

Chapter 9: Investigation of Legionellosis Cases

9.1 Introduction

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

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

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

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

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

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

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

Confirm the diagnosis

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

Report the case

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

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

Identify potential sources of infection

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

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

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

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

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

Is the patient aware of anyone else with legionnaires' disease, now or in the past?

If yes, give details _____

Is the patient aware of anyone with similar symptoms to themselves?

If yes, give details _____

Based on the HSE South Eastern area checklists

Search for link with other cases

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

Investigate possible sources of infection

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

9.2.1 Community-acquired case – single case

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

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

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

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

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

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

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

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

Domestic premises

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

9.2.2 Travel-associated cases

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

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

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

Checklist 6. Implicated site visit

Action	Completed (yes/no)	Comment
<p>1. Obtain water system plans showing</p> <ul style="list-style-type: none"> • The incoming water supply (mains or private source) • All tanks/cisterns, expansion/pressure vessels, booster vessels and pumps • Any water softeners or other treatments • Any calorifiers/water heaters • The type and nature of materials and fittings (e.g. taps, showers, water closet cisterns, pressure release valves, and pipework) and the kinds of metals, plastics, jointing compounds, etc. present • Cooling towers or heating circuits • Air conditioning systems or humidifiers within the building which are supplied with, and store water and which may produce aerosols • Any other equipment that contains water and could be a potential risk such as spa pools, humidified display cabinets, machine tools, fountains, etc. 		
<p>2. Identify all systems using water</p> <ul style="list-style-type: none"> • Systems which contain water at temperatures likely to support the growth of legionellae • Areas where growth of legionellae may be expected to be greatest • Cross-contamination between free-flowing and stagnant water • Locations at which the potentially contaminated water can be aerosolised • Locations where the aerosol might be released into the environment 		
<p>3. Examine inspection and maintenance protocols</p>		
<p>4. Examine logbooks recording water system maintenance and treatment</p>		
<p>5. Interview management and staff involved in maintenance programmes</p> <ul style="list-style-type: none"> • Role and function • Rosters/training • Recent illness history • Staff absenteeism 		
<p>6. Environmental water sampling</p> <ul style="list-style-type: none"> • Cooling tower • Hot and cold water systems • Water closet cisterns • Spa pools • Decorative fountains • Humidifiers • Air washers • Other (specify) <p>NB. Sampling should be conducted in accordance with ISO 11731-2:2004</p>		

7. Emergency control measures implemented <ul style="list-style-type: none"> •Hyperchlorination •Shock heating •Cleaning of tanks/heaters •Shut down of non-essential equipment •Exclusion of persons from areas of risk •Closure of high-risk items 		
8. Selection of long-term remedial measures in consultation with on-site staff		
9. Establish in consultation with on-site staff protocol for "post outbreak" routine monitoring		

Form completed by:

Date:

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

Source: European Working Group for Legionella Infection (EWGLI)

9.2.3 Nosocomial infection

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

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

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

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

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

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

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

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

9.2.4 Summary

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

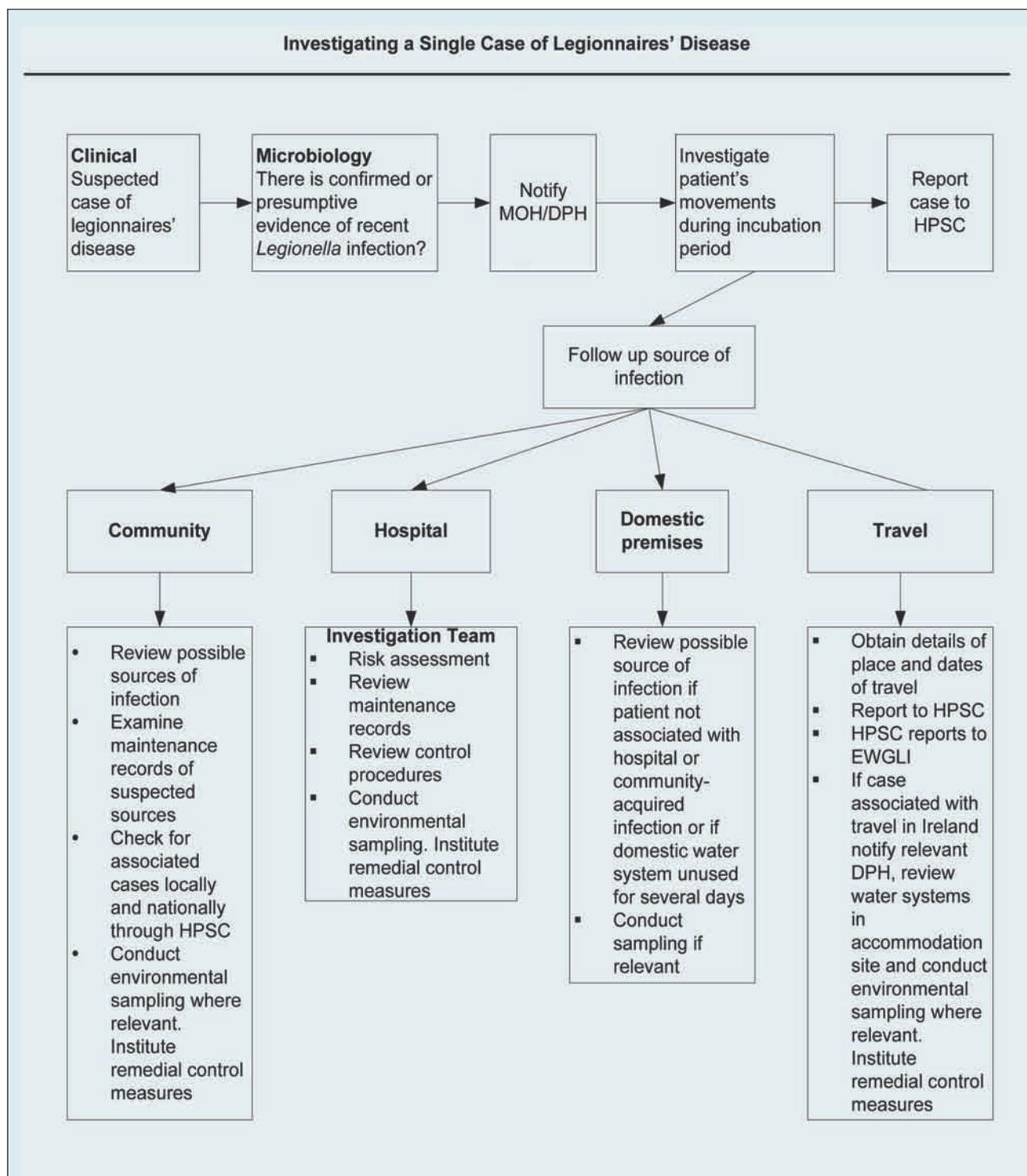


Figure 10. Investigation of a single case of legionnaires' disease¹⁶⁶

9.3 Investigating an outbreak of legionnaires' disease

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

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

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

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

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

9.3.1 Epidemiological investigation

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

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

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

9.3.2 Microbiological investigation

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

9.3.3 Environmental investigation

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

9.3.4 Public relations

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

9.3.5 Overview of the activities of the OCT

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

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

9.3.6 Investigation of sources

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

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

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

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

9.3.7 Site survey

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

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

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

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

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

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

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

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

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

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

9.4 Emergency control measures

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

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

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

9.4.1 Thermal disinfection

Hot water systems

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

It is important to emphasise that for effective thermal disinfection:

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

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

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

9.4.2 Chemical disinfection

Cold water systems

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

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

Cooling towers

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

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

NOTE

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

9.5 Outbreak report

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

9.6 Post-outbreak routine monitoring

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

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

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

Investigating an Outbreak of Legionnaires' Disease

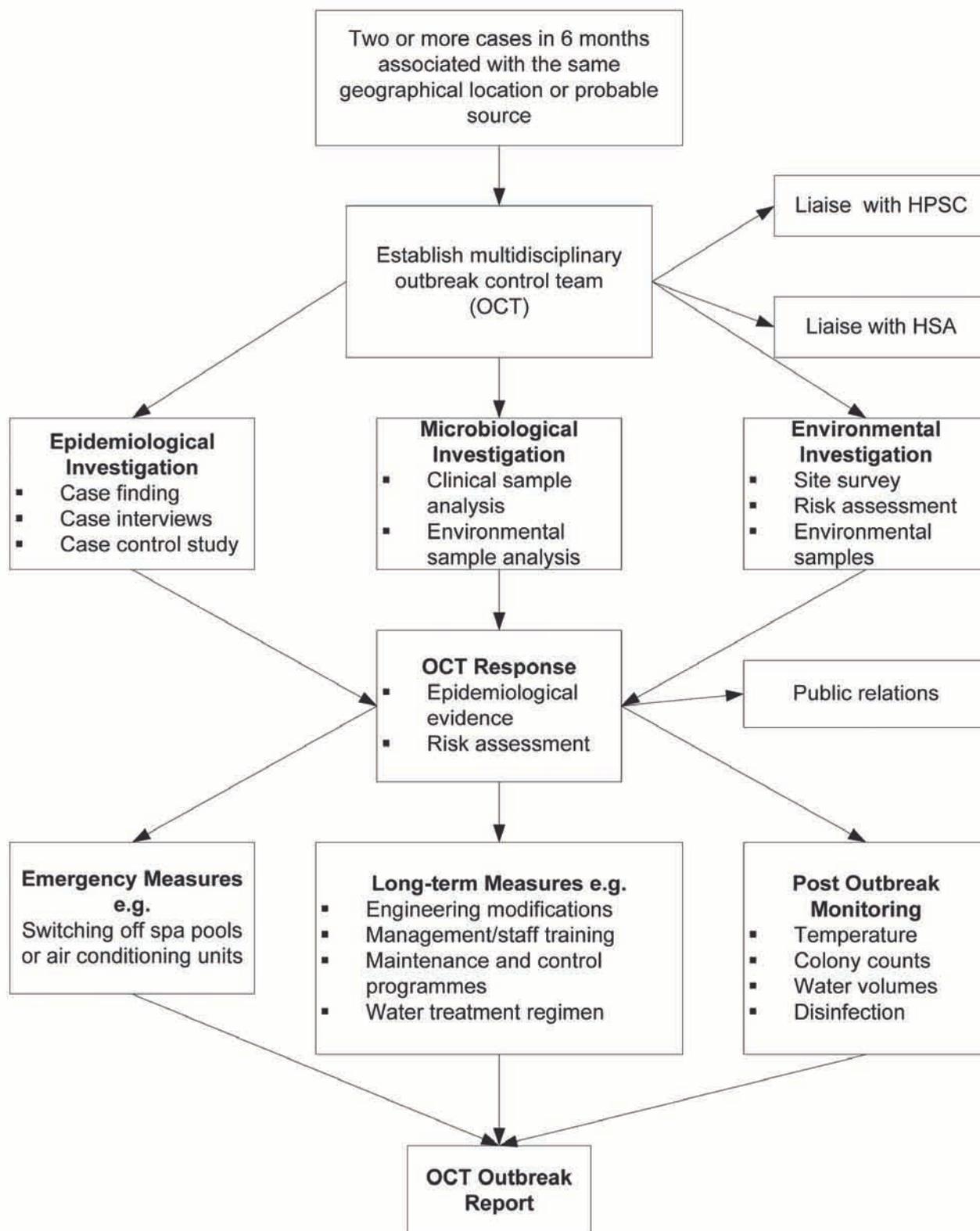


Figure 11. Investigating an outbreak of legionnaires' disease