have been reported[15]. The risk of acquiring legionella infection is principally related to 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%[14]. 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[16]. Even though it is difficult to establish the infective dose for humans, it is commonly considered that concentrations of legionella between $10^2$ and $10^4$/L are enough to cause one case of infection per year, while concentrations between $10^4$ and $10^6$/L can cause sporadic cases[17]. Erythromycin is the antibiotic of choice in confirmed cases of legionnaires' disease

### 1.6 How common is legionnaires' disease?

Studies that have estimated the incidence of community acquired legionnaires' disease found that legionella caused 2% to 16% of community acquired pneumonia in developed countries [18]. One study in the UK showed that in the context of severe community acquired pneumonia, legionella, accounted for 14-37% of cases with an associated mortality rate in excess of 25%[19]. Overall, legionella is probably the second-to-fourth-most common cause of community-acquired pneumonia.

Less than 5% of legionellosis cases are eventually reported to public health authorities through passive surveillance; most are probably never diagnosed[20 21]. Approximately 75% of cases are community acquired and approximately a quarter of all reported legionnaires' disease cases acquire their infection inside a hospital[20]. There are several reasons specific to legionnaires' disease that may contribute to this major degree of under diagnosis and under reporting and potentially the unnecessary delay of appropriate treatment.

- When a patient is diagnosed with pneumonia, treatment is generally started immediately. If the patient is treated with antibiotics that are effective against legionella, the patient recovers, without further need to establish the cause of the pneumonia.

- Legionnaires' disease requires specialised laboratory tests for diagnosis. Some of the diagnostic methods for legionnaires' disease lack sensitivity and specificity and may result in producing false negative results.

- Patients with serious underlying disease involving immunosuppression are particularly at risk for legionnaires' disease. If these patients die, death may be attributed to their serious condition, without diagnosing the legionella infection.

### 1.7 Definitions

*a) Confirmed case of legionnaires' disease*

An acute lower respiratory infection with focal signs of pneumonia on clinical examination and/or radiological evidence of pneumonia and one or more of the following:

1) Culture - isolation of any legionella organism from respiratory secretion, lung tissue or blood.

2) Seroconversion – a fourfold or greater rise in specific serum antibody titre to L. pneumophila serogroup 1 by the indirect immunofluorescent antibody test or by microagglutination.

3) Antigen detection – the detection of specific legionella antigen in urine using validated reagents.

*b) Presumptive case of legionnaires' disease*

An acute lower respiratory infection with focal signs of pneumonia on clinical examination and/or radiological evidence of pneumonia and one or more of the following:

1) By serology- A fourfold or greater rise in specific serum antibody titre to L. pneumophila other serogroups or other legionella species by the indirect imunofluorescent antibody test or by microagglutination.

2) By serology - a single high titre*, using reagents to L pneumophila serogroup 1 or other Legionella species and serogroups.

3) The detection of specific legionella antigen in respiratory secretion or direct fluorescent antibody (DFA) staining of the organism in respiratory secretion or lung tissue using evaluated monoclonal reagents.

4) Detection of legionella species DNA by Polymerase Chain Reaction (PCR)

***A single high serological titre**: as differing serological testing methods are used in different countries, and as an internationally accepted validation exercise has not been carried out, no specific serological test or titre level can be specified. It is suggested however that the single high titre result considered to indicate recent legionella infection, in the presence of compatible symptoms, be set at a sufficiently high level to be specific for legionella infection (ie. to produce a low level of false positives).

Should a case meet the clinical and microbiological criteria as outlined above the case is a notifiable disease and should be notified as such to the designated Medical Officer of Health in the relevant Department of Public Health.

*(c)Travel associated cases*

A case is defined as travel associated if the patient spent one or more nights away from their home in accommodation used for commercial or leisure purposes e.g. hotels, holiday apartments, ships, campsites etc in the 10 days before the onset of illness. The onset of symptoms of legionnaires'

disease must be within ten days of the last date of travel. Travel associated cases may involve travel within Ireland or with travel abroad. 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. See Appendix 2 and Appendix 3.

### 1.8 Legionnaires' disease in Ireland

Legionnaires' disease is a notifiable disease in Ireland as defined by the Infectious Disease Regulations 1981, revised in 1985, 1988 and 1996. Table 1 summarises the number of cases of legionnaires' disease notified to the Department of Health and Children and the National Disease Surveillance Centre. NDSC took over responsibility for the collation of clinical infectious diseases notifications on July 1st 2000.

**Table 1 Number of legionnaires' disease cases notified 1990-2000**

| Year | Legionnaires' disease Cases | Crude rate per 1,000,000 population |
|---|---|---|
| 1990 | 1 | 0.6 |
| 1991 | 0 | - |
| 1992 | 2 | 0.6 |
| 1993 | 0 | - |
| 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 | 2.5 |

1991 population: 3,525,719
1996 population: 3,626,087

### 1.9 Legionnaires' disease in Europe

In 1999, the overall European rate of infection was 5.4 cases per million population. The infection rate was highest in Belgium at 19.5 per million population followed by Denmark at 16.98 and the Netherlands at 16.75 per million population. The high rates of infection in both Belgium and the Netherlands were accounted for by large community outbreaks linked to whirlpool spas. Denmark, a country with a population just over 5 million, has consistently had a higher rate of infection than other countries which is possibly associated with the fact that it is a small country that carries out high levels of testing for legionella in patients with pneumonia and which has a centralised reference laboratory for diagnosing and reporting cases[22]. Rates reported in European countries in 1999 are shown in table 2.

**Table 2 Rate of legionnaires' disease in European countries in 1999**

| Country | Rate per million population |
|---|---|
| Belgium | 19.5 |
| Denmark | 16.98 |
| The Netherlands | 16.75 |
| Switzerland | 10.75 |
| Sweden | 9.71 |
| Malta | 7.9 |
| Spain | 7.76 |
| France | 7.6 |
| Scotland | 6.81 |
| Austria | 5.13 |
| Italy | 4.05 |
| England & Wales | 3.72 |
| Northern Ireland | 2.94 |
| Norway | 2.27 |
| Finland | 1.76 |
| **Ireland** | **0.6** |

Table 2 adapted from[22]

Ireland is conspicuous by its low rate particularly so in comparison with Northern Ireland, Scotland and England and Wales with whom we share similar ecological factors such as climate, geography and water quality. This would tend to suggest that a major degree of under diagnosis and under reporting of legionnaires' disease currently exists in Ireland with the possible consequence of treatment being delayed. Significantly, it has been reported that delay of appropriate therapy results in poor outcome [23].

A rapid urine antigen test (BINAX NOW) is available in Ireland and performs as well as the ELISA test [24 25]. Consideration should be given for the more widespread use of this test when a patient presents with pneumonia.

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This chapter has been prepared with particular reference to the following documents:

- Kool J. Preventing Legionnaires' Disease 2000. Thesis. Department of Infectious Disease, National Institute of Public Health and the Environment (RIVM), Bilthoven, The Netherlands
- Draft copy. European Guidelines for Control and Prevention of Travel Associated Legionnaires' Disease. April 2002

## 2.1 Definitions

The following classification of nosocomial legionnaires' disease is used for surveillance purposes:

*Definite Nosocomial*
Laboratory confirmed case that occurs in a patient who was in hospital for all ten days before the onset of symptoms.

*Probably Nosocomial.*
Legionnaires' disease in a person who was in hospital for between 1 and 9 of the 10 days before the onset of symptoms and either became ill in a hospital associated with one or more previous cases of legionnaires' disease or yielded an isolate that was indistinguishable by monoclonal antibody subgrouping or by molecular typing methods from isolates obtained from the hospital water system at about the same time.

*Possibly nosocomial:*
Legionnaires Disease in a person who was in hospital for between 1 and 9 of the 10 days before the onset of symptoms in a hospital not previously known to be associated with any case of legionnaires' disease and where no microbiological link has been established between the infection and the hospital.

Investigation is essential for any case of legionnaires' disease that cannot be excluded as having been acquired in hospital. See page 17.

## 2.2 Pathogenesis of nosocomial Legionnaires' Disease

Approximately a quarter of all reported Legionnaires' disease cases acquire their infection inside a hospital[1]. Figure 1 outlines the pathogenesis of nosocomial pneumonias. Recognised risk factors for legionnaires' disease at an individual patient level include being of an older age group (>50 years), male, cigarette smoker, and having a chronic underlying disease with or without an associated immunodeficiency[2]. 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[2 3 4]. 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[5].

Most nosocomial outbreaks have been linked to legionella colonising the hot water system[6] and several environmental surveys including one in Ireland have demonstrated the presence of L. pneumophila in hospital water distribution systems[7 8 9]. 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[10], respiratory therapy equipment that was cleaned with unsterilised tap water[11], ice machines[12] and aspiration of contaminated water associated with nasogastric feeding or swallowing disorders[13 14].

## 2.3 Recommendations for control of nosocomial legionnaires' disease

### (a) Staff education

- Educate physicians to heighten their suspicion for legionnaires' disease and to use appropriate legionella diagnostic tests for pneumonia patients
- Educate hospital personnel e.g. doctors, nursing staff, infection control, engineering and maintenance staff about measures to control nosocomial legionnaires' disease

**(b) Surveillance**

- Establish mechanisms to provide clinicians with appropriate laboratory tests for the diagnosis of Legionnaires' disease

- Maintain a high index of suspicion for the diagnosis of legionnaires' disease especially in high risk groups[2].

**(c) Interrupting transmission of legionella species**

(a) Nebuliser equipment

- Use sterile water for rinsing nebulisation devices and other respiratory care equipment
- Use only sterile water to fill reservoirs of nebulisers
- Do not use large volume room air humidifiers that create aerosols

**(b) Water distribution system**

- Meeting design requirements such as those outlined in the UK Health and Safety Commission document, Legionnaires' disease; the control of legionella bacteria in water systems. Approved code of practice and guidance[15].
- All hospitals should be obliged to carry out a formal risk assessment of the control and prevention of legionella bacteria.

The following summaries outline the actions that should be taken by those principally concerned with the prevention of an outbreak of nosocomial legionnaires' disease.

## 2.4 How to prevent an outbreak of legionnaires' disease:[16] Design stage of new unit or hospital or modification of existing building

**Proposed action by:**

- Clinician: Define clinical activities in new building especially potentially high risk areas for nosocomial legionnaires' disease e.g. transplant unit, renal unit, oncology unit, cardio-thoracic surgery, ICU, geriatric unit.

- Microbiologist: Act as a reference point for advice on sources and ecology of legionella and on measures likely to prevent or eradicate colonisation of hospital water systems

- Engineer: Meeting design requirements such as those outlined in the UK Health and Safety Commission document, Legionnaires' disease; the control of legionella bacteria in water systems. Approved code of practice and guidance[15]. Consult with clinicians and microbiologists on special design for protection of high risk patients e.g. ensuring the siting of air intakes are away from cooling towers

## 2.5 How to prevent an outbreak of legionnaires' disease:[16] Hospital with no prior record of nosocomial legionnaires' disease

Proposed action by:

- Clinician: More widespread use of appropriate legionella diagnostic tests in the investigation of all cases of nosocomial pneumonia. Look for other cases. Ensure respiratory therapy is not a potential source of infection. Discuss any introduction of high risk activity e.g. new transplant service, with microbiologist and engineer.

- Microbiologist: Investigate all clinical samples from nosocomial pneumonia cases for legionnaires' disease. Check any nosocomial infection with 'no growth' for legionella. A standard operating procedure should be drafted in consultation with the Infection Control Nurse and maintenance personnel to ensure the monitoring of water supplies and water associated therapy systems, daily flushing of all taps and showers in clinical areas and that appropriate measures are taken to rectify problems in a timely manner.

- Engineer: Ensure preventive maintenance both of heat rejecting systems i.e. cooling towers, evaporative condensers and of the domestic water system conforms to guidelines as described in UK Health and Safety Commission document, Legionnaires' disease; the control of legionella bacteria in water systems. Approved code of practice and guidance[15].

## 2.6 How to prevent an outbreak of legionnaires' disease:16 Hospital with a record of nosocomial legionnaires' disease

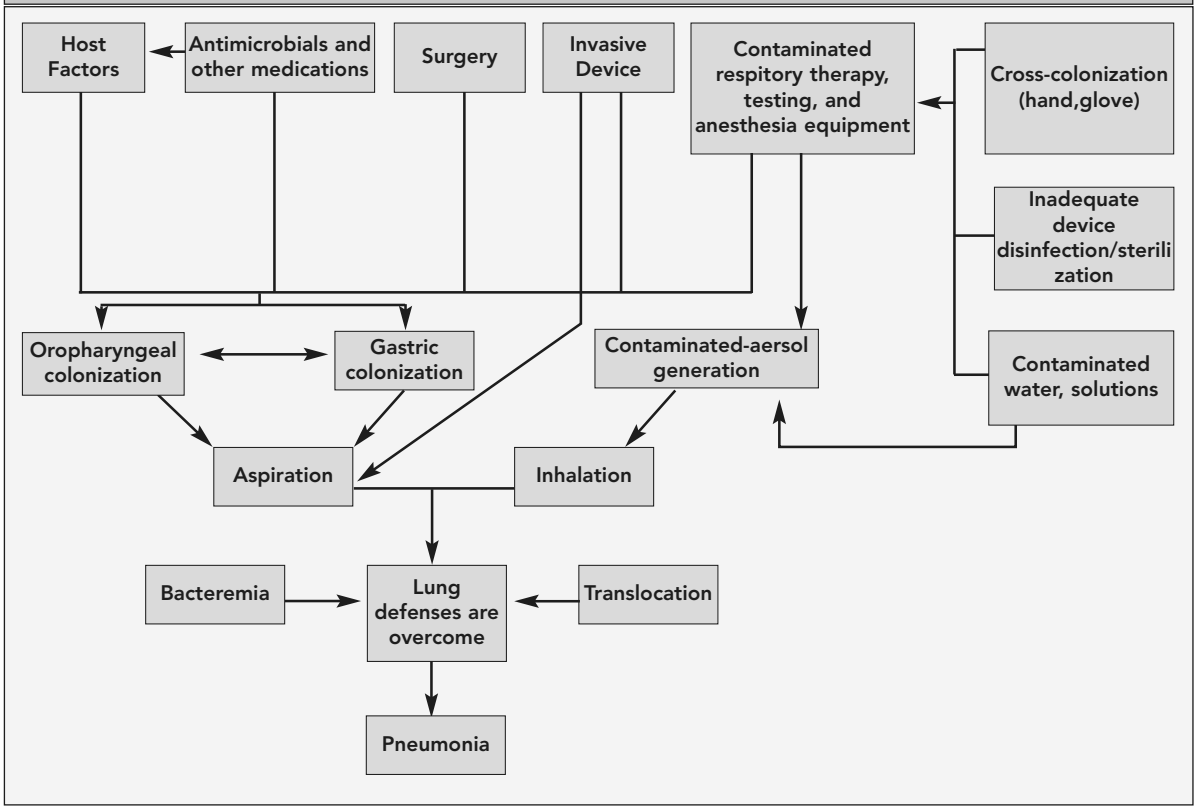
Proposed action by:

- Clinician: Maintain heightened level of surveillance. Warn GP's and other hospitals to look for legionnaires' disease in patients discharged, transferred or living in the vicinity of the hospital. Consider post mortem on patients with fatal nosocomial infection.

- Microbiologist: If a problem is identified by engineering and/or culture it is essential that the problem is rectified and that ongoing surveillance monitors the microbiological efficacy of the engineering works. This is likely to include regular environmental sampling until consistently negative. Any changes to water system e.g. pressure changes/ temperature changes should be followed by environmental sampling. Provide up to date information to engineers, clinicians, Infection Control Team and Hospital Management

- Engineer: Apply full measures as per UK guidelines[15]. Check systems and replace/renew any faulty equipment detected on routine preventive maintenance. Discuss any new information with microbiologist and clinician especially any changes in water handling.

**Figure 1 Pathogenesis of nosocomial bacterial pneumonia**




From: Guidelines for prevention of nosocomial pneumonia[17]

## 2.7 The Environmental Sampling Debate

The Centres for Disease Control (CDC) guidelines first published in 1994 state that "the relationship between the results of water cultures and the risk of legionellosis remains undefined"[17]. In other words there is no absolute level above which, disease is certain to occur and below which it isn't. Some believe that environmental sampling should only be undertaken after a case of legionnaires' disease has been confirmed whereas others would advocate that periodic environmental sampling i.e. routine sampling should be conducted even if no cases of legionnaires' disease have been detected.

Those who favour sampling and decontamination whenever legionella are found argue that infection cannot occur if the bacteria are not present[18].
However those against routine sampling believe that it is not worth the cost because:

- There are variations in sampling and laboratory methods
- Factors other than legionella counts such as aerosolisation and human susceptibility influence the risk of illness
- Legionella in the water will not always cause disease so positive test results could cause a false sense of alarm and lead to unnecessary spending for corrective measures
- Negative test results may cause a false sense of security leading to relaxation of preventive maintenance

- Health care facilities might be tempted to use routine sampling as a substitute for appropriate patient surveillance

### 2.8 When to take an environmental water sample

Published by the UK Health and Safety Commission in 2000, T**he Control Of Legionella Bacteria In Water Systems: Approved Code of Practice and Guidance** (Appendix 1) outlines when sampling should be performed and gives guidance on the appropriate action that should be taken. A summary of their recommendations follows:

**(a) Cooling Systems** [15]
In addition to routine sampling for aerobic bacteria, a routine monitoring scheme should also 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 method should be in accordance with ISO 11731. Samples should be taken as close as possible to the heat source as possible and preferably tested by an accredited laboratory that participates in an external quality assessment scheme. It should be a target of all currently testing laboratories to attain accreditation from the National Accreditation Board (NAB).

**Table 1 Action levels following microbial monitoring of cooling towers**

| **Aerobic count** cfu/ml at 30$^{C}$ (minimum 48hrs incubation) | **Legionella bacteria** cfu/litre | **Action required** |
|---|---|---|
| 10,000 or less | 100 or less | **System under control** |
| 10,001-100,000 | 101-1000 | **Review control programme *** |
| >100,000 | >1000 | **Implement corrective action **** |

*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.

**The system should immediately be 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.

N.B. A failure to detect legionella bacteria should not lead to a 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.

**(b) Hot and cold water systems**[15]
It is recommended that routine monitoring should be carried out;

i. In water systems treated with biocides where hot water storage temperature is <60°C and distribution temperature is <50°C. This 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.

ii. 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, frequent samples e.g. weekly should be taken until the system is brought back under control

iii. When an outbreak is suspected or has been identified

iv. Testing for legionella may also be required in hospital wards with 'at risk' patients e.g. immunologically compromised.

**Table 2 Action Levels following microbial monitoring of hot and cold water systems**[15]

| Legionella bacteria cfu/litre | Action required |
|---|---|
| >100 but <1000 | **Resample and review control programme*** |
| >1000 | **Resample, review programme, disinfect system **** |

* If only one or two samples are positive the water system should be resampled. 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.

** The system should be resampled and an immediate review of the control measures and risk assessment carried out to identify any remedial actions including possible disinfection of the system

### (c) Water sampling for legionella in domestic premises

The Scottish Centre for Infection and Environmental Health (SCIEH) has recently 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)[19].

It was clear from the results of the BRE study that it was not unusual to isolate legionella pneumophila from domestic water systems and its presence per se did not present an unacceptable risk to occupants. Host factors, previously described, play a significant part in determining if exposure results 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.

SCIEH 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:

- 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

SCIEH has 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

Copies of ISO 11731 can be purchased from the National Standards Authority of Ireland, Glasnevin, Dublin 9 (Tel 01-8073800)

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### 3.1 Case Definitions

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

1. **Sporadic**: a single case not associated with any other cases

2. **Cluster/outbreak**: two or more cases associated with a single source with dates of onset within 24 months of each other

Each case of legionnaires' disease should be reported immediately to the nominated Medical Officer of Health of the relevant health board (Director of Public Health). Each case reported should be investigated to determine whether it is part of an outbreak or cluster, work related, suspected to be a hospital acquired infection or is travel associated. Investigation should include confirmation of the diagnosis, tracing the patient's movements during the incubation period and onward reporting of the case to the National Disease Surveillance Centre using the enhanced surveillance form. The Health and Safety Authority should also be informed when a workplace is a possible source of infection.

### 3.2 Response to a single case of legionnaires' Disease

Four key steps should be taken following the reporting of a single case of Legionnaires' disease. These are:

**a. Confirmation of the diagnosis.**

**b. Investigation of patient's movements during the incubation period.**

**c. Reporting the case**

**d. Check that there are no other recent cases.**

a. Confirmation Of The Diagnosis

For the purposes of surveillance and public health action, the clinical diagnosis of legionnaires' disease should be supported by confirmed or presumptive microbiological evidence of recent legionella infection. When the clinical and microbiological evidence is consistent with a diagnosis of legionnaires' disease the attending physician should notify it immediately to the relevant Department of Public Health. The Department of Public Health should then liaise with the environmental health department so that appropriate investigations can begin.

b. Investigation of patient's movements during the incubation period

Should the diagnosis be confirmed or there be a presumptive diagnosis of legionnaires' disease the patient's movement should be checked during the incubation period. The incubation period in legionnaires' disease is between two to ten days. It is essential to detail the patient's movement accurately during this period of time to determine whether the case is part of a cluster or outbreak. Given that the exact onset of an illness is not always certain, enquiries should be made about the two weeks before the onset of illness. Full address of places of residence, places of work, details of travel and any stay in hospital should be obtained. Any particular exposure to recognised sources of legionella should be recorded along with any history of immunosupression and treatment. The following are all sources or potential sources of legionnaires' disease:

- Hot and cold water systems
- Cooling towers and evaporative condensers
- Respiratory and other therapy equipment
- Spa pools/natural pools/thermal springs

- Fountains/sprinklers
- Humidifiers for food display cabinets
- Water cooling machine tools
- Vehicle washes

The patient should be requested to fill out a diary for the previous two weeks of every place he/she has been. A checklist as outlined in Table 1 should be provided to ensure that possible recognised sources/venues of infection for Legionnaires' disease are not omitted.

Table 1. Possible sources of infection for legionnaires' disease

| |
|---|
| Hotels |
| Hospitals |
| DIY Shows |
| Garden Shows |
| House Improvement Shows |
| Bathroom Centres |
| Sports Centres |
| Seminars/Cinemas/Theatres |
| Dental Unit Waterlines |
| Whirlpool spas/Jacuzzis |
| Natural spas |
| Humidifiers |

If the patient is unable to provide the information the patient's GP or next of kin may be able to help.

c. Reporting the case

The Medical Officer of Health should report the case to NDSC using the enhanced surveillance form. The completed from should be faxed to NDSC. Cases with incomplete details should still be promptly reported if they are suspected to be associated with other cases or are associated with travel.

All cases, which have a place of work as a possible source of infection, should also be notified to the Health and Safety Authority by the Department of Public Health in the relevant health board.

d. Check that there are no other recent cases

Check that there are no other recent cases. Information on other possible cases may be available from infectious disease notifications to the health board, NDSC, local hospitals or neighbouring health boards.

### 3.3 Community Acquired Case

Legionella are widespread in the environment and aerosols containing the organism can be dispersed into the atmosphere and travel distances of up to 500 metres from their source[1]. If the patient proves to have a history of exposure to a recognised source of legionella infection e.g. patient lives or works near wet cooling systems (cooling towers) or has being exposed to another recognised source of infection, examination of the maintenance records of these systems should be considered by the

Department of Public Health in consultation with the Principal Environmental Health Officer, Microbiologist and Health and Safety Authority. A formal risk assessment, detailed in **The Control Of Legionella Bacteria In Water Systems: Approved Code of Practice and Guidance** (Appendix 1), should be carried out by a competent person and if deficiencies are identified then sampling of the workplace particularly any wet cooling systems should be considered. The method of sampling and analysis should be in accordance with ISO 11731[2]

Consideration should also be given to asking the management or the Occupational Health Department of the patient's place of work, if appropriate, about recent levels of sick leave or respiratory symptoms in the workforce to determine if other cases are occurring. If the patient lives in a nursing home or residential home enquiries should be made about respiratory symptoms in other residents and the maintenance of water systems.

In the absence of evidence of associated cases further investigation is not warranted but local surveillance should be maintained.

Spa pools also known as "jacuzzis" are an increasingly recognised source of outbreaks of legionnaires' disease and large outbreaks have been associated with pools on display as well as in use[3]. If a patient reports contact with a spa pool the control measures for the pool should be reviewed to ensure they comply with published guidelines [4 5.]

It has been reported that a proportion of sporadic cases of legionnaires' disease may be residentially acquired[6]. See 'Water sampling for legionella in domestic premises'-page 19.

### 3.4 Nosocomial Infection

Investigation is essential for any case of Legionnaires' disease that cannot be excluded as having been acquired in hospital. For definitions please see page 14

#### *Definite or Probable Nosocomial Cases*

When a definite or probable case of nosocomial Legionnaires Disease is identified an Investigation Team should convene under the chairmanship of the relevant Consultant Microbiologist, or else, if agreed with the hospital a Specialist in Public Health Medicine. The team should consist of infection control personnel from the hospital, a hospital engineer, a representative of senior hospital management, a Specialist in Public Health Medicine and an Environmental Health Officer and should consider further investigation and control measures. The risk assessment for control of legionella and maintenance records should be reviewed-potential sources include the domestic 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, clinical humidifiers, humidifiers in ventilation systems, cooling coils in air conditioning systems, fountains and sprinklers. A case search should be conducted for other nosocomial cases including unexplained nosocomial pneumonia in patients or hospital staff. HIPE and laboratory sources may also be of use in this regard.

Any deficiencies in control measures should be remedied as soon as possible but if precautionary disinfection of parts of the water systems is considered justified this must only be undertaken after any sampling. Environmental sampling should be considered where a review of the legionella control programme or maintenance records has identified potential problems or where the hospital water system has recently been modified. The method of sampling and analysis should be in accordance with ISO 11731[2]. See "When to take an environmental water sample-page 18".

*Possible Nosocomial Cases*

If the case is classified as possible nosocomial, unless the risk assessment and review of maintenance records has highlighted a problem, further investigation is not usually warranted.

If the patient did not spend all of the incubation period in the hospital and no other cases are linked to the hospital the possibility remains that either the home or the hospital may be the source of infection. Therefore both should be investigated at the same time. Detection of indistinguishable strains of legionella in the patient and the patient's domestic water system is evidence of infection in the home.

### 3.5 Travel associated cases

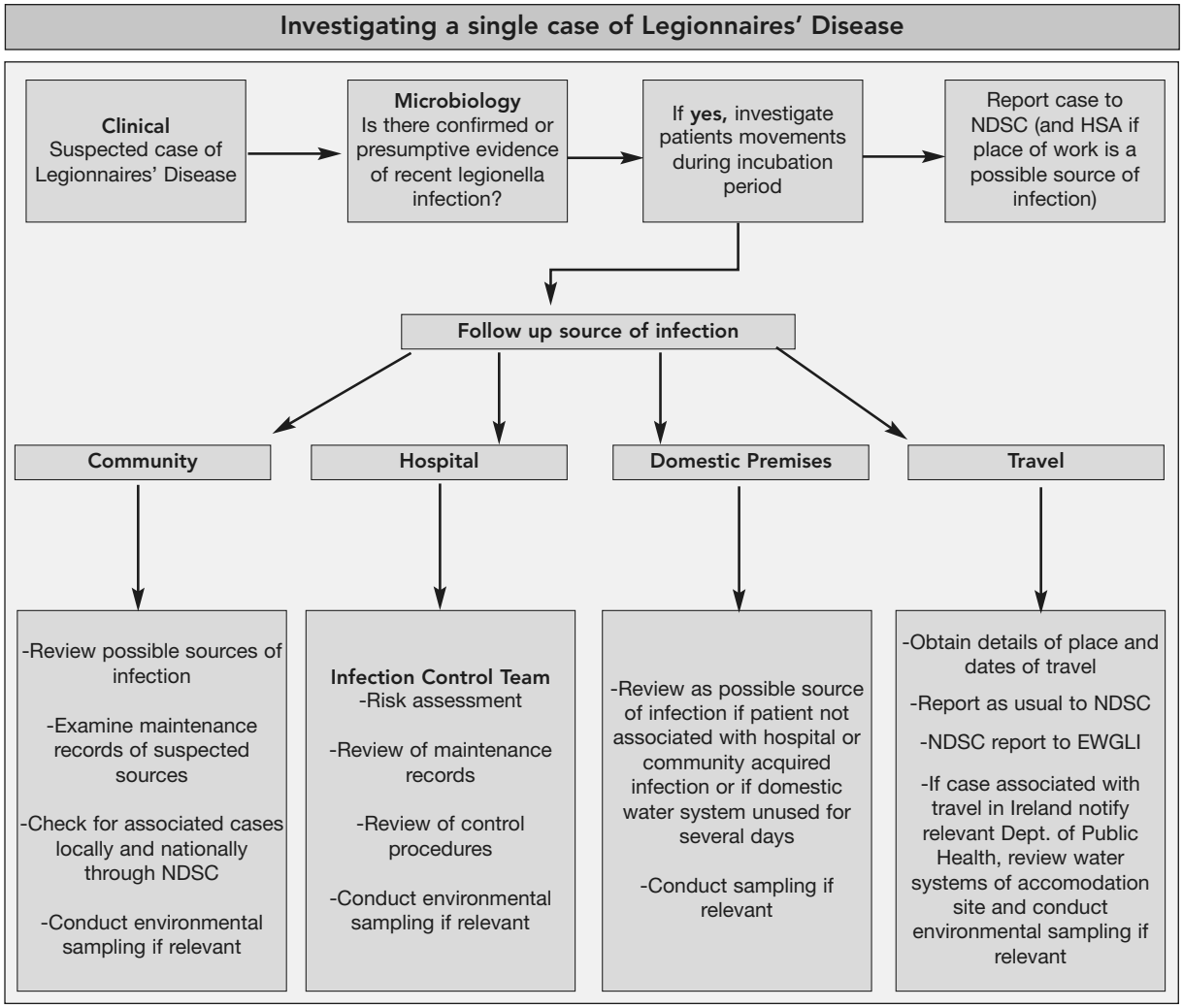
A case is defined as travel associated if the patient spent one or more nights away from home, either in the same country of residence or abroad in accomodation used for commercial or leisure purposes e.g. hotels, holiday apartments, ships, campsites etc in the 10 days before the onset of illness. Many travel associated cases are linked to travel abroad. When these are reported to NDSC their details are forwarded to the European Surveillance Scheme for Travel Associated Legionnaires' Disease (EWGLI).

Legionnaires' disease can occur up to 10 days after the patient returns to their own home and infection could be linked to this source rather than the accomodation at which they stayed before the onset if illness. If a decision is made to sample the domestic water supply the method of sampling should be in accordance with ISO 11731[2]. Isolation of legionella from the patient's home of the same type as that isolated from the patient suggests infection at home rather than in the hotel. See "Water sampling for legionella in domestic premises-page 19".

### 3.6 Concluding Summary

The investigation of single cases of legionnaires' disease should always be carried out in a systematic and methodical way. 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.

### 3.7 Proposed action by Health Board following notification to Medical Officer of Health




### 3.8 Investigating an outbreak of legionnaires' disease

An outbreak can be defined as 2 or more cases of Legionnaires' disease associated with the same geographical location or probable source during the preceding 24 months.

An outbreak management team (OMT) should be convened by the Director of Public health in the relevant health board. It should be multidisciplinary and should include representatives from the following groups:

- Microbiologist
- Physician
- Infection Control Nurse
- Representative of senior management where appropriate
- Environmental Health Officer
- Specialist in Public Health Medicine
- NDSC
- Health & Safety Personnel
- Engineer
- Press Officer
- Other personnel should also be considered as appropriate.

Advance arrangements should be made for:

- Contact numbers of all OMT personnel (and deputies)
- Logistical backup - clerical/administrative, communications, HQ etc.
- Sampling equipment
- Meteorological data acquisition
- On-call provision for staff
- An available reference laboratory
- Liaison with other Authorities - Local Authorities, Health & Safety Authority etc.
- Liaison with General Practitioners

### 3.9 Epidemiological Investigation

The Specialist in Public Health Medicine (SPHM) should ensure that the appropriate epidemiological investigations are carried out. Arrangements should be made for interviewing cases, case finding and case control studies as appropriate.

### 3.10 Microbiological Investigation

Arrangements should be made for the collection of clinical samples for microbiological confirmation of infection in suspected cases. Sampling and microbiological analysis, should preferably 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 water systems and the detection and ecology of legionella species should interpret the laboratory findings.

### 3.11 Environmental Investigation

The Principal Environmental Health Officer should ensure that the appropriate environmental investigations are carried out including early visiting of the implicated site and sampling as appropriate.

### 3.12 Public Relations

Arrangements should be made by the Press Officer to keep members of the press informed. The OMT should agree what should be released to the press.

### 3.13 Report on Outbreak

A detailed report on the investigation and its findings should be completed.

### 3.14 Overview of the activities of the OMT

The OMT has responsibility for overseeing the investigation of sources, including site surveys and environmental sampling, emergency and long term control measures and post-outbreak routine monitoring.

### 3.15 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 OMT as soon as possible and continuous contact should be maintained between investigating personnel and OMT during the outbreak.

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

Environmental Health Officers should 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 OMT. 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 take appropriate steps to ensure that their plant is not likely to be a source of legionnaires' disease.

### 3.16 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 dead and live 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 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 & 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, 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 should be 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

See also Appendix 4

### 3.17 Environmental Sampling

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 systemwide colonisation of the water systems
- 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

Sample sites should be chosen to be representative of the whole water system. The piping plans should be consulted prior to selecting the sampling points. The number and layout of risers or main loops dictate the sampling strategy in the hot water system. The following recommendations represent a minimum of samples to be taken:

a) up to 15 risers-all are sampled
b more than 15 risers-15 are sampled + 20% of the others

Systemwide, basic and complementary sites should be sampled i.e.

- **Systemwide**
  - Incoming cold water to the facility

- Hot water leaving the water heater
- Circulating hot water returning to the heater

- **Basic**
  - The outlet nearest to the entry of the hot water into the facility
  - The most distant sites within the water distribution system
  - The work area/room where the infected person worked/accommodated

- **Complementary**
  - Work areas/rooms on different floors to be representative of the different loops of the water distribution system

### 3.18 How to sample

The method of sampling and analysis should be in accordance with ISO 11731[2]. Samplers should be trained in sampling methods. Unless otherwise indicated 1 litre samples should be collected in sterile 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.

#### a. Sampling systemic points

Samples are collected in the boiler room from the discharge valves of the hot water outgoing pipeline, return water and cold water to be heated. If hot water storage heaters are installed, samples from the sludge drain valves should also be collected. If there are no suitable sample points representative of the water in the heater, the flow from the heater or the flow returning to the heater, then this fact should be recorded.

#### b. Sampling basic and complementary points

***Hot water:*** Collect the water discharging from the tap immediately after it is switched on. This "immediate" sample will be representative of the colonisation of the outlet. Leave the water running for at least a further 60 seconds, measure the temperature and collect a second sample, the "post flush sample", which will be more representative of the water flowing in the system.

*Swabs* - Sample the inner walls of shower heads and handles with a sterile cotton swab using a rotating motion. Sample shower hoses at the point where it is attached to the tap. Swabs are transported in 0.5-1.0 ml of the same residual water.

*Sieves on mixer valves* – remove the sieves and culture any deposit within them.

***Cold water:*** Collect an immediate sample as for the hot water, then leave the water running for 2 minutes before measuring the temperature of the flowing water. Finally collect a second sample i.e. the post-flush sample. When the water temperature is < 20 C, the number of samples can be reduced.

***Water closet cisterns***: These should not be overlooked as potential sources of infection as they can become heavily colonised if the ambient temperature is high. Collect water samples directly from the cistern using a clean sterile container.

***Cooling towers***: If suitable sample points are available collect a sample from the water returning to the cooling tower in addition to a sample from the cooling tower pond as far away from the fresh water inlet as possible. Collect samples of 200ml to 1000ml.

***Spa pools***: Collect water samples of 1000ml from the pool, filter housing and balance tank where

fitted. In some investigations water from the pool has yielded few legionellae at the time of sampling although filter material and biofilm from inside the pipes contained large quantities of legionellae. This probably reflected the type and positioning of the biocide treatment and zones within the piping where the biocidal effect did not penetrate adequately. Therefore, it is also important to inspect the air and water circulation pipes and hoses for the presence of biofilm containing legionellae. Biofilm samples should be collected with swabs from the inside of some sections of these pipes. It is sometimes possible to do this by removing a jet but quite often sections of pipe will have to be cut out to gain adequate access.

*Air washers, humidifiers and decorative fountains*
Collect samples of at least 200ml directly from the source.

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 aerator and taps, the occurrence of scale, and the presence of various rubber and plastic attachments.

### 3.19 Sample transport and laboratory processing

Samples must be kept at ambient temperature and protected from direct light. Water and swabs should be processed on the day of collection or the next day when stored at a refrigerator temperature[2]. Do not freeze samples. It is important to follow the sampling procedure, as incorrectly collected samples make interpretation of the results difficult. It is particularly important that any residual sample concentrates and legionellae isolated are retained until the investigation is complete. This may be several months or even as long as a year.

Analysis of water samples for legionella should preferably be carried out by an accredited laboratory, which takes part in an external quality assessment scheme for the isolation of Legionella from water. It should be a target of all currently testing laboratories to attain accreditation. Established in 1985 to accredit calibration and testing laboratories the National Accreditation Board (NAB) is the Irish National Body with responsibility for accreditation in accordance with the relevant International Organisation for Standardisation (ISO) standards.

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.

### 3.20 Emergency control measures

Emergency control measures should be carried out as soon as possible after the outbreak has been recognised but not before samples have been collected. Non-essential equipment such as spa pools and cooling towers associated with air conditioning systems can be rendered safe by switching them off until samples can be collected and remedial measures implemented. A risk assessment should be carried out and emergency control measures 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 or another oxidising biocide, cleaning of tanks and water heaters and raising the circulating hot water temperature if this is below 60°C. For example:

- Render source safe either by a precautionary shock heating (min 5mins each water outlet at 65°C), disinfection and cleaning or by disabling the equipment until it has been shown to be safe.

- Hyperchlorination (>10ppm) of cooling tower on 3 occasions plus mechanical cleaning. Cleaning of tanks, shower heads, water heaters and circulation of 5ppm free chlorine through the water system for minimum 3 hours.

- The operating temperatures of most cooling water 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 in the water supplying 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

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.

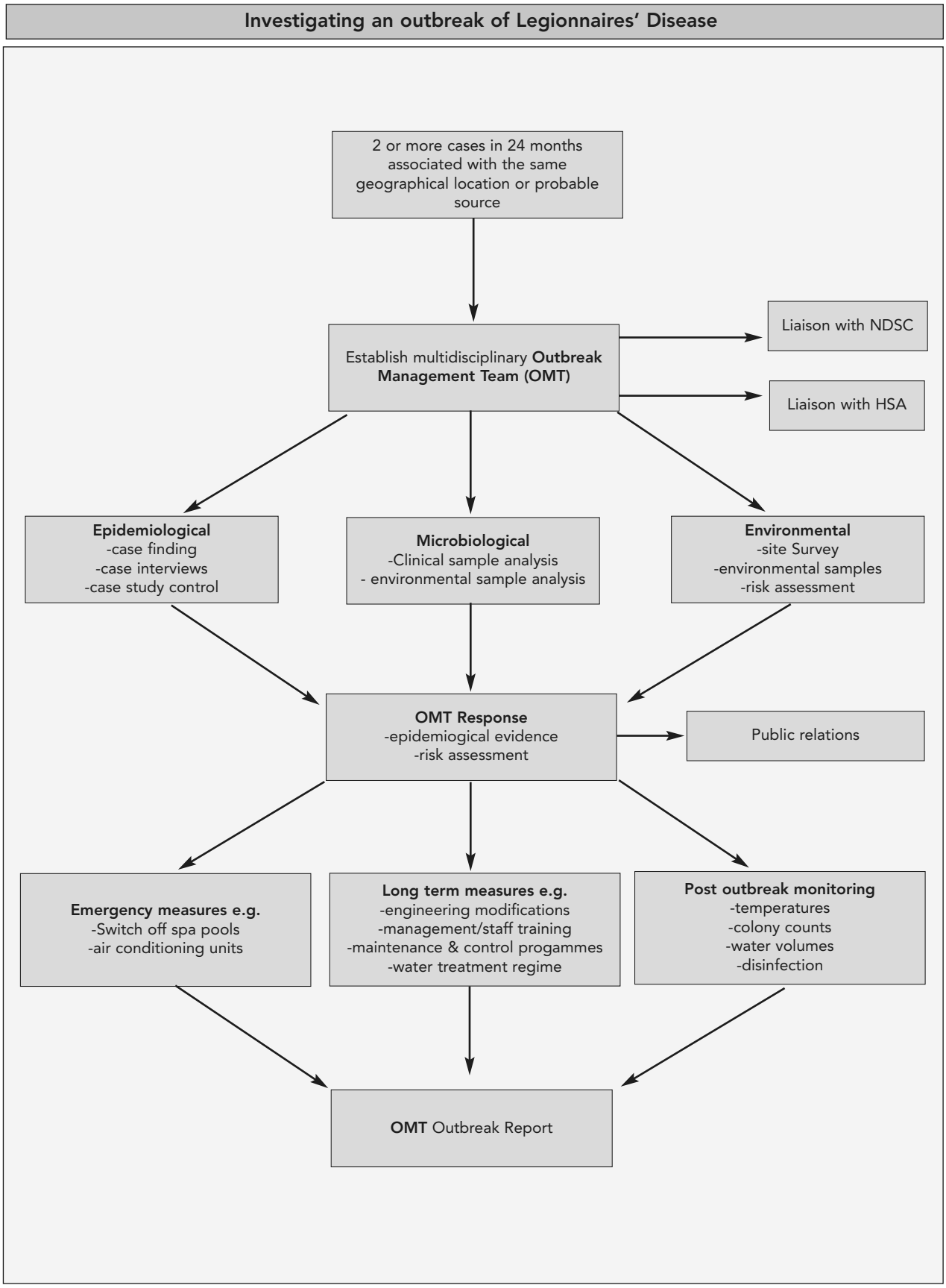
An effective water treatment regime is essential for legionnella control. In addition to controlling legionellae, water treatment must also address the control of general microbial activity, biofilm development, corrosion, scale deposition and the retention of particulate solids. A cooling tower for 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. 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 chlorination

### 3.21 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 (heterothrophs), water volumes, disinfection. Initially sampling frequency may be as high as weekly then this can be gradually reduced to monthly 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.

### 3.22 Proposed Action by Health Boards



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### Useful Documents

- The Control of Legionellae in Health Care Premises: a Code of Practice, Health Technical Memorandum 2040 Dept. of Health UK 1994

- Health & Safety in Residential Care Homes HS(G)104 [HSE UK]

- Health and Safety Commission 2000. Legionnaires' disease; the control of legionella bacteria in water systems. Approved code of practice and guidance

- European Guidelines for Control and Prevention of Travel Associated Legionnaires' Disease (Draft format)

- PHLS Guidance for investigating single cases of legionnaires' disease (Draft format)

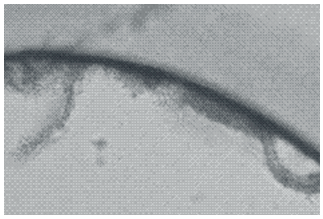
# Dental Unit Water Lines-a risk for Legionnaires' Disease ? A Literature Review

### 4.1 Background:

Dental unit water lines (DUWs) carry water from the water supply to high speed hand-pieces, ultrasonic scalers, air-water syringes and to the dental unit cup-filler. It has been widely reported that microbial contamination is common in dental water lines[1 2 3]. Modern dental hand-pieces normally incorporate an antiretraction valve, which prevents suck-back of oral microbes. Very few studies have shown the presence of oral bacteria in the water lines of dental units equipped with these check valves[3 4]. This supports the view that DUWs are mainly colonised by bacteria derived from incoming mains water and to a lesser extent, from patients mouths[2 3].

More than 25 different species of bacteria have been isolated from DUWs and predominant among these are the environmental gram negative bacteria. However, DUWs may also harbour opportunistic pathogens which are responsible for respiratory disease namely Pseudomonas aeruginosa[2 5], Pseudomonas Burkholderia Pseudomonas cepacia [6], and Legionella pneumophila[7 8]. The priniciple contributing factor is the network of small diameter water lines feeding dental handpieces that are coated with a fine layer of bacteria called a biofilm (See figure 1.)

Figure 1 Biofilm in a dental water line-x65



This biofilm forms naturally on most types of plastic tubing due to the stagnation of contaminated water inside these small flexible tubes. Additionally the tubing is small in diameter so its surface area is large relative to the volume of water that flows through it. The build up rate is faster too because microbes suspended in the water have a shorter distance to fall before contacting the tubing surface. The biofilm can gradually become visible to the naked eye and can eventually partially obstruct the lumen of the water line. Biofilm can be observed in various degrees in all dental units, old and new and even in units that have never been used to treat patients[9]. The water temperature will also contribute to bacterial growth. The water in most dental lines exceeds 20°C. For patient comfort some dental surgeries will heat dental water to around 37° C. This temperature range is ideal for the growth of legionella. It has recently been reported that 83% of samples from DUWs exceeded the American Dental Associations recommendations that no more than 200 cfu/ml of bacteria should be present in waterlines; 95% exceeded European Union drinking water guidelines[10].

### 4.2 Patient Risk

The British Dental Association in their July 2000 fact file state that there is no evidence that any patient has ever caught legionnaires' disease in a dental chair. A nationwide survey performed by the Legionella Reference Laboratory looking at risk factors in notified cases of legionnaires' disease failed to find any association with prior dental treatment[11]. However 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. 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: including being of an older age group (>50 years), male, cigarette smoker, and having a chronic underlying disease with or without an associated immunodeficiency. The risk of acquiring legionella infection is principally related to 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[12]. When a susceptible person inhales a contaminated aerosol consisting of droplets of the right size to reach the alveoli (1 to 5 micron) he or she can develop the disease[13]. The handheld devices that are attached to DUWs are potentially a very efficient means of transmitting bacteria including legionella species from the water to patients.

### 4.3 Occupational Risk

Because of daily exposure, dentists themselves and dental nurses may be at greater risk than patients. Looking for evidence of exposure to legionella in the dental surgery higher titres of legionella antibodies amongst dental personnel than amongst the general population have been reported[14]. There is also a reference to a Californian dentist suspected of dying from legionella dumoffi species acquired from his dental unit water lines. They were found to contain 100,000 cfu/ml while the count in his home water supply was below 100 cfu/ml[15].

### 4.4 Solutions

Recommendations by the Centres for disease Control and Prevention (CDC), Atlanta, aim to reduce the potential risk of patient to patient contamination through dental water lines rather than reduce environmental bacteria within biofilm[16]. CDC recommends:

1. Installing check valves to prevent patient fluids from being sucked back into the handpieces and water lines

2. Flushing water lines and handpieces for a minimum of 20-30 seconds after each patient use

3. Flushing water lines without the handpieces for several minutes at the beginning of each working day

4. Using sterile saline or sterile water as a coolant-irrigator for surgical procedures involving the cutting of bone

While the CDC guidelines may be important in minimising patient to patient contamination they will not lower bacterial counts to safe levels. The American Dental Association[17] has stated: *At the present time, commercially available options for improving dental unit water quality are limited and will involve some additional expense. They include the use of:*

- *Independent water reservoirs*
- *Chemical treatment regimens*
- *Daily draining and air purging regimens*
- *Point-of-use filters*

*Preliminary data suggest that some combination of the above strategies will be necessary to control biofilm formation and to achieve the desired level of water quality. To date, however, there are insufficient data to establish the effectiveness of available methods. Industry and independent researchers should be strongly encouraged to explore as wide a range as possible of alternatives and adjuncts to the above listed options. Dental practitioners should always consult with the manufacturer of their dental units before initiating any waterline treatment protocol.*

The following critical research and development needs were identified by the American Dental Association:

1. Research is needed to define the natural history of biofilms, specifically to more clearly determine the relationship of the numbers and types of microorganisms in the fixed population (sessile) to their free-floating (planktonic) counterparts.

2. Improved, research-based, methods need to be developed to effectively eliminate existing biofilm and prevent or control formation of new biofilm in dental unit waterlines.

3. Alternative devices for monitoring the microbial quality of water used during dental care should be developed that are simple, reliable, and cost-effective.

Ultimately, the only way of ensuring the quality of dental unit water is by regular microbiological monitoring to determine the microbial load and species present. This is also required to ensure the efficacy of disinfection procedures. There is an onus on the manufacturers of dental units to tackle the problem of microbial biofilms and to introduce design modifications, which will discourage biofilm formation and permit more effective disinfection of dental unit water lines.

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## 5.1 Introduction

Even though the vast majority (80%-90%) of legionnaires' disease cases are sporadic, outbreaks of legionnaires' disease will invariably receive a lot of attention. Sources of outbreaks and sporadic cases are similar and include hot water systems in hotels, hospitals, cooling towers and whirlpool baths. There have been well publicised outbreaks in Europe in the last two years, which highlight the potential public health impact of the disease.

By mid July 2001 over 751 cases of suspected legionellosis had been reported in Murcia in northern Spain. Three hundred and ten of these cases had been laboratory confirmed. Two deaths were reported. The preliminary epidemiological investigation identified the most likely source of the outbreak as a cooling tower in the city centre.

Ninety-three cases of legionnaires' disease were identified in an outbreak associated with a trade fair in Kapellen, Belgium in November 1999. There were 5 deaths. Although the source of the epidemic was not proved, there was reason to believe that an aerosol producing device in the tent was responsible. Laboratory testing (PCR) showed that a whirlpool and a fountain were contaminated with legionella.

The Westfriese Flora is a one week flower show held every year in Bovenkarspel, in the north west of the Netherlands, with agricultural and consumer demonstrations on the same grounds. The 1999 show attracted 80,000 visitors from all over the country. Over 180 people who had visited the show developed legionella pneumonia and 21 died. Again a whirlpool spa that was on display was the source of the outbreak.

The experience in Belgium and The Netherlands would suggest that there is a need to examine existing legislation with regard to safeguarding the health of the general public particularly in circumstances where large numbers of people could be exposed to legionella bacteria.

## 5.2 Safety Health and Welfare at Work Act 1989

**Worker health and Safety**: Section 6 of the Safety Health and Welfare at Work Act (SHW 89) requires employers to provide their employees with a safe place of work and maintenance of work equipment. Regarding Non-worker Safety, section 7 of SHW 89 lays down the duty of care of employers to persons who are not their employees but may be affected by the workplace. Section 7 is currently used to ensure building contractors prevent children accessing building sites or when construction work impinges on passing traffic. Section 7 is not used to ensure product or service safety e.g. a patient who suffers from the complications of surgery is not covered.

**Biological Agents Regulations**: SI 146 of 1994 lays down the measures for ensuring worker health and safety when working with biological agents. Legionella is classified as a Group 2 agent (1 is non-pathological and 4 are viral haemorrhagic fevers). This mainly applies to laboratory staff that have a high probability of working directly with pathological biological agents.

**Summary**: Current Health and Safety legislation is sufficient to allow for preventive measures, enforcement action and prosecution of employers who allow their staff to become exposed to legionella. It is not however sufficient to regulate the safety and health of members of the public who may become exposed to spa-pool/jacuzzi aerosol, ornamental fountains, air conditioning systems used in arena's or other public settings. Current Health & Safety legislation is enforced by spot inspections and is not a licensing system, so its use in source tracing is limited.

### 5.3 Infectious Diseases Regulations 1981 (SI No. 390 of 1981)

The principal current regulations are contained in the Infectious Diseases Regulations (SI No. 390 of 1981) as amended by the Infectious Diseases (Amendment) Regulations 1985 (SI No. 268 of 1985), Infectious Diseases (Amendment) Regulations 1988 (SI No. 288 of 1988) and Infectious Diseases (Amendment) Regulations 1996 (SI No. 384 of 1996).

Article 11 of the 1981 regulations state: "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 and for removing conditions favourable to such infection".

Although legal advice has suggested it could be argued that Article 11 is sufficient to take proactive action against a probable source of infection of legionella, the consensus opinion of this subcommittee is that, given the present wording, serious interpretational, operational and enforcement difficulties could arise should a health board wish to take action to regulate the safety and health of members of the public who may become exposed to legionella bacteria via spa-pool/jacuzzi aerosol, ornamental fountains, air conditioning systems used in arena's or other public settings

**Summary**: Legionella specific legislation is by-and-large absent in Ireland. There is an urgent need for the Department of Health and Children, the Department of the Environment and the Department of Enterprise and Employment to consider (a) legislative controls on standards of maintenance and disinfection of vulnerable plant & equipment at high-risk sites and businesses (b) a system of statutory notification by the owner/occupier of high-risk sites (c) the provision of legislative backing to an appropriate statutory authority such as the health board for the monitoring and control of high-risk sites including those instances where there is a recognised public health risk e.g. trade shows with open air fountains/jacuzzis etc.

# **Appendix 1:** UK ACoP and Guidance

The Health and Safety Commission (HSC) in the UK has recently published an Approved Code of Practice (ACoP) and Guidance - *Legionnaires' disease: The control of legionella bacteria in water systems.*

This single publication replaces three earlier UK HSC publications - the 1995 ACoP (L8), the technical guidance (HSG70) and the hot and cold water system supplement to the technical guidance (MISC 150). This document contains the most up to date engineering and technical advice that can provide a practical approach to the effective management and control of legionella.

**Copies of *The Control of legionella bacteria in water systems*:**

Approved Code of Practice and Guidance,
ISBN 0 7176 1772 6,
price £8.00, ref. L8,

are available from

HSE Books,
PO Box 1999,
Sudbury,
Suffolk, CO10 2WA,
tel: 01787-881165 or fax: 01787-313995.

This document can also be ordered online at http://www.hsebooks.co.uk

# Appendix 2: European Working Group on Legionella Infection (EWGLI)

### The surveillance scheme

The European Surveillance Scheme for Travel Associated Legionnaires' Disease 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 PHLS Communicable Disease Surveillance Centre in London and is funded by the European Union Directorate General V.

Currently 45 centres in 33 countries (16 EU, 17 non-EU) collaborate in the surveillance scheme. NDSC is the Irish participant.

### Aims

1. To reduce the incidence of travel associated legionnaires' disease

2. To prevent further cases through enhancing the identification and control of known sources of legionella

3. To provide an early warning system to all collaborators and other public health officials

### Objectives

1. To identify outbreaks or clusters of cases of legionnaires' disease in travellers and to provide a rapid alert to all collaborating countries, WHO and other relevant centres

2. To facilitate international collaborations between epidemiologists and microbiologists to assist in the investigations of any travel associated outbreak

3. To provide information and build on the information on the epidemiology and microbiology of travel associated legionnaires' disease through the establishment of a European surveillance scheme

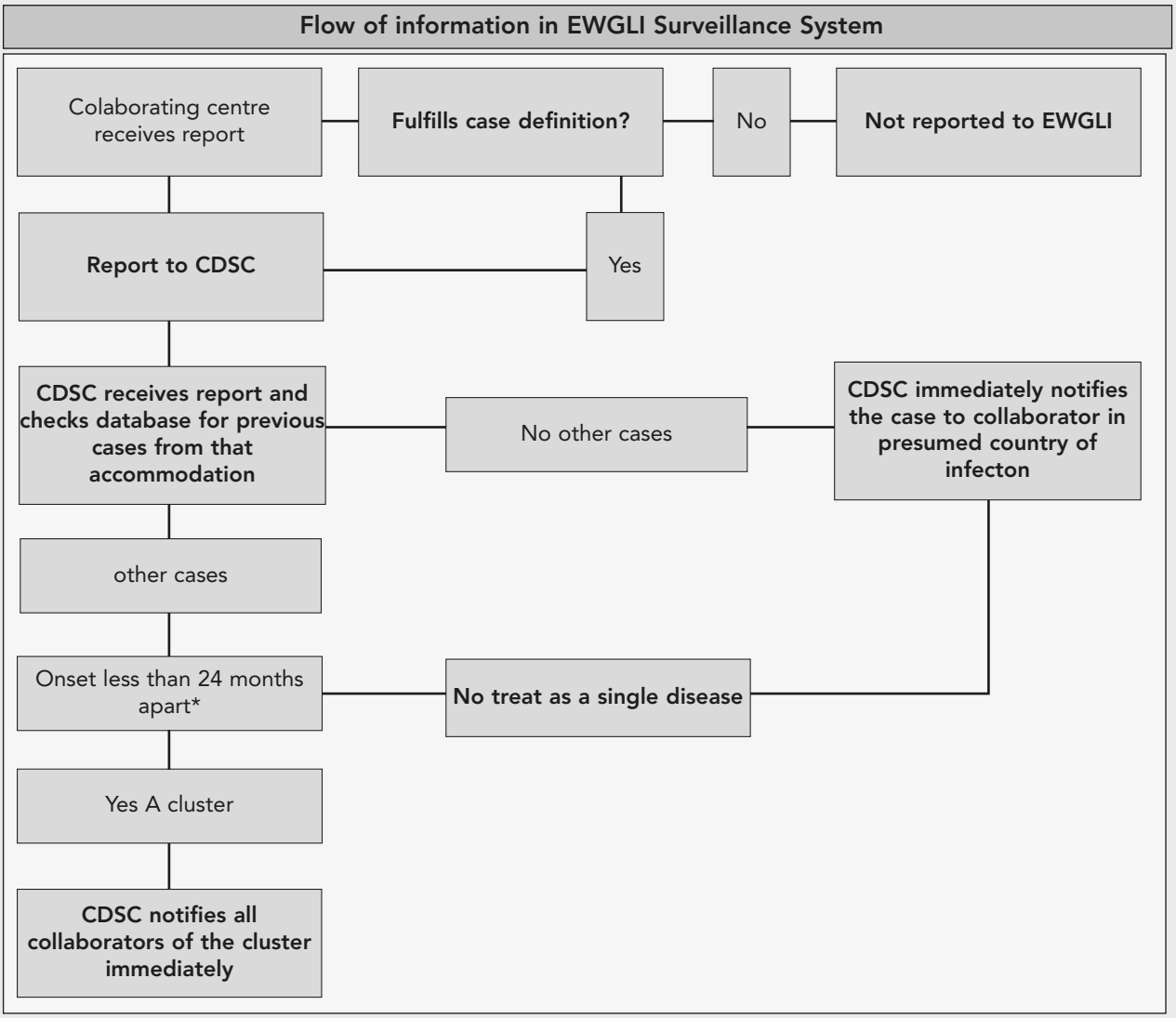
4. To provide regular feedback to all collaborating centres and WHO on all cases of legionnaires' disease held on the European database

5. To develop the communication facilities between centres and enlarge the scheme to include new collaborating centres from non-participating European and other countries

6. To produce a set of European guidelines for the control and prevention of legionnaires' disease with particular reference to travel associated infection

7. To improve the laboratory support to participating EWGLI laboratories in the External Quality Assurance (EQA) scheme for detection of legionella species in water

8. To improve the laboratory support to participating EWGLI laboratories by developing standardised methods and strategies for the identification and typing of legionella species




From 2001, a pilot cluster definition of onset less than 24 months apart is in place. Previously a cluster was defined as onset less than six months apart. Non-cluster cases were defined as 'linked' if other cases were reported at a site with onset more than six months apart. The link definition is no longer used. The pilot definition will be reviewed at the EWGLI meeting in Bilthoven, June 2001

CDSC, Collindale, London is the coordinating centre for EWGLI

# **Appendix 3:** Legionnaires' Disease and Holiday Accommodation

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 infection. At this point samples of water may be taken from the site. If legionella 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.

This 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 can then be informed.

Under the EU Package Travel Directive (1990), since 1996 the surveillance co-ordinator for England and Wales has informed the Association of British Travel Agents (ABTA) and the Federation of Tour Operators (FTO) of any English cases, which are associated with accommodation likely to be used by tour operators. The EWGLI collaborators in some other countries also pass information to their tour operators (Denmark, Netherlands, Sweden). The European Directive was implemented in Ireland with the Package Holidays and Travel Trade Act, 1995 (SI 17 of 1995). NDSC has contacted the Irish Travel Agents Association with a view to discussing the feasibility of establishing a similar reporting mechanism.

# **Appendix 4:** Check List for Implicated Site Visit

| Action | Completed Yes/No | Comment |
|---|---|---|
| **1. Obtain water system plans showing**<br><br>• The incoming water supply (mains or private source)<br>• All tanks / cisterns, expansion / pressure vessels, booster vessels and pumps<br>• Any water softeners or other treatments;<br>• Any calorifiers / water heaters;<br>• The type and nature of materials and fittings (e.g. taps, showers, water closet cisterns, pressure release valves, & pipework) and the kinds of metals, plastics, jointing compounds etc. present;<br>• Cooling towers or heating circuits;<br>• Air conditioning systems or humidifiers within the building which are supplied with, and store, water and which may produce aerosols;<br>• 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**<br><br>• Systems which contain water at temperatures likely to support the growth of legionella<br>• Areas where growth of legionella may be expected to be greatest<br>• Cross-contamination between *dead* and *live* water<br>• Locations at which the potentially contaminated water can be aerosolised<br>• 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**<br><br>• Role and function<br>• Rosters/Training<br>• Recent illness history<br>• Staff absenteeism. | | |

| Action | Completed Yes/No | Comment |
|---|---|---|
| **6. Environmental water sampling**<br><br>• Cooling tower<br>• Hot and cold water systems<br>• Water closet cisterns<br>• Spa pools/Jacuzzis<br>• Decorative fountains<br>• Humidifiers<br>• Air washers<br>• Other (specify)<br><br>**NB** Sampling should be conducted in accordance with ISO 11731 | | |
| **7. Emergency control measures implemented**<br><br>• Hyperchlorination<br>• Shock heating<br>• Cleaning of tanks/heaters<br>• Shut down of non essential equipment | | |
| **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 check-list is a guide. There may be extra issues that require additional attention depending on individual sites & circumstances.**

# Appendix 5: Legionnaires' Disease:-Minimising the Risk Check List for Hotels and Other Accommodation Sites

Legal claims for legionnaires' disease can be a significant cost e.g. a man who became infected in a hotel was recently awarded 21,000 euro compensation. In 2000, nearly 400 cases of legionnaires' disease in European residents were reported to be associated with staying in hotels or other holiday accommodation.

The illness is often fatal and the publicity attracted by such cases can severely harm the hotel business. 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, while10 to 20 % of cases can be linked to outbreaks. Any clients 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 clients have returned home.

**3. How is legionnaires' disease contracted?**
Breathing in air containing the legionella bacteria in an invisible aerosol. 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/jacuzzi. 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.

The legionella bacteria do not appear to multiply below 20°C and do not survive 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 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 pipe 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 hotel that does not have an active programme to control the growth of legionella bacteria is negligent in ensuring the safety of their guests. This programme should include the following:

- Have one named person responsible for legionella control.
- Ensure the named person is trained in control of legionella and other staff are trained to be aware of the importance of their role in controlling legionella

- Keep hot water hot and circulating at all times: 50°C - 60°C ( ie. greater than or equal to 60°C in calorifiers and not less than 50°C at the outlets) It should be too hot to put hands into/under for more than a few seconds (warning signs can be used next to taps and showers). Blending or mixing valves at or near taps and showers may be used to reduce the water temperature to greater than or equal to 43°C with a view to reducing scalding risk. These need to be placed as close to the point of use as possible.

- Keep cold water cold at all times. It should be maintained at temperatures below 20°C. This may involve insulating any segments that are exposed to external heat sources.

- Run all taps and showers in guest rooms for several minutes at least once a week if they are unoccupied and always prior to occupation.

- Keep shower heads and taps clean and free from scale. The water distribution system should be cleaned regularly to remove sludge and other deposits that afford protection to the legionella bacteria. Other controls, whether temperature or biocide based, may not work effectively in the presence of slime and/or 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 every season

- Clean and disinfect all water filters regularly - every one to three months

- Inspect water storage tanks, cooling towers and visible pipe work monthly. Ensure that all coverings are intact and firmly in place

- Inspect the inside of 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 system modifications or new installations do not create pipework with intermittent or no water flow. Both "dead legs" and "capped spurs" within the plumbing system provide areas of stagnation and cooling and these segments need to be removed to prevent colonization. Replacement of rubber fittings within the plumbing system may be required to eradicate Legionella.

- If there is a spa pool (also known as whirlpool spas, Jacuzzis, spa baths) ensure
    - It is continuously treated with 2-3mg/l chlorine or 4-6mg/l bromine and the levels are monitored at least three times a day
    - replace at least half of the water each day
    - backwash sand filters daily
    - clean and disinfect whole system once a week

- keep daily records of all water treatments and readings such as temperature and chlorine concentrations and ensure they are checked regularly by the manager.

- **Further advice about specific controls should be sought from experts in this field who are competent to carry out a full risk assessment of the hotel site.**

### 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 chosing a system and it is important to remember that no system will work if not maintained and checked regularly.

### 9. Further information

These guidelines are not intended to be a comprehensive engineering text and readers are advised to consult further publications such as:

1. The Management of Legionnaires' Disease in Ireland – document issued by the National Disease Surveillance Centre (N.D.S.C.); www.ndsc.ie

2. Approved Code of Practice and Guidance (AcoP) – Legionnaires' disease: Control of legionella bacteria in water systems. Published by the Health and Safety Commission (HSC) in the UK in 2000; Tel. 01787 881165 (ISBN 0 7176 1772 6) www.hsebooks.co.uk

3. Technical Memorandum TM13 (Minimising the Risk of Legionnaires' disease) 2000 edition by the Chartered Institute of Building Service Engineers UK; www.cibse.org

4. European Guidelines for Control and Prevention of Travel Associated Legionnaires' Disease – draft document issued by the European Working Group for Legionella Infections (E.W.G.L.I.) www.ewgli.org