Memorandum/Mémorandums

Epidemiology, prevention and control of legionellosis: Memorandum from a WHO meeting*

This Memorandum describes the following aspects of legionellosis: clinical presentations of legionella infection, general epidemiology (including nosocomial outbreaks and travel-associated legionnaires' disease), surveillance and reporting of cases, the organism and its environment, and measures for prevention and control. These topics were discussed by experts at a meeting in Geneva on 27–29 November 1989. This article also includes their conclusions and recommendations for research in critical areas including surveillance and preventive activities that have been found to be effective.

Legionella infection appears in two principal forms: legionella pneumonia (legionnaires' disease) and non-pneumonic legionellosis such as in Pontiac fever. The conditions that lead to one or other of these outcomes after exposure to legionella are not clear. However, many aspects of the biology of legionella and the epidemiology, prevention and control of legionellosis have been presented and discussed in two earlier WHO publications (*1*, *2*).

Clinical presentation

The clinical presentations range from asymptomatic infections with identifiable seroconversion to rapidly progressive pneumonias characteristic of legionnaires' disease. Pneumonic legionellosis is usually caused by *Legionella pneumophila*, *L. micdadei*, and *L. boremanii*; other species have been implicated much less frequently.

The highest incidence is in people aged over 40 years. Men are more frequently found to have the disease than women. Infection in children is rare. Groups at increased risk include smokers, alcoholics and people who are immunosuppressed owing to illness or treatment.

Legionella pneumonia has no special features that distinguish it from other pneumonias. The incubation period is usually 2–10 days although periods as long as three weeks have been reported in immunosuppressed individuals. The infection is marked by high fever, headache and myalgia. About a third of patients develop diarrhoea or vomiting and about half become confused or delirious. Hospital admission becomes necessary 3–6 days after onset of the disease which can be serious; a fatality rate of 12% is not unusual.

Legionella infection in the non-pneumonic form is called Pontiac fever, which is characterized by a high attack rate (up to 95%) among previously healthy people, has an incubation period of 4–60 hours (usually 36–48 hours), and presents as an acute, short-lived self-limiting illness with high fever. There is no radiographic evidence of changes in the lung. Clinical diagnosis is usually retrospective and treatment is symptomatic.

Little is known about the bacterial toxins of legionella compared with other intracellular parasites. The agent is characterized by low endotoxic activity which is related to structural peculiarities of its lipopolysaccharide. Legionella strains produce metalloproteinase (cytolysine or major secretory protein) which induces haemorrhagic pneumonia and histopathological changes in the lungs of guinea-pigs, like those characteristic of legionnaires' disease (*3*).

A protein of M_r (relative molecular mass) 24 000

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in the outer membrane of legionella is associated with increased infectivity in macrophages. Further studies of these mechanisms may prove fruitful in understanding the pathogenesis of legionellosis.

Legionella infection may be contracted from a variety of environmental sources (see below) but there is no convincing evidence of person-to-person spread. Inhalation is generally believed to be the route of entry.

General epidemiology

Prevalence and incidence

The morbidity and mortality due to legionellosis tend to be underreported in terms of both sporadic and epidemic cases in most health statistics. Most countries still do not have an active disease-oriented surveillance system for the disease. Existing data do not permit confident estimates of the total incidence rates in populations.

The incidence of non-pneumonic legionellosis with a short incubation period (Pontiac fever) in the general population is totally unknown. Although attack rates in outbreaks of Pontiac fever have been reported to be as high as 95% of the exposed population, reports of sporadic cases are unlikely to be made even if they are recognized.

Attack rates in outbreaks of legionnaires' disease have been reported as high as 30% of the exposed population in high-risk categories. Among the general public in the USA, sporadic cases have been reported at annual rates of 0.2 per 100 000 population under passive surveillance (*4*) and 12 per 100 000 under more active surveillance (*5*).

The frequency of sporadic cases can also be estimated as a fraction of all community-acquired pneumonias. In such a study in the United Kingdom, using 25 hospitals over a one-year period, 2% of all hospitalized pneumonias were found to be cases of legionnaires' disease (*6*). In France (*7*) and the Federal Republic of Germany (*8*) it was found that up to 10% of community-acquired pneumonias were due to legionella.

Nosocomial outbreaks

In hospitals there are not only the likely sources of legionella but also populations of very susceptible persons who are at high risk of acquiring the infection. Predictably, both the attack rate and the mortality are high in the exposed susceptible patient population.

The water (mainly hot water) systems in hospitals are the usual source of infection; these systems are often complex, especially in hospital buildings that have been enlarged or modified. The site of spread of legionella can be the water outlets such as taps, showers and baths, or cooling towers that serve air-conditioning systems in hospitals and other buildings.

Hospital patients may be immunosuppressed owing to illness (cancer), age, or treatment (radiation therapy, anticancer drugs and immunosuppressive drugs). Preventive measures against legionella contamination are especially needed in areas where the patients might be susceptible individuals.

Case fatality rates of legionnaires' disease are higher for nosocomial cases than for community-acquired cases, and lie in the range 30–50% according to some reports. Early diagnosis of legionellosis is especially important in nosocomial cases so that the most effective treatment can be instituted as early as possible.

Travel-associated cases

Travel-associated legionnaires' disease, both sporadic and epidemic, has been reported from many countries in all continents. A high proportion of the reported cases each year has been associated with tourists from countries like Sweden (10–30%) and England and Wales (29–59%). During the period 1982–88, 562 cases in travellers were reported from England and Wales, 499 (89%) following visits abroad and the rest associated with travel in the United Kingdom; 67 of these cases, most of whom were previously fit and healthy, died from legionnaires' disease contracted while travelling, mostly on holiday. There is likely to be considerable under-detection and perhaps under-reporting of this disease, so that the true extent of travel-associated legionellosis is unclear.

Although most cases of legionnaires' disease in travellers appear to be sporadic, there have been many outbreaks in this group, particularly due to contaminated water systems in hotels. The publicity surrounding a number of these outbreaks has been harmful to tourism with adverse effects on local economies. Clusters of cases in association with hotels, particularly those in holiday resorts, occur every year. The national surveillance scheme in England, operated by the Communicable Diseases Surveillance Centre, Colindale, identified 67 clusters of two or more cases comprising 214 people, linked to specific hotels during the period 1979–88. Sixty-three of the clusters, comprising 182 people, were associated with hotels abroad and four clusters, involving 32 people, with hotels in the United Kingdom. Clusters from self-catering apartment hotels and cruise liners were also identified.

Several countries in Europe now routinely report any travel-associated cases of legionnaires' disease to the apparent source country. The extent to which source countries initiate investigations, or control measures, on receipt of this information, is unclear and

it is disappointing that a number of hotels in several countries have been associated with cases over many years. Reports of a cluster of cases associated with any hotel or other building should always be an indication to initiate an investigation to attempt to find the source of infection.

Surveillance and reporting

Active surveillance

Routine surveillance data on infectious diseases may be obtained through provider-initiated reports (passive surveillance) or health-department-solicited reports (active surveillance) (*9*). Most of the countries that conduct surveillance of legionnaires' disease use either a laboratory reporting system or notifications by clinicians. In general, neither of these passive surveillance methods provides sufficient information with which to identify clusters of cases associated with a particular hotel or other premises. For this purpose it is usually necessary to collect supplementary information. In England and Wales, the passive surveillance system based on reports from laboratories triggers an active surveillance system. When a laboratory report of a case of legionnaires' disease is received at the national Communicable Diseases Surveillance Centre, it sends a short questionnaire to the patient's clinician or clinical microbiologist. Information is sought on the patient's place of work and any hospitals, hotels or other accommodation visited during the two weeks before onset. Many common-source outbreaks have been detected by this means, both from sources in the United Kingdom and abroad (*10, 11*)

International reporting

The early detection of outbreaks associated with hotels, self-catering accommodation blocks, conference centres, and cruise liners will be greatly improved through international reporting. People involved in such incidents often show the first signs of disease only after they have returned to their own homes. For this reason, cases may be reported from many countries. The collection of data on such cases at a central point will allow the early detection of the outbreak and facilitate the rapid application of control measures

At present, a number of countries routinely report travel-associated cases to the suspected source country, and in Europe a few also report simultaneously to the WHO Collaborating Centre in Stockholm. The extension of this voluntary scheme in Europe, and the establishment of similar schemes in other regions, where appropriate, should be encouraged. The protection of the travelling public will be enhanced further by instituting a formal international reporting system.

Case definition

There is no clinical symptom or sign, or any combination of symptoms that is specific for legionnaires' disease. The diagnosis of legionellosis must therefore be confirmed by specific laboratory tests. Pneumonia connected with epidemiological information, e.g., recent travelling, hospitalization and immunosuppression, should raise the suspicion of legionnaires' disease at an early stage.

Validated diagnostic methods

Correct diagnosis is necessary for the effective recognition, treatment and study of legionnaires' disease. As laboratory test criteria are a part of the case definition, these methods require special attention.

The sensitivity of culture from respiratory specimens was greatly enhanced when the buffered charcoal yeast extract agar (BCYE) with α-ketoglutarate was described (*12*), which can also be used as a semi-selective medium by the addition of cefamandole, polymyxin B and anisomycin (BMPA) (*13*). When there is a heavy load of concomitant microorganisms, pre-treatment of the specimen by acid or heat may be necessary. Details of culture procedures can be found in laboratory manuals and textbooks on legionella.

It is essential in epidemiological investigations to have access to isolates from patients in order to be able to establish identity with environmental isolates. Patient management may also benefit when the diagnosis is verified by culture and the antibiotic sensitivity of the strain can be determined and unnecessary antibiotic treatment terminated.

The following specimens are suitable for culture: transtracheal aspirate, bronchial lavage, pleural exudate and lung tissue. Sputum, if from the lower respiratory tract, can also be cultured. Blood culture, also in special media, may be tried but the experience is still rather limited.

Serology is still the most widely used diagnostic test, especially the indirect fluorescent antibody test (IFA/IFAT) which has so far been validated only for *L. pneumophila* serogroup 1 (*14*). Micro-agglutination, a test that can more easily be adopted by local laboratories, has recently been validated. Seroconversion (a fourfold or greater rise in antibody titre) is the criterion for a serologic diagnosis. A standing titre, at a cut-off level that has to be determined by local evaluations, leads to a presumptive diagnosis of legionellosis.

Detection of antibodies to legionella species and serogroups other than *L. pneumophila* serogroup 1 needs further validation before any interpretation criteria can be decided upon. Until then, seroconversion specific to legionella species is only suggestive of legionellosis, and cases diagnosed on such grounds

should not be reported in international notification systems.

Antigen detection in clinical specimens by direct fluorescent antibody staining (DFA) and enzyme-immunoassays (EIA) on urine are useful for the clinical management but need further evaluation before diagnoses obtained by these methods can be included in an international surveillance system. DNA technology is being studied for the diagnosis of legionellosis but these methods need further development before they can be useful clinically.

In order to improve the early recognition of legionellosis for the purpose of proper patient management and improved surveillance, a rapid and inexpensive test for use at the local level, including primary health level, is needed. Such a test needs to be carefully validated.

The organism and its environment

Bacteria of the family Legionellaceae can be found in both natural and man-made environments. Only a handful of studies have examined natural aquatic habitats for the presence of these bacteria. On the other hand, numerous investigations on the presence of legionella in artificial environments have been made. These man-made environments are thought to act either as amplifiers or disseminators of legionella and are thus of great importance in understanding the epidemiology of legionnaires' disease.

Natural environments

The first report of the isolation of *L. pneumophila* from a natural environment was made by Morris et al. (*15*). Following an outbreak in Bloomington, Indiana (*16*), these authors reported the isolation of *L. pneumophila* from water or soil from a nearby river. In 1979, Fliermans et al. (*17*) reported the indication by DFA and isolation of *L. pneumophila* from aquatic environments that were not related to any outbreak. Subsequent to these initial studies, members of the Legionellaceae family were isolated from different areas in the world (*18–21*). These bacteria have also been recovered in abundance in Puerto Rico in marine and fresh waters (*22, 23*). In the latter study Legionellaceae were also recovered from epiphytes in trees at over nine metres above ground. Finally, these bacteria have been found in large numbers in hot spring waters used in hydrotherapy (*24*).

These different studies reported from all over the world clearly suggest that the distribution of Legionellaceae is worldwide and that the concentration of these bacteria is directly related to the water temperature (*25, 26*). It has also been shown that viable but non-culturable forms of legionella can occur in water systems (*27*) and that they can be recovered (made culturable) by heat shock (*28*). This relationship with temperature may explain why Legionellaceae have survived and been recovered in cold climates where the ice cover over rivers may be for as long as six months.

Legionella have been reported to grow in association with other microorganisms (*29*) and to infect a variety of free-living amoebae and ciliates (*30*). It is inevitable that legionella will enter and colonize man-made water systems. Aquatic bacteria may enter during water treatment or during repair and construction activities (*31*). Legionella are only one member of a diverse population of microorganisms that can colonize man-made water systems. This growth forms into biofilms or slime layers on the surface of pipes and tanks in contact with the water (*32*).

Man-made environment

It is now recognized that legionella have colonized the water systems in man-made environments even in the absence of disease. They are commonly found in hot water tanks and cooling towers, both domestic and industrial. This colonization has also been shown to be related, among other factors, to the water temperature which appears to be the most important determinant in the isolation of legionella in these environments (*33*). Other factors that have been shown to be of importance are stagnation, obstruction, and the presence of other microorganisms and of biodegradable materials (*34*).

Other man-made environments that have been shown to be colonized by legionella are cold water systems, ornamental fountains and process waters. The exact importance of colonization by legionella in these settings as it relates to the occurrence of disease is largely unknown. The evidence linking water supplies with legionnaires' disease is less well established for non-pneumophila legionella than for *L. pneumophila*, with a few exceptions (*35, 36*).

The survival and stability of legionella in an aerosol depends on several factors related to the bacteria:

— metabolic activity (*in vitro*, legionella with a weak metabolic activity, i.e., during a stationary phase of culture, are more stable);
— repeated subculture (these bacteria have a lower survival rate);
— virulence of the strain is an important survival factor in aerosols (*37*) (*L. pneumophila* serogroup 1 and the Pontiac subgroup known to be associated with clinical legionellosis have better survival rates in the aerosols).

It was reported that the survival of legionella in

aerosols was a function of the relative humidity: survival rose from 3 minutes to 15 minutes when the relative humidity was raised from 30% to 80% (*38*).

Isolation procedures and sampling scheme

The initial studies that examined water samples for the presence of Legionellaceae relied heavily on animal inoculation (guinea pig) for their isolation (*17*).

Negative enrichment procedures were proposed but the development of semi-selective media made the latter procedure obsolete. It was demonstrated that direct plating of water samples on semi-selective media was the method of choice for the isolation of *L. pneumophila* from water samples (*39*). The semi-selective media were described by Edelstein et al. and Wadowsky and Yee in 1981 (*13, 33*). Both these media were based on charcoal yeast extract medium proposed by Feeley et al. (*40*) and subsequently improved by Pasculle et al. (*12*).

It is generally believed that although these media are adequate for the isolation of *L. pneumophila* their ability to support the growth of non-pneumophila legionella is less than optimal. Additional media for these bacteria as well as rapid diagnostic methods for environmental samples are badly needed.

Prevention and control

Susceptible populations and implicated sources

Legionnaires' disease is a widespread, life-threatening and often unrecognized infection which may present explosive outbreaks, the main predisposing factors being age of >50 years, males, immunosuppression, cigarette smoking, and alcohol consumption. Nosocomial spread is well documented (*41*), but sporadic and outbreak cases also occur in apparently healthy people of all ages. Treatment with erythromycin is associated with a lower case fatality rate, but mortality remains high in immunocompromised patients even with normally appropriate treatment.

Several sources of legionella-contaminated water have been documented to lead to cases of legionellosis, such as:

- cooling towers and evaporative condensers;
- hot water supplies in hospitals, hotels and other institutional buildings;
- personal respiratory therapy equipment;
- free-standing room humidifiers in hospitals;
- industrial cutting oil/water emulsions;
- communally used whirlpools, spas, and naturally warm water spas in leisure and rehabilitation centres;
- enclosed industrial settings with water-spray systems (e.g., mines, textile factories);
- water treatment devices (e.g., water softeners) serving cooling towers;
- biologically fouled systems (e.g., steam turbine condenser, cooling towers) subjected to high pressure cleaning.

Many other water systems and sources have been found to contain legionella from time to time, but their role in causing disease has not been adequately documented. Factors that determine whether an outbreak is legionnaires' disease or Pontiac fever have not been defined.

Control of outbreaks

Outbreaks of legionellosis have provided opportunities for the study and evaluation of control measures. The latter, when effective, decreases the prevalence of legionella in the watery environment, prevents the dispersion of legionella in aerosols, and limits the exposure of susceptible humans to contaminated aerosols. Antimicrobial prophylaxis of exposed persons has not been shown to be effective.

Outbreaks, where the organism was in the hot water supplies, have been controlled by the following measures (*42, 43*):

- raising the stored hot water temperature to 60°C;
- ensuring the hot water is kept at $\geqslant 50$°C up to every point of use;
- as an alternative to raising the hot water temperature, chlorinating at 2–3 mg of free residual chlorine per litre up to every point of use;
- avoiding sudden disturbance or changes in the mode of operation (e.g., standby equipment on line, new services or sources, pump failures).

In outbreaks, where the source of the organism was a cooling tower, evaporative condenser or other industrial recirculating water system, the following control measures have been followed by the cessation of cases (*42, 44*):

- stopping use of the plant or equipment;
- draining, cleaning (including use of biodispersants to remove biological material from surfaces) and disinfecting;
- fitting effective drift eliminators, repairing defects or resiting the plant or equipment;
- resuming use of the equipment with regular maintenance (periodic cleaning, continuous control of the water's condition through adequate bleed-off of foul water and addition of clean fresh water, scale and corrosion control, and biocide additions);

— draining the water when the equipment is not in regular use.

In instances of nosocomial infections traced to aerosol-generating equipment in patients' rooms (*45*) the following control measures have been followed by cessation of further cases:

— the use of only sterile water in personal respiratory therapy equipment;
— the single use of sterile disposable equipment or, if the equipment is reused, its sterilization or proper cleaning and disinfection between uses;
— substitution of steam humidifiers for equipment that provides humidification by the aerosolization of unsterile water.

In instances of legionellosis associated with whirlpool or natural warm water spas, the following control measures have been followed by the cessation of cases (*42, 46, 47*):

— stopping use of equipment;
— draining, cleaning (to remove slime and detritus) and disinfecting;
— reusing whirlpools with continuous disinfection;
— regularly removing the shower-heads and inhalation equipment for treatment with heat or chlorine.

Following an outbreak (from whatever source) and implementation of control measures, active surveillance of the disease in the exposed population is needed to demonstrate that the outbreak has ceased. In several instances, further cases have been traced to identified sources over a period of years, often as a result of failure to implement control measures or their discontinuation or interruption (*42*). The occurrence of such cases demonstrates the need for disease surveillance, monitoring of water quality (including microbiological content), and maintenance procedures.

Preventive strategies

Strategies for prevention of legionellosis, in the absence of known clusters of the disease, are based largely on the experience from outbreak investigations. The long-term efficacy and cost-effectiveness of these measures in routine maintenance have not been determined but extrapolations from what is known may be useful.

For the efficient operation of cooling towers and evaporative condensers as heat exchangers, one has to maintain regimens that are effective at keeping the surfaces clean. Well-managed systems indeed are less frequently colonized with legionella although the dosing of water with biocides alone (without regular drainage and cleaning) does not limit the organism's growth (*48*).

Although routine maintenance procedures for water systems may not prevent legionellosis, the following measures have been shown to reduce the prevalence of legionella in water systems (*49–52*):

— maintaining the hot water at $> 50°C$ up to the point of use;
— limiting thermal stratification within the central hot water storage equipment;
— removing obstructions to flow or conditions where static water can be drawn into flowing water (e.g., filters, strainers, bypasses without isolating valves);
— not using standby equipment (unless kept empty) or alternative untreated water sources;
— instituting adequate management control and maintenance regimens for recirculating the water systems (e.g., whirlpools, cooling waters).

Health education should help reduce the number of persons at high risk of legionellosis because of cigarette smoking, alcohol use, and excessive immunosuppressive medication.

No vaccine has been shown to be effective against legionella. The role of immune modulators and legionella antigens in human legionellosis is being evaluated by the Gamaleya Institute of Epidemiology and Microbiology, Moscow.

Organization and management

Legionellosis presents challenges in organization and management because of the multidisciplinary chain of causation, the wide range of cases from unrecognized to prominent outbreaks, and the constant risk of water systems as sources of the disease.

To be effective, control measures must be consistently and continuously applied, which may require implementation and monitoring by a designated and trained person. A notice on the water system machinery (e.g., "Regular cleaning necessary to prevent microbial growth") might serve as a useful reminder.

Systematic multidisciplinary investigation of legionellosis should reveal the cause of the outbreaks by differentiating between exposures or activities that lead to infection and those that do not (*44*). Well documented protocols for environmental sampling are useful (*53, 54*).

Legal controls enforcing water system management by the owners and reporting of the disease are practised or proposed in several countries (*55*). Reporting of disease has led to identification and control of outbreaks, but legal or structured controls of water system design, operation or maintenance have so far not been shown to prevent the disease.

Conclusions and recommendations

1. The morbidity and mortality due to legionellosis tend to be underreported in terms of both epidemic and sporadic cases in most health statistics; many countries still do not have an active disease-oriented surveillance system for legionellosis. The contribution of legionnaires' disease in the causation of respiratory diseases in non-industrialized countries is essentially unknown.
2. The association between a case and a water source of legionella has often been demonstrated, but the precise mode of spread from the water source is much less understood; inhalation is generally believed to be the route of entry. Person-to-person spread has not been convincingly demonstrated.
3. There is a need to improve surveillance to recognize sporadic and epidemic legionella infection. Adequate recognition of an outbreak of legionellosis requires active disease-oriented surveillance and the commitment to a rapid response.
4. Since travel is an important risk factor, effective international surveillance is essential to identify and control the point sources of infection. International surveillance is limited at present by regional and national differences in case definition, reporting and availability of suitable diagnostic techniques.
5. To protect the travelling public, international reporting to collaborating centres should be encouraged and implemented; a formal international reporting system would enhance this protection. For international reporting purposes a standard case definition is needed Such a definition is proposed in the Annex. The collaborating centre will be responsible for analysing the data and identifying and reporting clusters associated with specific hotels or other locations. Such reports should be generated with sufficient speed so that the specific source can be identified and control measures applied.
6. The development of validated, rapid and inexpensive diagnostic tests for the diagnosis of legionnaires' disease should be strongly encouraged. Culturing of the organism continues to be recommended because it is essential for epidemiological purposes, and it may be helpful in the treatment of the patient.
7. Standardization and validation of currently used diagnostic methods should be encouraged through international collaboration, as should the establishment of reference panels of reagents.
8. Specific means of identifying strains and subtypes of legionella such as DNA-fingerprinting, enzyme profiles or poly- or monoclonal antibodies can and should be used to relate environmental sources and cases. In view of the reported variation in virulence of legionella, virulence factors should be studied at the molecular and genetic level.
9. There is a need for research on the pathophysiology of non-pneumonic legionellosis, including Pontiac fever, because it may provide clues for the treatment and control of legionella pneumonia.
10. No available data suggest that legionellosis is more frequently contracted from waters in tropical climates than in temperate climates. Neither is there evidence to suggest that faecal or other contaminants indicate the presence of legionella.
11. There is no convincing evidence to implicate waste water in the transmission of legionellosis.
12. Preventive measures (in the absence of known cases) must be based on surveillance, education, and the simple maintenance procedures that are used in the control of outbreaks. Studies should be done to determine the proportion of sporadic cases due to exposure in the home, the workplace, and cooling tower aerosols outdoors. Building owners and managers are encouraged to make adequate resources available to keep the water systems clean and in a good state of repair. Records should be kept of water system maintenance. Countries are encouraged to promote training and professional awareness and competence among persons responsible for environmental and water system management. Hospitals should give priority to prevention in areas occupied by immunosuppressed patients (including transplant recipients and those receiving chemotherapy).
13. Countries are encouraged to investigate all suspected outbreaks. Information from such investigations will be greatly enhanced if a common approach including the following were to be adopted:
    - systematic comparison of environmental exposure of affected and unaffected people;
    - use of well-characterized epidemiological bacteriological markers;
    - a standard protocol for investigating the engineering and microbiology of implicated sources; to facilitate this an international consultation should be held prior to the 5th European Working Group on Legionella;
    - use of experienced, trained multidisciplinary teams including engineers, environmental microbiologists, epidemiologists and a reference laboratory;
    - a search of the records of water system main-

tenance and operation, particularly the dates and times of changes of equipment or water sources or other significant changes in routine use.

14. In the event of an outbreak, countries should be encouraged to promptly implement appropriate control measures that have been shown to be effective in other outbreaks.
15. There is no evidence that favours the determination of safety of a given water system on the basis of the concentration of legionella in a sample. The routine testing of water systems for the presence of legionella alone is therefore not recommended. Furthermore, no benefit has been shown from applying treatment controls for legionella to public or municipal water supplies before such water enters individual buildings.
16. There is a need for further evaluation of the benefit and/or economic feasibility of the following measures which have been proposed in some countries:

    — switching from wet to dry heat rejection systems;
    — replacement of central hot water storage with instantaneous mains-fed heaters at the points of use;
    — determination of the effectiveness of routine maintenance of water systems on the occurrence of legionellosis.

17. The effects of preventive measures on the ecology of water systems should be considered carefully to avoid creating conditions that might lead to other potential hazards to health, as a result of:

    — chemicals in the atmosphere:
    — chemicals in the aquatic environment;
    — increasing water temperatures encouraging the growth of thermophilic microorganisms responsible for disease;
    — energy wastage.

Annex

Case definition for international reporting

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

(1) Isolation of any legionella organism from respiratory secretion, lung tissue or blood.
(2) A fourfold or greater rise in specific serum antibody titre to *L. pneumophila* serogroup 1 by indirect immunofluorescent antibody test or microagglutination.

Note 1: A fourfold or greater rise in specific serum antibody titre to legionella species other than *L. pneumophila* serogroup 1, using a locally validated serological test, is currently regarded as a suggestive laboratory diagnosis, pending international evaluation.

Note 2: The detection of specific legionella antigen in respiratory secretion or urine, or direct fluorescent antibody (DFA) staining of the organism in respiratory secretion or lung tissue using evaluated monoclonal reagents is currently regarded as a suggestive but not a diagnostic laboratory test.

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