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ANSI/ASHRAE Standard 188-2015

Legionellosis: Risk Management for Building Water Systems

Published June 26, 2015

Patricia T. Graef, P.E.
Member SSPC-188
May, 2018



ANSI/ASHRAE Standard 188-2015

► **PURPOSE:** Establish minimum legionellosis risk management requirements for building water systems.

► **SCOPE:**

1)...for design, construction, commissioning, operation, maintenance, repair, replacement, and expansion of new and existing buildings and their associated water systems

2)...applies to human-occupied commercial, institutional, multi-unit residential, and industrial buildings—**excludes single-family residential buildings**

3)...for owners/managers of human-occupied buildings and those involved in design, construction, installation, operation, commissioning, maintenance/service of centralized building water systems and components



The SSPC 188 Team: 32 Voting Members

——(7 Professional Organizations & Many Other Active Professionals)——

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* Denotes members of voting status when the document was approved for publication



Voting Member Professional Organizations on SSPC 188

- 1) **CDC:** *Centers for Disease Control & Prevention*
- 2) **AWT:** *Association of Water Technologies*
- 3) **ASHE:** *American Society for Healthcare Engineering*
- 4) **APIC:** *Association for Professionals in Infection Control & Epidemiology*
- 5) **ASPE:** *American Society of Plumbing Engineers*
- 6) **IAPMO:** *International Association of Plumbing & Mechanical Officials*
- 7) **NSF** International



The ASHRAE SPC-188 Team

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Legionellosis: Risk Management for Building Water Systems





Slides adapted from...

ANSI/ASHRAE Standard 188-2015

► Standard 188 can be purchased from ASHRAE at:
<http://www.techstreet.com/ashrae/products/1897561>

► Standard 188 can be read for free from ASHRAE website under the Preview ASHRAE Standards, bottom left of page, at:
<https://www.ashrae.org/standards-research--technology/>.

CDC Toolkit

<https://www.cdc.gov/legionella/maintenance/wmp-toolkit.html>



A Practical Guide to Implementing Industry Standards

Many buildings need a water management program to reduce the risk for *Legionella* growing and spreading within their water system and devices. This toolkit is designed to help people understand which buildings and devices need a *Legionella* water management program to reduce the risk for Legionnaires' disease, what makes a good program, and how to develop it.

Download the Toolkit



[Developing a Water Management Program to Reduce *Legionella* Growth and Spread in Buildings: A Practical Guide to Implementing Industry Standards](#)^{13.2} [13.3 MB, 36 pages] –

June 5, 2017



Use the toolkit's quick [yes/no worksheet](#) to find out if your building or certain devices in your building need a water management program.



Background

- ▶ While Legionnaire's disease has been known for many years, recent outbreaks have increased awareness of the disease, its causes and prevention strategies
- ▶ The Centers for Disease Control & Prevention estimates:
 - each year between 8,000 & 18,000 cases LD in U.S.
 - more than 10% of these cases are fatal
- ▶ ASHRAE has been actively involved in providing information on *Legionella* since 1979 in response to the first Legionnaire's disease outbreak in 1976.



Let's go back to 1976
for a brief review of...

Legionnaires' Disease



1976: Bellevue-Stratford Hotel / Philly



221 Sick!

34 Deaths!



That's where we were in 1976...

- An unknown disease & 34 deaths!
- An intense CDC investigation!
- No known cause!

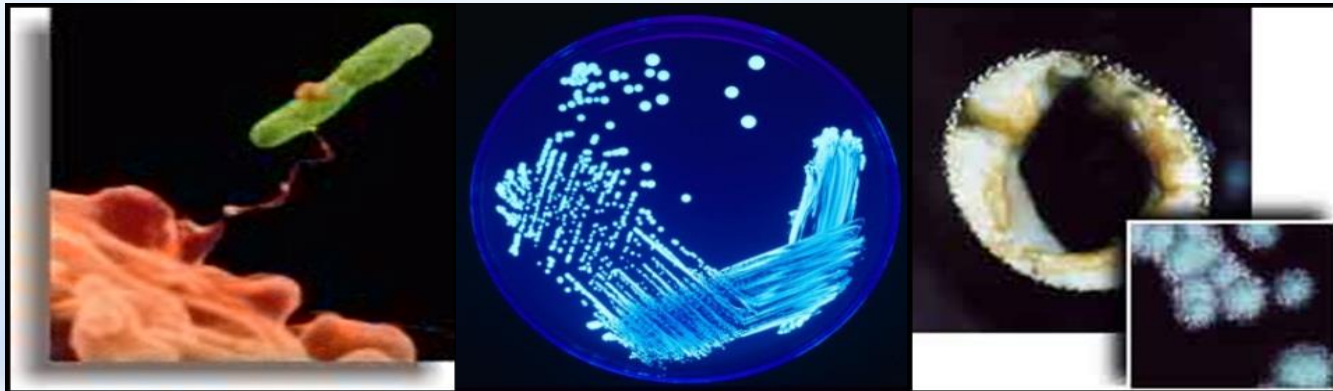


But, we had a name:

LEGIONNAIRES' DISEASE!

It was later discovered...

...that Legionnaires' disease is
caused by an aquatic
BACTERIA!



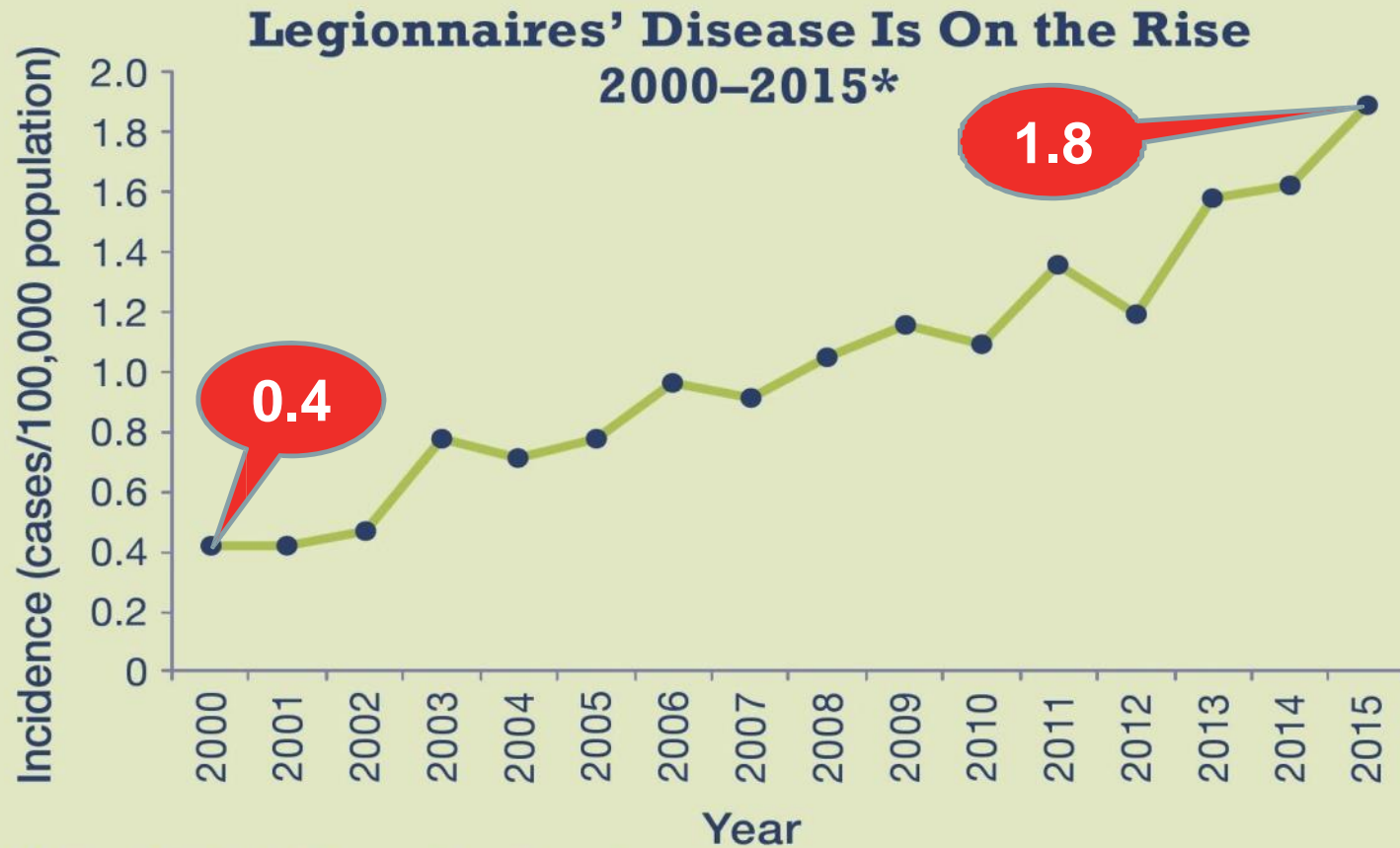


Legionella pneumophila

"Lung-Loving"

- One of 58+ named *Legionella* species
- The species responsible for ~90% of Legionellosis cases
- Has 15+ Serogroups
- The major infectious *Lp* Serogroup is Serogroup 1 (*Lp1*)

June 2017 Report = 4.5 x!



*National Notifiable Diseases Surveillance System

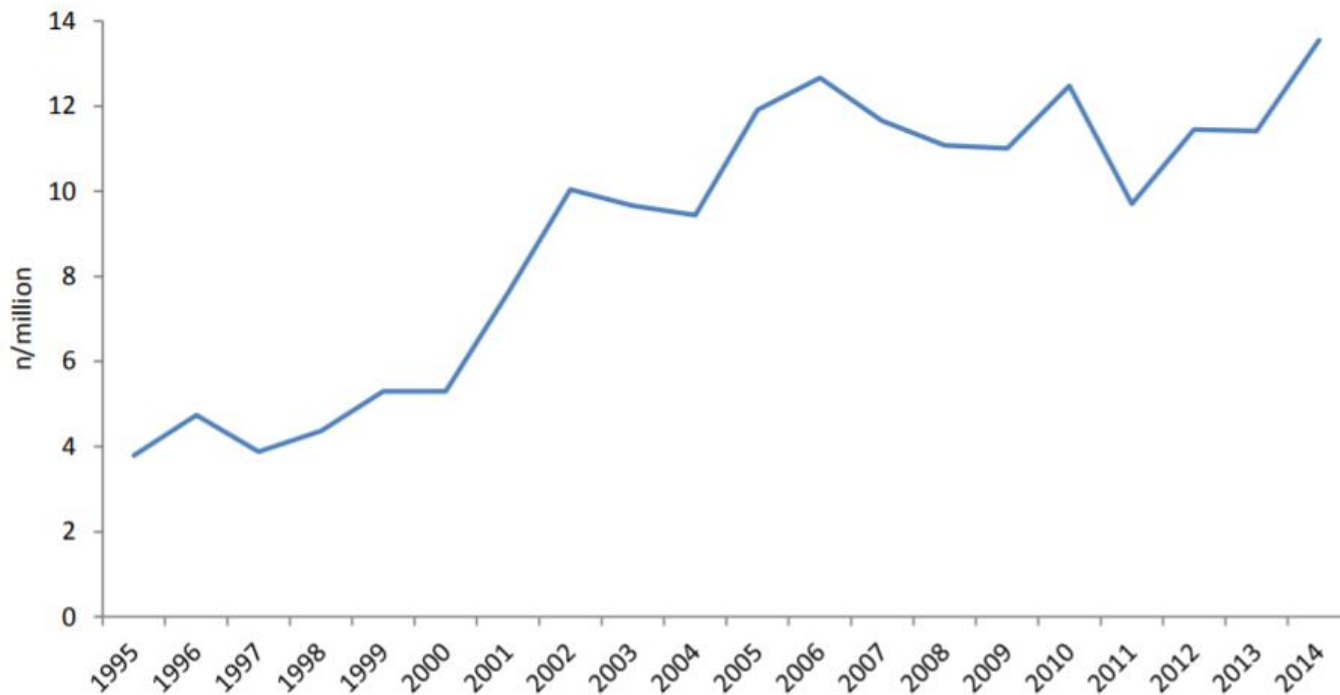
ECDC Report Legionnaires' Disease in Europe





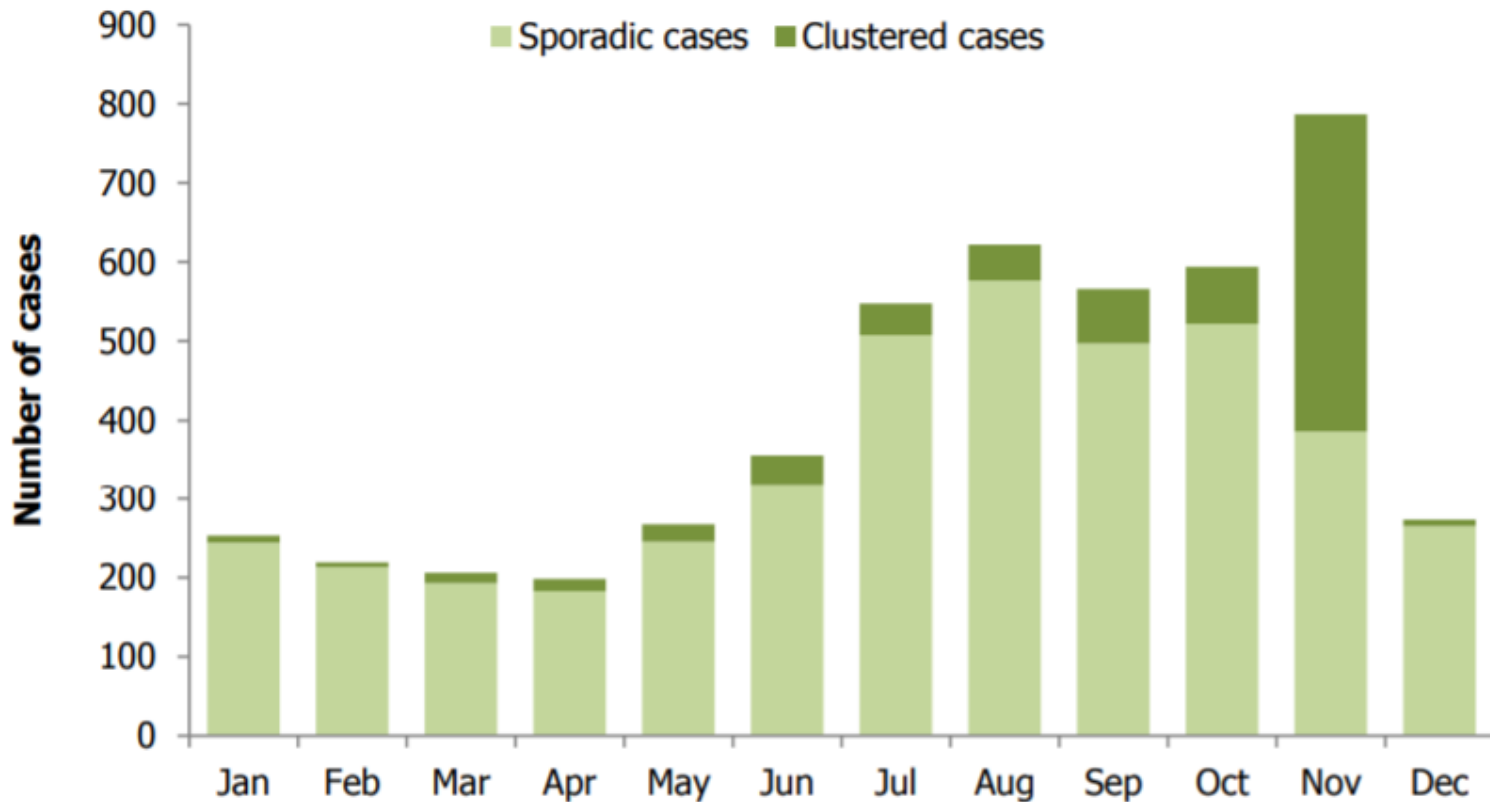
ECDC Report Legionnaires' Disease in Europe

Figure 1. Notification rate of Legionnaires' disease in the EU/EEA* by year of reporting, 1995–2014



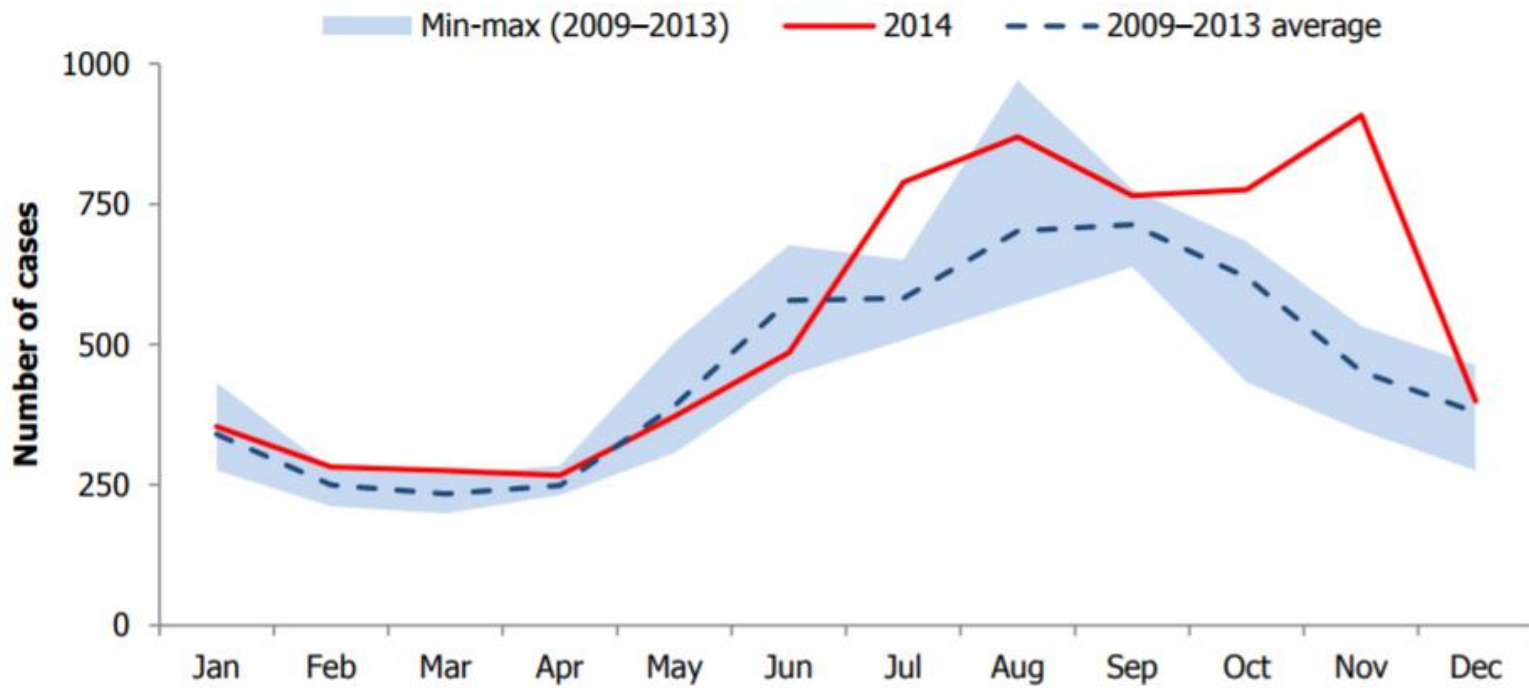
ECDC Report Legionnaires' Disease in Europe

Figure 7. Reported clustering of Legionnaires' disease, by month of onset, EU/EEA, 2014



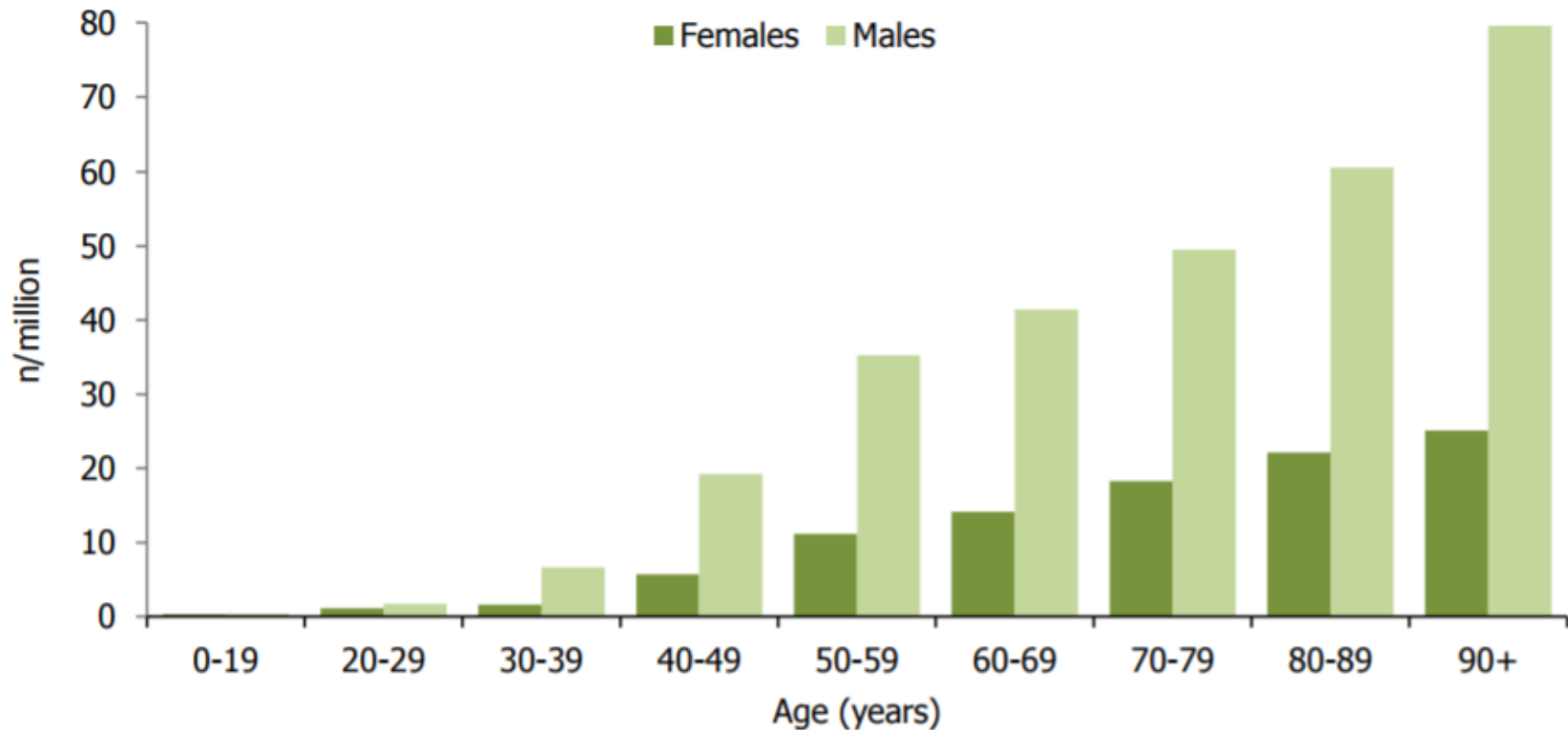
ECDC Report Legionnaires' Disease in Europe

Figure 2. Reported cases of Legionnaires' disease by month of onset, EU/EEA, 2014, and comparison with 2009–2013 range and average



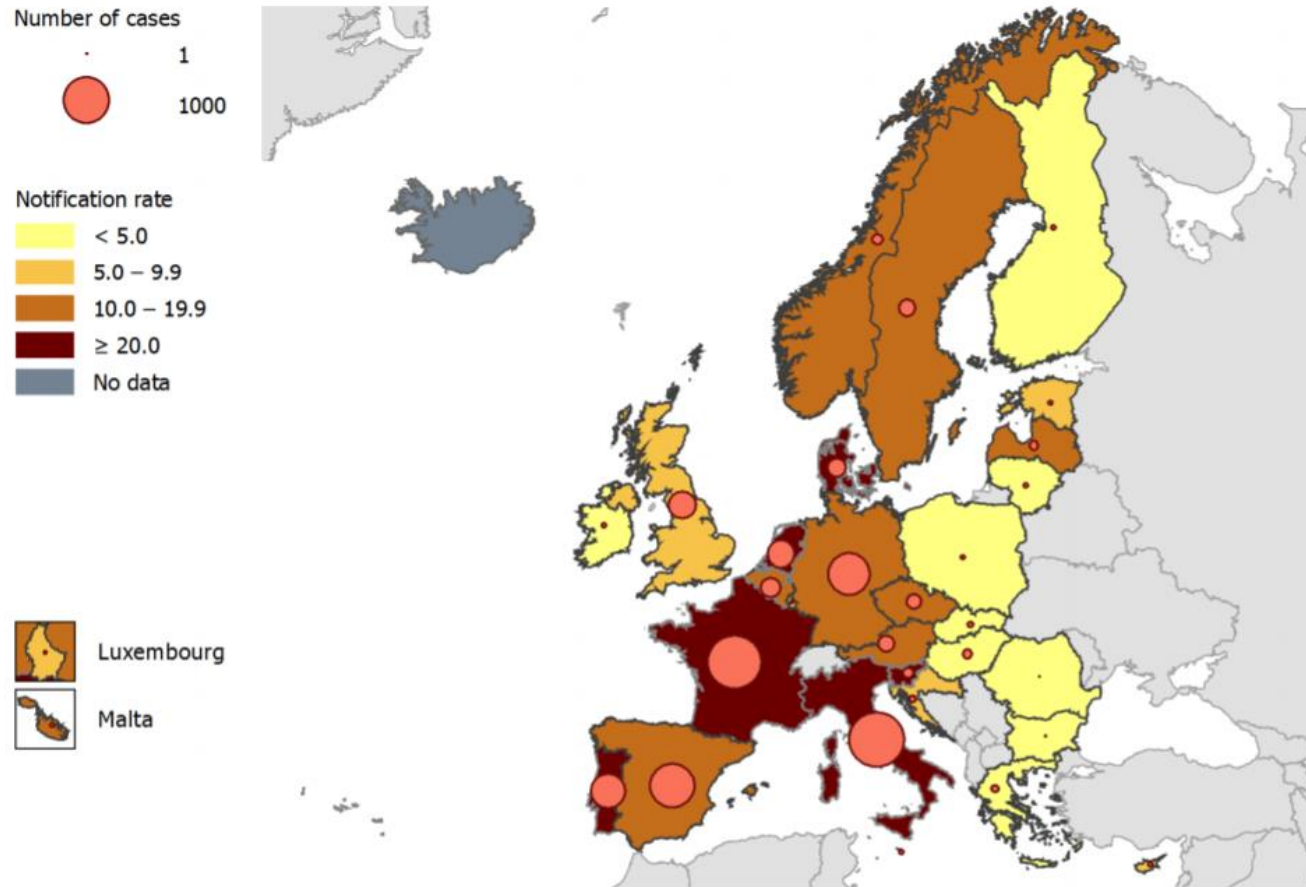
ECDC Report Legionnaires' Disease in Europe

Figure 6. Notification rates of Legionnaires' disease per million by sex and age group, EU/EEA, 2014



ECDC Report Legionnaires' Disease in Europe

Figure 5. Reported cases and notifications of Legionnaires' disease per million, by reporting country, EU/EEA, 2014



Interesting Statistics from Singapore Study

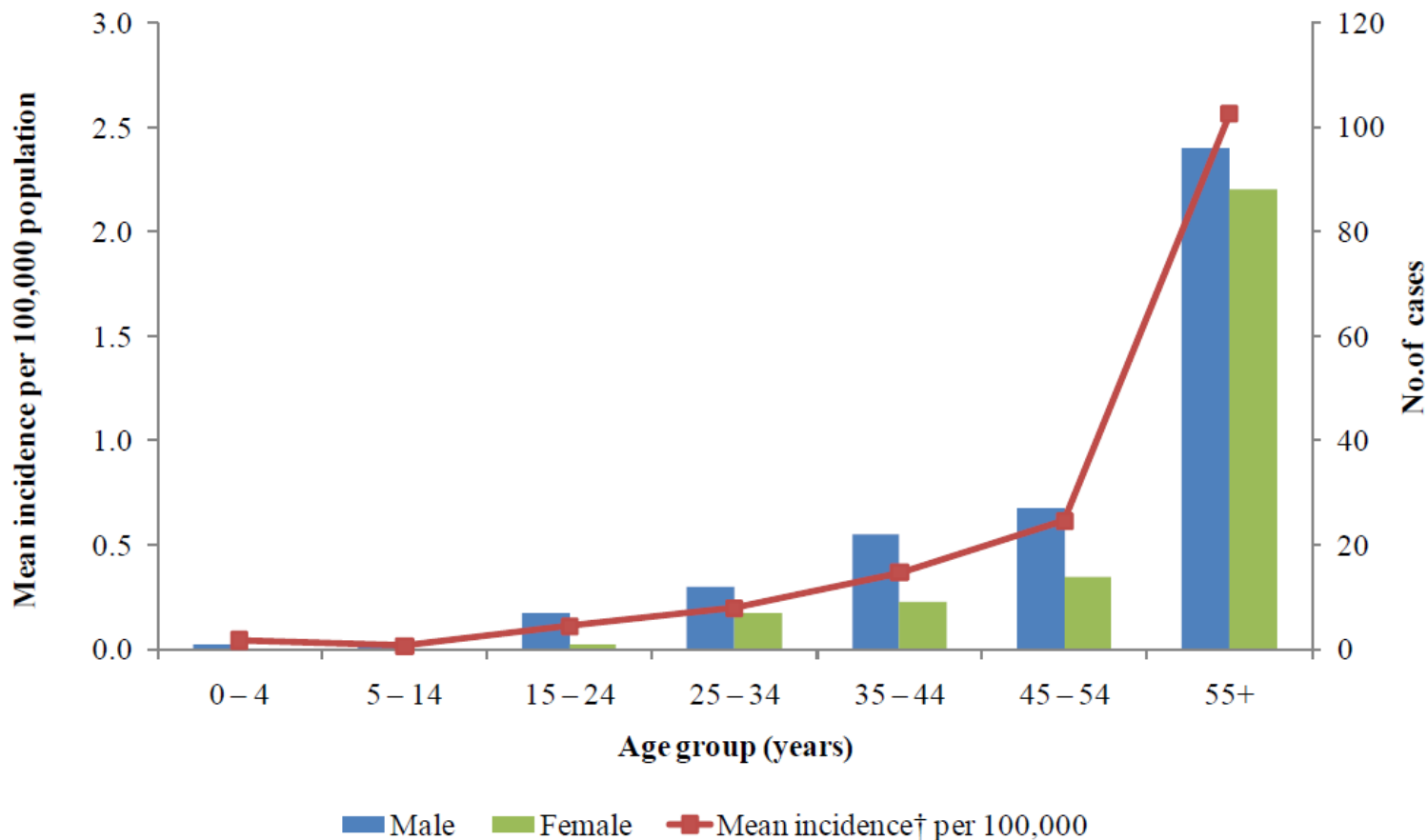
- During the 11-year period from 2000 to 2010, a total of 250 indigenous and 35 imported cases were reported.
- An additional 4 reported cases among tourists and 49 foreigners who sought medical treatment in Singapore were excluded.
- Of the 285 reported cases included in the study, 205 were classified as legionnaires' disease and 80 as Pontiac fever

**Epidemiological
News Bulletin**  **QUARTERLY**



Interesting Statistics from Singapore Study

Figure 1
Age-gender distribution and mean age-specific incidence* (per 100,000 population) of reported legionellosis (indigenous and imported)** in Singapore, 2000-2010

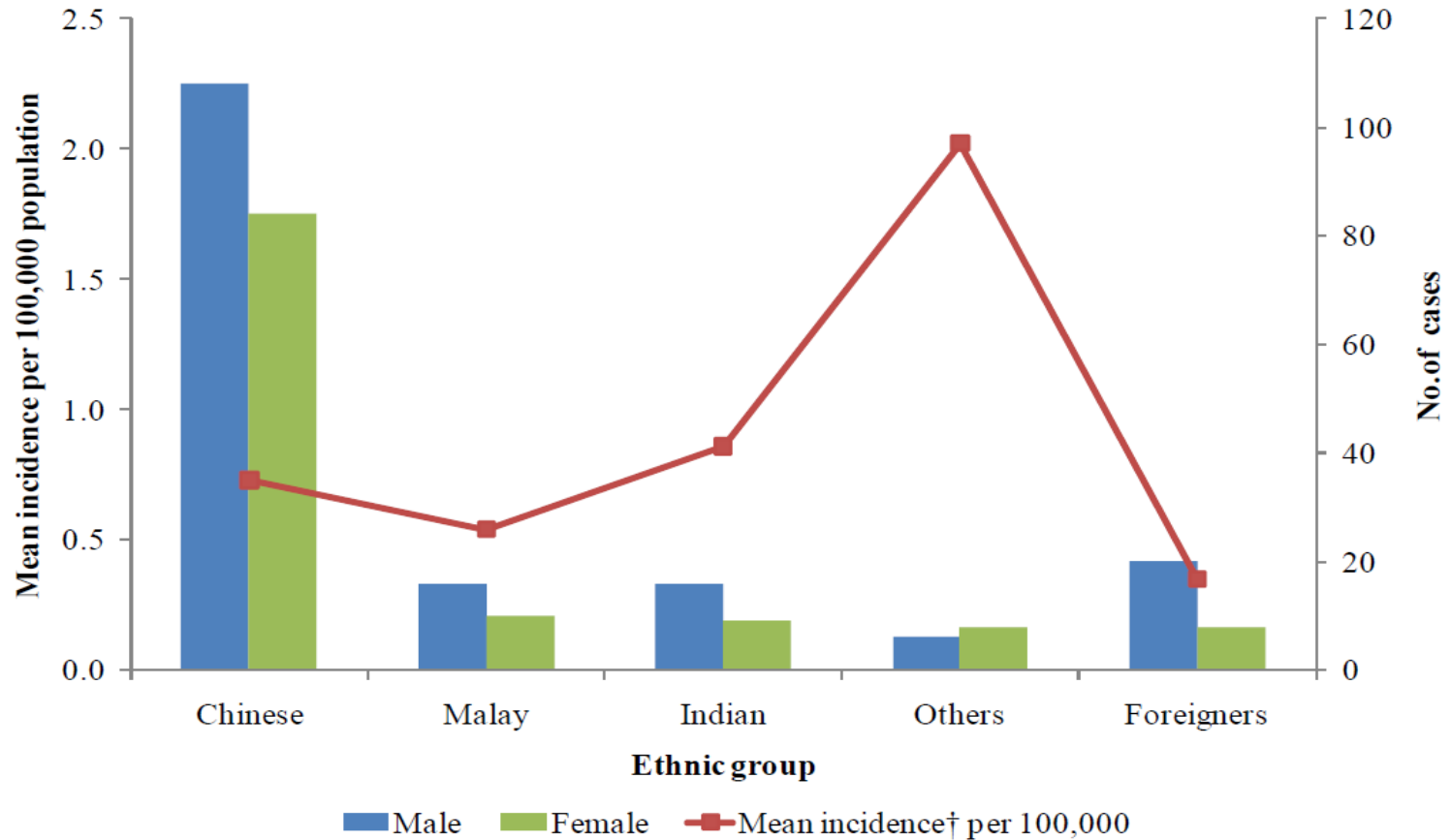


* Based on estimated mid-year population of 2005.

** Exclude 4 tourists and 59 foreigners seeking medical treatment in Singapore.

Interesting Statistics from Singapore Study

Figure 2
Ethnic-gender distribution and mean ethnic-specific incidence* (per 100,000 population) of reported legionellosis (indigenous and imported) in Singapore, 2000-2010**



* Based on estimated mid-year population of 2005.

** Exclude 4 tourists and 59 foreigners seeking medical treatment in Singapore.

Legionella Terms/Definitions

1. *Legionella*: the name for a specific genus (biological classification) of bacteria. Legionellae is the plural, referring to more than one *Legionella* bacterium. (LB)
 2. Legionellosis: any illness caused by the exposure to *Legionella*. Legionnaires' disease (LD) and Pontiac fever (PF) are the two most common types of legionellosis.
-



Legionellosis: Pontiac Fever

- Mild, Flu-like illness – ***without*** pneumonia
- Appears < 1-3 days after exposure
- Lasts up to 5 days, generally less
- Does not require hospitalization
- **Susceptibility:** ~95% (\pm) of those exposed

Playboy Mansion hot tub bacteria spawned Legionnaires' disease outbreak back in February



View of the Playboy Mansion, owned by publisher Hugh Hefner in Beverly Hills, California. (GABRIEL BOUYS/GETTY)

Los Angeles County health officials say the bacteria that causes Legionnaires' disease was found in a hot tub at the [Playboy Mansion](#) where scores of [people became ill](#) after attending a fundraiser in February.

The legionella bacteria also causes a milder illness called Pontiac fever. Symptoms include fever and headache.

Many people who attended a fundraiser party at the Playboy Mansion came down with a respiratory illness after the DomainFest conference in February, 2011.

Officials contacted 439 people and found that 123 had fevers and at least one other symptom with 69 falling ill on the same day.

[The Associated Press](#)

Monday, April 18, 2011, 10:34 AM

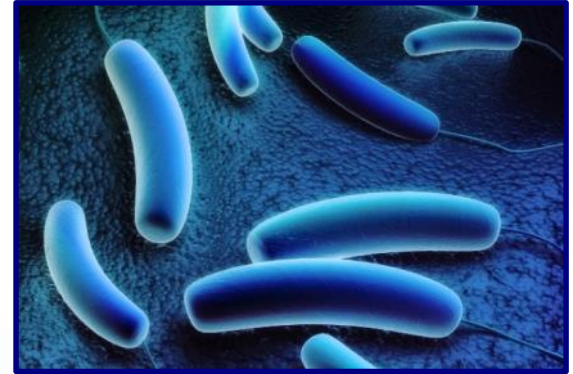


Legionellosis: Legionnaires' Disease

- Potentially ***fatal***, multi-system respiratory illness, accompanied by *pneumonia*
- Symptoms: high fever, chills, muscle pain, headache & dry cough; vomiting, confusion & delirium are also common
- Appears **2-10** days after exposure
- Recovery can be long-term & debilitating
- **Susceptibility:** ~5% (\pm) of those exposed

Legionella Microbiology

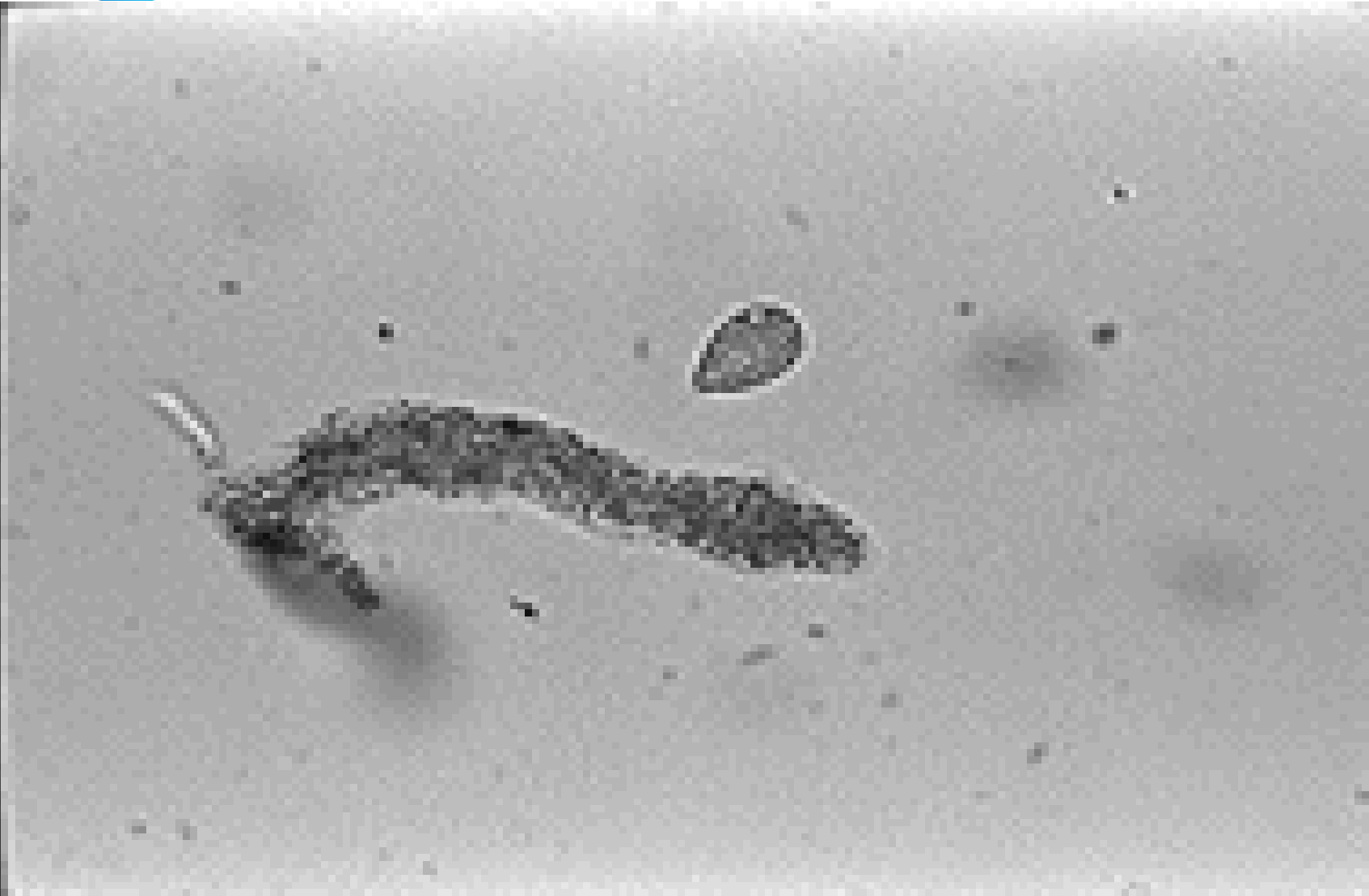
- Gram negative, rod-shaped, aerobic bacterium
- 60+ species & 70+ serogroups have been described
- Commonly found, natural inhabitant of fresh waters and some soils
- Survives and multiplies as intracellular parasites in certain Protozoa (Amoebae)



Amoeba proteus. Source: www.microscopy-uk.org.uk

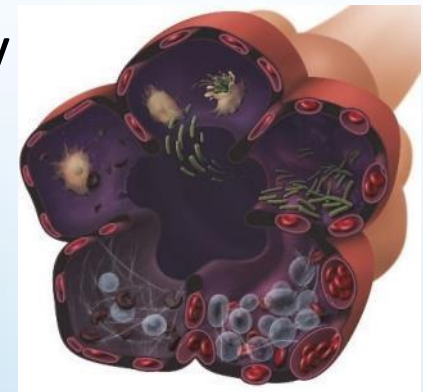


Protozoa 'Eat' Bacteria!



LB: An Interesting Pathogenesis!

- *Legionella* enter the host by penetrating deep into the alveolar regions of the lungs
- Alveolar macrophages normally ingest an invading bacteria to destroy it; **however**, within the macrophage, *Legionella* grow and replicate, as they do naturally in the environment within protozoa , eventually bursting and killing the macrophage!
- Numerous new LD bacteria are released into the lungs and worsen infection →



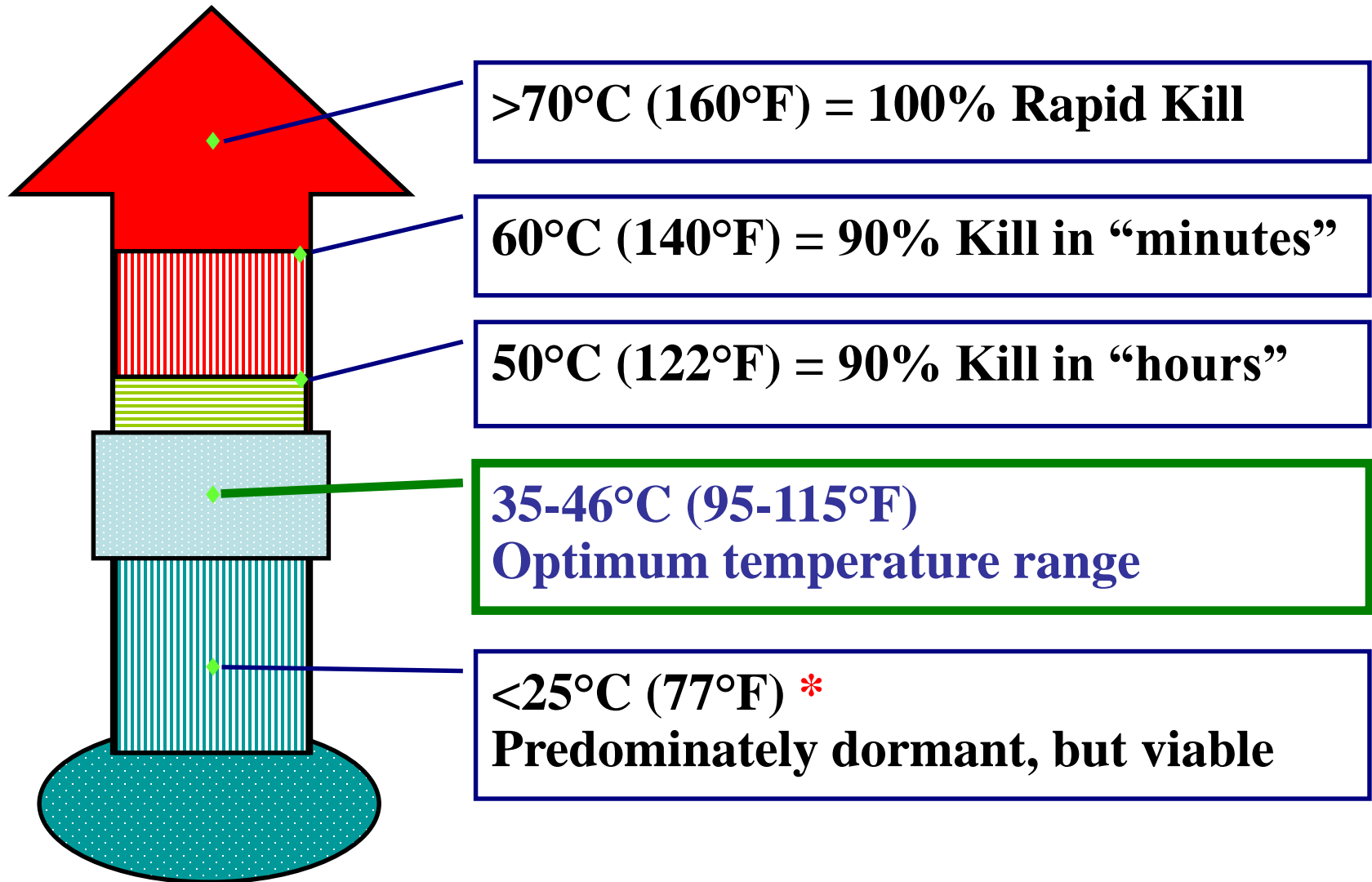


Three Essentials For Transmission

1. Correct Temperature and Environment for Amplification of LB
2. Method of Transport
3. Susceptible Host



Legionella & Water Temperature Control





Transmission & Infection

- Legionellosis is **not transmitted** from person to person
- **Inhalation** (into the lungs) → of water aerosols or soil containing LB can cause disease
- **Aspiration** (into the lungs) → of water/fluids during drinking w/coughing/gagging can cause disease



At-Risk (Susceptible) Hosts →

- Immune Suppressed (Transplants, Cancer, Cardiac, Steroid/Drug Therapy)
- Sick / In Poor Health
- Elderly / Infirm
- Heavy Smokers, Lung Disease, Diabetes

However, ~24% of Legionnaires disease cases occur in otherwise healthy individuals

Weakened Immune Systems



Cooling Towers: Another LD Myth

*Cooling Towers are **Not** the major reservoir or source of Legionnaires' disease!*

- **The potable/domestic water distribution systems** of large buildings, including hospitals and hotels, are considered the primary source of *Legionella* and disease as supported by data and expert sources, such as the CDC and peer-reviewed research studies.
- **Cooling towers** have long been thought to be the major source for *Legionella* and disease, but current data suggest this is an overemphasized source.



Aerosol Mist Arises From...

- Faucets & shower heads
- Spas & whirlpool tubs
- Humidifiers
- Decorative fountains
- Sprinklers
- Cooling towers
- Evaporative condensers
- Medical/dental equipment... and Others





Disease Profile

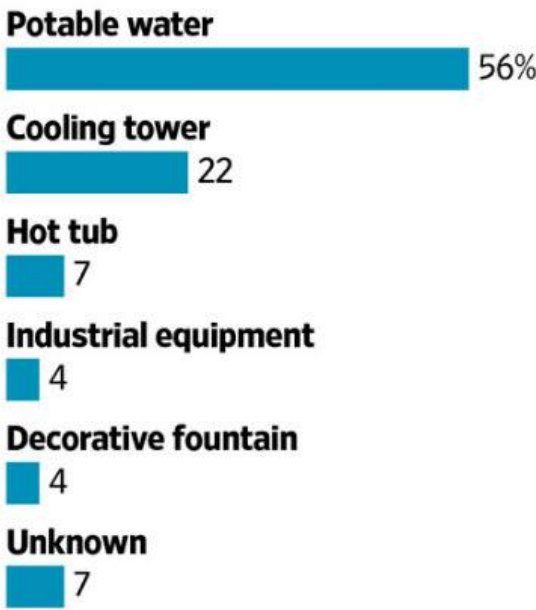
In 27 outbreak investigations conducted between 2000 and 2014, the CDC found that potable water was the most frequent source of exposure and resorts and hotels were the most frequent places where outbreaks occurred.

U.S. reported cases of Legionnaires' disease

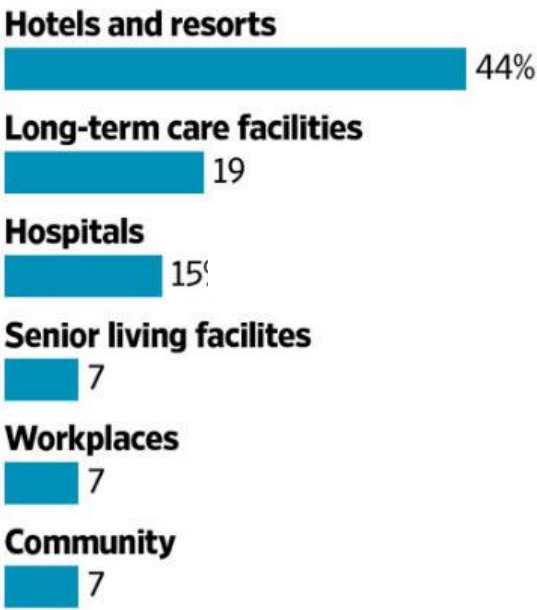


Source: Centers for Disease Control and Prevention

Source of exposure

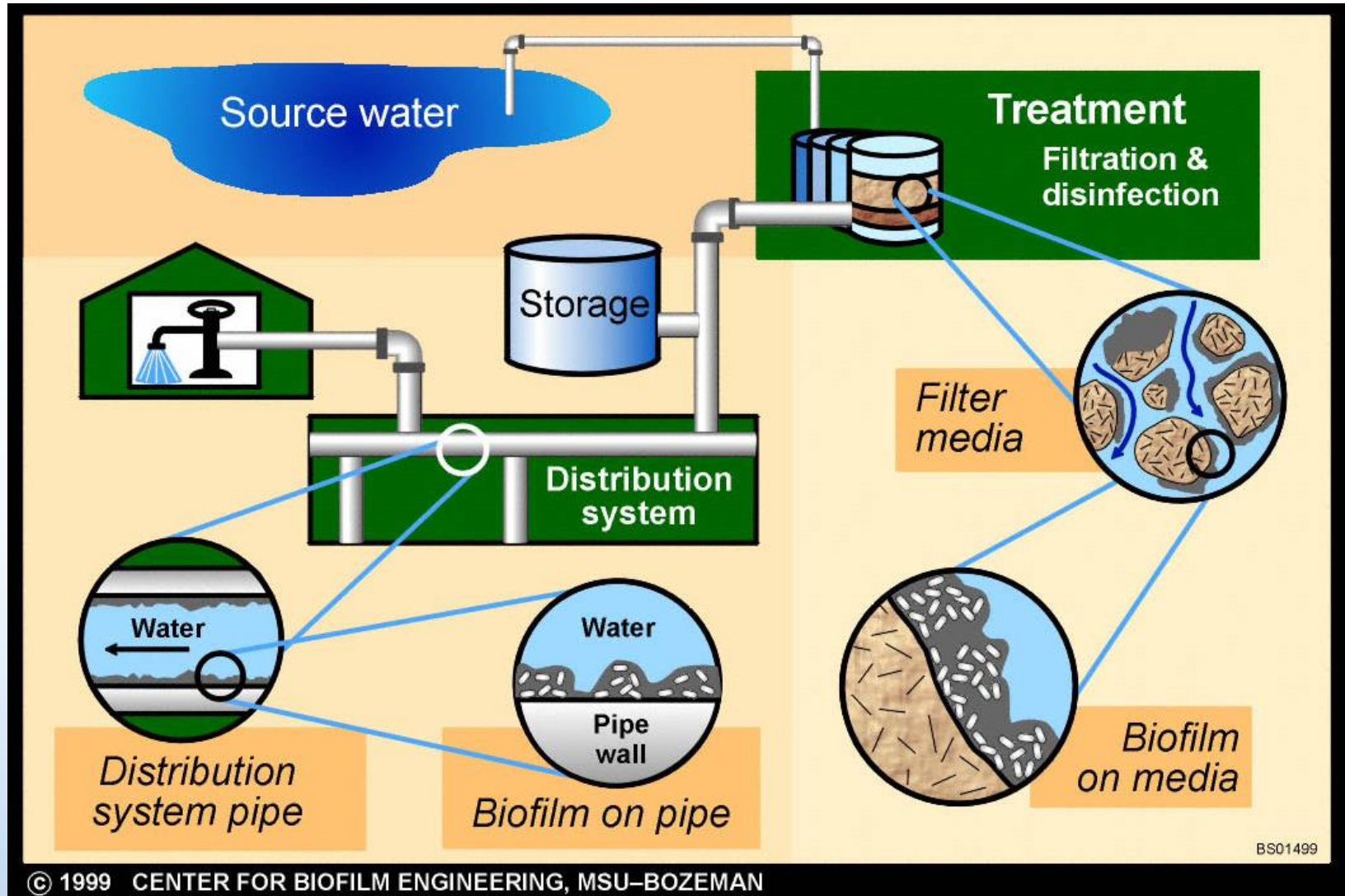


Outbreak settings

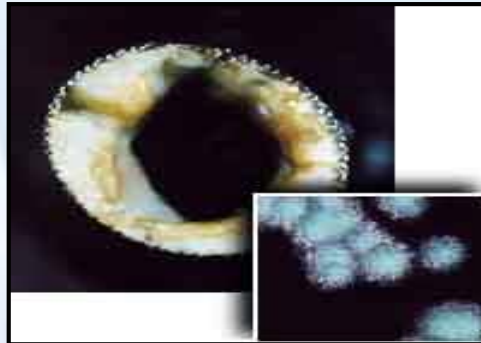
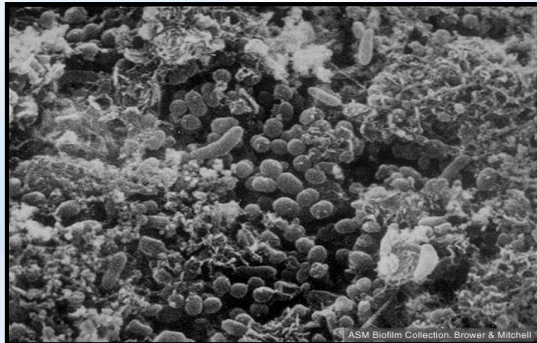
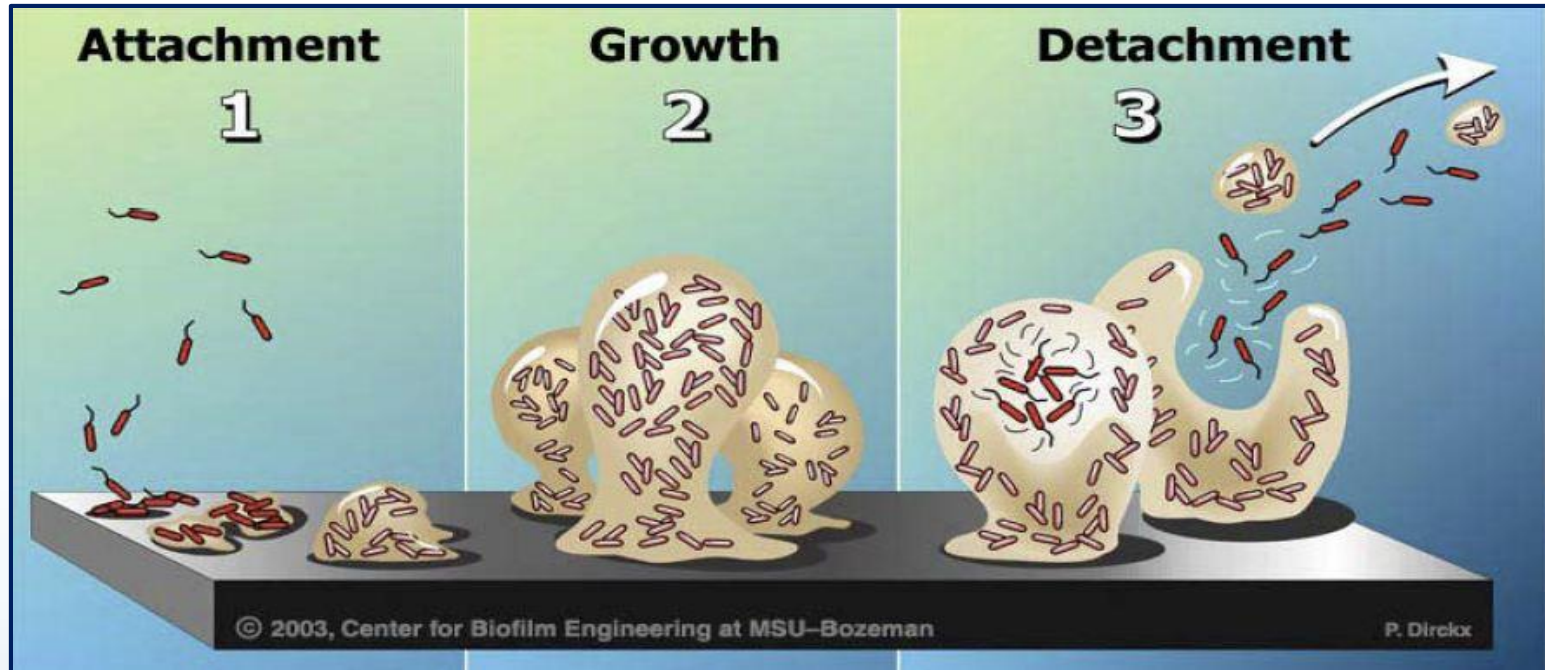


THE WALL STREET JOURNAL.

Biofilm Is In Our Water Systems



Legionella Thrive Within Biofilm



Possible Building Hazards

Where? can *Legionella* grow:

- Hot and cold water storage tanks
- Water heaters
- Water-hammer arrestors
- Expansion tanks
- Water filters
- Electronic faucets
- Aerators
- Faucet flow restrictors
- Shower heads and hoses
- Nonsteam aerosol-generating humidifiers
- Infrequently used equipment, including eyewash stations
- Ice machines



Low Flow Fixtures



US standards now require that lavatory faucets and faucet aerators use no more than 8.8 liters per minute in commercial and multifamily structures, and for public applications flow rate is capped at 2 lpm. Additionally, self-closing or metering faucets must not use more than 1 liter per cycle

Decorative Fountains



- **Decorative Fountains** can produce aerosols, harbor nutrients and have sources of heat.



- **More water features are being protected by glass.**

Hot Tubs and Spas

- ✓ Temperature conducive to amplification of Legionella Bacteria ~39C
- ✓ Production of aerosols
- ✓ Exposed to nutrients





Misting DeviCe: Bogalusa, LA

- An ultrasonic mist-maker device was operating over one section of the produce display
- No one at the grocery store was familiar with the operation or maintenance of the machine
- High levels of *Legionella* (*Lp1*) were recovered from the device: 13 cases / 2 deaths!



Hospital ICE Machine!



- Aspiration of ICE CHIPS contaminated w/Legionella
- 20% of Ice machines w/LB
- 3 cases / 1 death

LD Strikes the Magic Kingdom



- A review was conducted and it was learned that two cooling towers had elevated levels of Legionella bacteria.
- The towers were treated with chemicals that destroy the bacteria and were shut down until it was proven that it was safe to put them back into service.
- 12 people, ages 52 to 94, were diagnosed with Legionnaires' disease
- One Death

Cooling Towers

- **Cooling towers** have long been thought to be the major source for *Legionella* and disease, but the current data suggest this is not so.



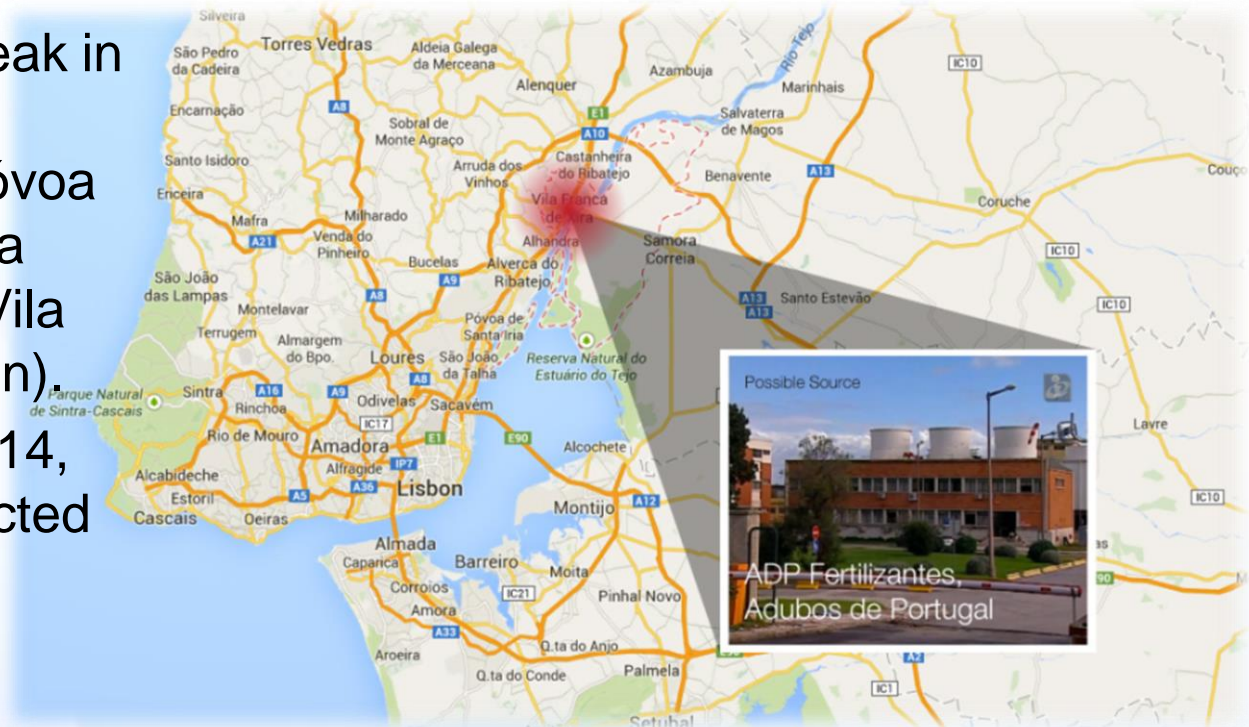
Cooling Towers



- Cooling towers are often associated with major outbreaks because the mist can travel great distances

Outbreak in Portugal

- The Legionella outbreak in Portugal began in November 2014 in Póvoa de Santa Iria, Forte da Casa and Vialonga (Vila Franca de Xira, Lisbon).
- As of 5 December 2014, 336 people were infected and eleven died.



**BREAKING
NEWS**

12 Die of Legionnaires' Disease in New York City ...

Legionnaires' outbreak widens to 12 dead in New York ...

BBC NEWS

August 11, 2015



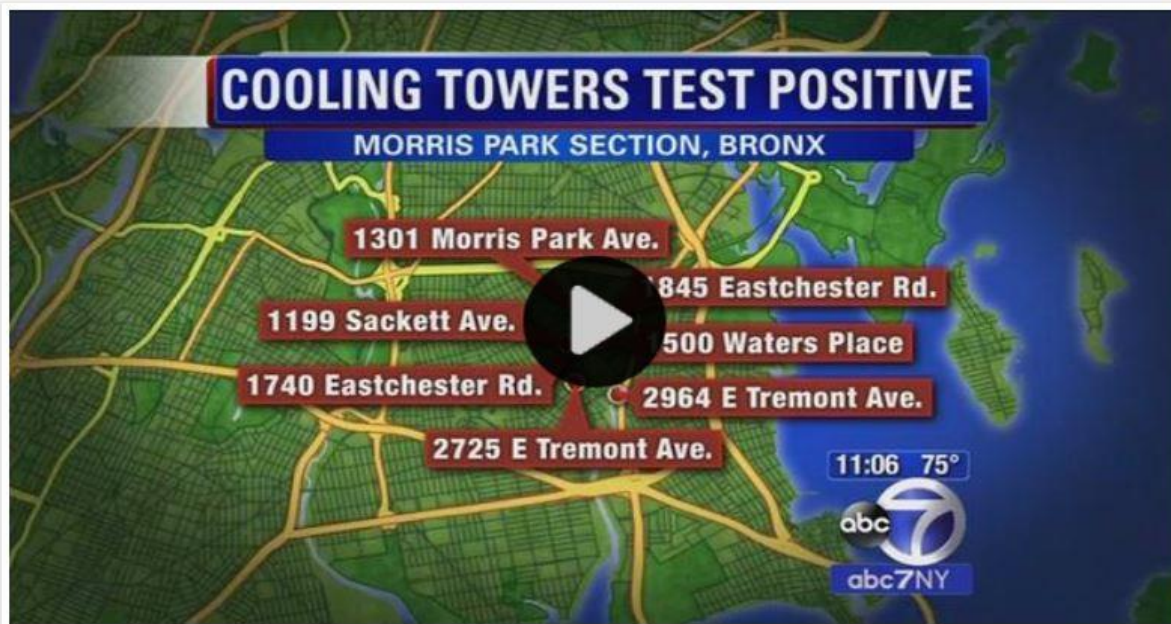
► **130 Cases Reported with 12 Deaths ...** Officials say the outbreak is centered on the area near the Opera House Hotel in South Bronx



BREAKING NEWS ACCUWEATHER ALERT: Track the rain with the power of AccuTrack radar

LEGIONNAIRES' OUTBREAK 2015

1 DEATH, MORE LEGIONNAIRES' DISEASE CASES CONFIRMED IN THE BRONX



NJ Burkett reports from Morris Park.

LEGIONNAIRES' OUTBREAK 2015



3 more Legionnaires' disease cases confirmed in the Bronx, total now 10



Health department investigating new Legionnaires' cluster in the Bronx



Hot water back on for some in Bronx complex where Legionella bacteria discovered



Legionnaires' found in water distribution system of 4 South Bronx apartment buildings

September 30, 2015

NEWS



NYC: Emergency Regulations

AUGUST 17, 2015 | Albany, NY

Governor Cuomo Announces Statewide Emergency Regulations to Combat Legionnaires' Disease

HEALTH

Register a Cooling Tower and Submit Reports

New statewide regulations require registration and periodic reporting of testing, inspection, and certification of cooling towers.

AVERAGE TIME OF
TRANSACTION

🕒 60
MINUTES

REGISTER





CMS: New *Legionella* Directive!

DEPARTMENT OF HEALTH & HUMAN SERVICES
Centers for Medicare & Medicaid Services
7500 Security Boulevard, Mail Stop C2-21-16
Baltimore, Maryland 21244-1850



Center for Clinical Standards and Quality/Survey & Certification Group

Ref: S&C 17-30-ALL

DATE: June 02, 2017

TO: State Survey Agency Directors

FROM: Director
Survey and Certification Group

SUBJECT: Requirement to Reduce *Legionella* Risk in Healthcare Facility Water Systems to Prevent Cases and Outbreaks of Legionnaires' Disease (LD)

Effective Immediately: June 2, 2017



CMS: Expectations

- ▶ “Conduct a **facility risk assessment** to identify where *Legionella* and other opportunistic waterborne pathogens could grow and spread in the facility water system.”



CMS: Expectations

- ▶ “Implement a **water management program** that considers the ASHRAE industry standard (188) and the CDC Toolkit that includes”:
 - Control measures
 - Temperature management
 - Disinfectant level control, and
 - Environmental testing for pathogens

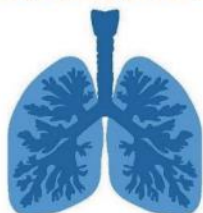


CMS: New *Legionella* Directive!

- This policy memorandum applies to:
 - Hospitals
 - Critical access hospitals (CAHs), and
 - Long-term care (LTC).
- This policy memorandum is also intended to provide general awareness for all healthcare organizations.

PreventLegionnaires.org/June 2016

LEGIONNAIRES' DISEASE HELPFUL INFORMATION



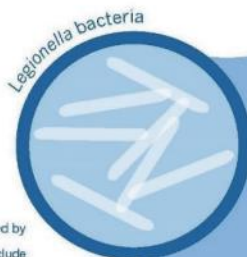
THE DISEASE A severe form of pneumonia caused by *Legionella* bacteria. Symptoms of this type of respiratory infection include high fever, chills, cough, muscle aches, headaches, and diarrhea.

MOST PEOPLE EXPOSED TO THE BACTERIA DO NOT BECOME ILL.

THE DRINKING WATER SUPPLY IS THE PRIMARY SOURCE

TRANSMISSION *Legionella* bacteria reach people when a water supply is contaminated. Hospitals, hotels, and large buildings are common locations for outbreaks. The drinking water supply is the primary source. Once the bacteria enters a water supply, it can multiply and be distributed throughout the building, coming into contact with people through fountains, mist machines, humidifiers, cooling towers, showers and sinks.

WHO'S SUSCEPTIBLE? The bacteria may enter the lungs through aspirated water droplets. While smokers, the elderly, and those with asthma, chronic lung disease or suppressed immune systems are more likely to become infected, healthy people may also be at risk.



POSSIBLE PATHWAYS FOR EXPOSURE TO LEGIONELLA BACTERIA



FAUCETS



HOT TUBS & POOLS



SHOWERS & BATHS



HUMIDIFIERS & MISTERS



FOUNTAINS



PIPES



DRINKING WATER



COOLING EQUIPMENT

PREVENTION, MAINTENANCE & MONITORING To prevent Legionnaires', the drinking water supply must be kept free of *Legionella* bacteria. The American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) and the Centers for Disease Control and Prevention (CDC) have developed a standard for risk management to support proper maintenance and monitoring of building drinking water systems.

FALSE

Legionnaires' disease most often occurs in large outbreaks.

THE FACTS

96% of Legionnaires' disease cases affect individual people, not a larger group. There are between 8,000 and 18,000 cases per year in the United States.

The primary cause of Legionnaires' is cooling towers.

Peer-reviewed studies published in the New England Journal of Medicine, The Lancet: Infectious Diseases, and many other publications have found the drinking water supply to be the primary source of the bacteria.

You can't get Legionnaires' from a shower head.

Bacteria can grow in the plumbing and in the shower head, which breaks up the water into a fine mist which can easily be inhaled allowing bacteria to travel directly to the lungs.

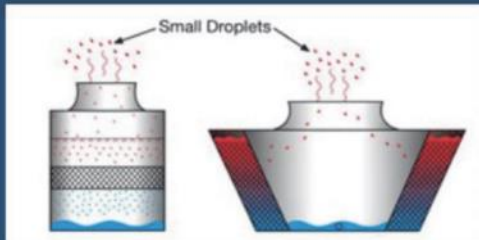
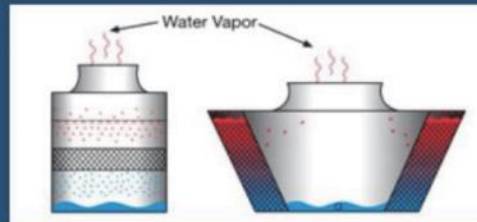


optimal temperature for bacteria growth

For more information visit: PreventLegionnaires.org

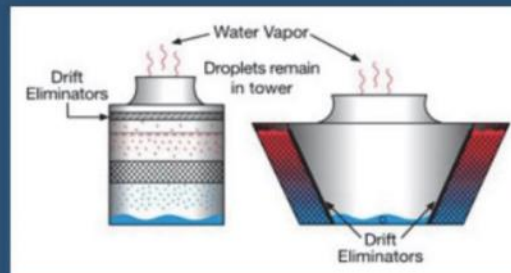
Drift Eliminators

In every cooling tower there is a loss of water to the environment due to the evaporative cooling process. This evaporation is usually in the form of pure water vapor and presents no harm to the environment.



Drift, however, is the undesirable loss of liquid water to the environment via small droplets that become entrained in the leaving air stream. There, water droplets carry with them chemicals and minerals, thus impacting the surrounding environment.

Drift eliminators are designed to capture large water droplets caught in the cooling tower air stream. The eliminators prevent the water droplets and mist from escaping the cooling tower. Eliminators do this by causing the droplets to change direction and lose velocity at impact on the blade walls and fall back into the tower. Efficient drift eliminators will keep drift losses to less than .001% of the re-circulating water flow rate.





Vital Signs: Deficiencies in Environmental Control Identified in Outbreaks of Legionnaires' Disease — North America, 2000–2014

Laurel E. Garrison, MPH¹; Jasen M. Kunz, MPH²; Laura A. Cooley, MD¹; Matthew R. Moore, MD¹; Claressa Lucas, PhD¹; Stephanie Schrag, DPhil¹; John Sarisky, MPH²; Cynthia G. Whitney, MD¹

Abstract

Background: The number of reported cases of Legionnaires' disease, a severe pneumonia caused by the bacterium *Legionella*, is increasing in the United States. During 2000–2014, the rate of reported legionellosis cases increased from 0.42 to 1.62 per 100,000 persons; 4% of reported cases were outbreak-associated. *Legionella* is transmitted through aerosolization of contaminated water. A new industry standard for prevention of *Legionella* growth and transmission in water systems in buildings was published in 2015. CDC investigated outbreaks of Legionnaires' disease to identify gaps in building water system maintenance and guide prevention efforts.

Methods: Information from summaries of CDC Legionnaires' disease outbreak investigations during 2000–2014 was systematically abstracted, and water system maintenance deficiencies from land-based investigations were categorized as process failures, human errors, equipment failures, or unmanaged external changes.

Results: During 2000–2014, CDC participated in 38 field investigations of Legionnaires' disease. Among 27 land-based outbreaks, the median number of cases was 10 (range = 3–82) and median outbreak case fatality rate was 7% (range = 0%–80%). Sufficient information to evaluate maintenance deficiencies was available for 23 (85%) investigations. Of these, all had at least one deficiency; 11 (48%) had deficiencies in ≥2 categories. Fifteen cases (65%) were linked to process failures, 12 (52%) to human errors, eight (35%) to equipment failures, and eight (35%) to unmanaged external changes.

Conclusions and Implications for Public Health Practice: Multiple common preventable maintenance deficiencies were identified in association with disease outbreaks, highlighting the importance of comprehensive water management programs for water systems in buildings. Properly implemented programs, as described in the new industry standard, could reduce *Legionella* growth and transmission, preventing Legionnaires' disease outbreaks and reducing disease.

Introduction

Legionnaires' disease, a severe, sometimes fatal pneumonia, can occur in persons who inhale aerosolized droplets of water contaminated with the bacterium *Legionella*. Exposure to *Legionella* in freshwater environments such as lakes and streams does not lead to disease; however, in manmade water systems, *Legionella* can grow and spread to susceptible hosts, including persons aged ≥50 years, smokers, and persons with

underlying medical conditions such as chronic lung disease or immunosuppression.

CDC investigated the first outbreak of Legionnaires' disease in 1976. Currently, approximately 5,000 cases of Legionnaires' disease are reported to CDC each year; however, Legionnaires' disease might be underdiagnosed. During 2000–2014, the rate of reported cases of legionellosis, which comprises both Legionnaires' disease and Pontiac fever, a milder, self-limited,



U.S. Department of Health and Human Services
Centers for Disease Control and Prevention

TABLE 1. CDC field Investigations of Legionnaires' disease outbreaks — North America, 2000–2014* (n = 27)

Year of Investigation	Setting	Source	Environmental and clinical isolate match†	No. confirmed and suspected cases			No. deaths	Case fatality rate (%)
				Total§	Confirmed§	Suspected§		
2001	Workplace	Industrial equipment	No	4	4	0	2	50
2001	Hotel/Resort	Potable water	Yes	21	5	16	1	5
2002	Long-term care facility	Potable water	Yes	31	12	19	2	6
2003	Hotel/Resort	Potable water	No clinical isolate	3	3	0	0	0
2004	Hotel/Resort	Potable water	No clinical isolate	8	7	1	0	0
2004	Hotel/Resort	Hot tub	No environmental or clinical isolate	6	5	1	0	0
2004	Community	Cooling tower	No clinical isolate	9	7	2	2	22
2005	Community	Decorative fountain	Yes	18	18	0	1	6
2005	Long-term care facility	Cooling tower	Yes	82	82	0	23	28
2006	Hospital	Potable water	Yes	10	10	0	3	30
2006	Senior living facility	Potable water	No clinical isolate	6	3	3	0	0
2008	Hotel/Resort	Potable water	Yes	13	11	2	0	0
2009	Senior living facility	Potable water	Yes	10	10	0	1	10
2010	Hotel/Resort	Potable water	Yes	11	10	1	0	0
2010	Hotel/Resort	Cooling tower	Yes	8	6	2	1	13
2010	Workplace	Cooling tower	Yes	29	7	22	0	0
2011	Hospital	Potable water	No clinical isolate	13	3	10	1	8
2011	Hotel/Resort	Unknown¶	No environmental or clinical isolate	3	3	0	0	0
2011	Long-term care facility	Potable water	No clinical isolate	10	4	6	8	80
2011	Hotel/Resort	Potable water	No clinical isolate	5	5	0	0	0
2012	Hospital	Potable water (possibly also decorative fountain)	Yes	21	21	0	5	24
2013	Long-term care facility	Unknown	No	19	15	4	5	26
2013	Hotel/Resort	Cooling tower	No clinical isolate	15	15	0	1	7
2013	Long-term care facility	Cooling tower	Yes	41	39	2	6	15
2013	Hotel/Resort	Hot tub	No environmental isolate	4	3	1	0	0
2014	Hotel/Resort	Potable water (and possibly hot tub)	No clinical isolate	6	6	0	1	17
2014	Hospital	Potable water	Yes	9	9	0	2	22
Total				415	323	92	65	7**

* Excludes one pseudo-outbreak, two non-outbreaks, and eight cruise ship outbreaks.



TABLE 2. Deficiencies in water system maintenance contributing to growth and transmission of *Legionella* among outbreaks of Legionnaires' disease investigated by CDC — North America, 2000–2014 (n = 23)

Setting	Source	Deficiency	Category*			
			Process failure	Human error	Equipment failure	Unmanaged external change
Hotel/Resort	Potable water	Temperatures in optimal range for <i>Legionella</i> growth [†] in cold potable water	✓			
Hotel/Resort	Potable water	Temperatures in optimal range for <i>Legionella</i> growth [†] in potable water Inadequate disinfectant in potable water	✓			
Hotel/Resort	Potable water	Temperatures in optimal range for <i>Legionella</i> growth [†] in potable water Inadequate disinfectant in potable water	✓			
Hotel/Resort	Potable water	Temperatures in optimal range for <i>Legionella</i> growth [†] in hot water heaters and in potable water Inadequate disinfectant in potable water, including water	✓			

Hotel/Resort	Potable water (and possibly also hot tub)	Temperatures in optimal range for <i>Legionella</i> growth [†] in potable water Lack of disinfectant in potable water (resort served by well water, disinfectant not required by state law) Lack of potable water distribution mapping plans (staff unable to describe system) Poor access to filters and disinfectant feeder because of hot tub placement and equipment design Broken water main [‡] (not followed by appropriate flushing of the distribution system)	✓	✓	✓	✓
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Hotel/Resort	Potable water (and possibly also hot tub)	Temperatures in optimal range for <i>Legionella</i> growth [†] in potable water Lack of disinfectant in potable water (resort served by well water, disinfectant not required by state law) Lack of potable water distribution mapping plans (staff unable to describe system) Poor access to filters and disinfectant feeder because of hot tub placement and equipment design Broken water main [‡] (not followed by appropriate flushing of the distribution system)	✓	✓	✓	✓
Hotel/Resort	Hot tub	Inadequate maintenance of hot tub Lack of knowledge by contracted pool operator		✓		
Hotel/Resort	Hot tub	Inadequate disinfectant in hot tub water because of inaccurate disinfectant feeding equipment, resulting in inadequate disinfectant delivery (unrecognized by hot tub operator) Inadequate hot tub maintenance and disinfectant monitoring Unenforced limits on bather loads Improper air circulation because of dysfunctional exhaust vents of dehumidifier in pool room, leading to increased exposure to aerosolized bacteria		✓	✓	
Hotel/Resort	Cooling tower	Inadequate disinfectant in cooling tower because of irregular addition of disinfectant by contractor Inadequate record keeping		✓		



TABLE 2. (Continued) Deficiencies in water system maintenance contributing to growth and transmission of *Legionella* among outbreaks of Legionnaires' disease investigated by CDC — North America, 2000–2014 (n = 23)

Setting	Source	Deficiency	Category*			
			Process failure	Human error	Equipment failure	Unmanaged external change
Hotel/Resort	Unknown (suspected to be a decorative fountain, but possibly potable water or hot tub)	Temperatures in optimal range for <i>Legionella</i> growth† in potable water Inadequate disinfectant in potable water and hot tubs Disinfectant not routinely added to decorative fountain, inadequate maintenance of decorative fountain suspected (but fountain was hyperchlorinated before testing)	✓	✓		
Hospital	Potable water	Temperatures in optimal range for <i>Legionella</i> growth† at hot water storage tank Inadequate disinfectant in potable water Use of tap water in personal respiratory device Insufficient clinical testing for <i>Legionella</i> among patients with pneumonia meeting criteria for possible Legionnaires' disease <small>(hospital and not addressed)</small> Insufficient clinical testing for <i>Legionella</i> among patients with		✓		✓
Hospital	Potable water (and possibly also decorative fountain)	Inadequate chlorine in potable water <i>Legionella</i> water management program not comprehensive (i.e., testing for disinfectant and pH in potable water not required) Failure to recognize cases of Legionnaires' disease as being health care-associated Delayed reaction to contamination of potable water with <i>Legionella</i> because of 1) Unrecognized contamination (decreased sensitivity of samples because of small volume) 2) Reliance upon action threshold to prompt remediation (when health care-associated cases occurred below threshold) Failure of copper-silver ionization system to control <i>Legionella</i> colonization in hospital Extensive construction** at hospital Lack of start-up and shutdown procedure for decorative fountains Disinfectant not added to decorative fountain <small>inadequate disinfectant in potable water</small>			✓	✓
Long-term care facility	Potable water	Inadequate disinfectant in potable water	✓			
Long-term care facility	Cooling tower	Inadequate disinfectant in cooling tower because of timed delivery that did not allow disinfectant to be delivered when cooling tower was not running			✓	

See table footnotes on page 8.



TABLE 2. (Continued) Deficiencies in water system maintenance contributing to growth and transmission of *Legionella* among outbreaks of Legionnaires' disease investigated by CDC — North America, 2000–2014 (n = 23)

Setting	Source	Deficiency	Category*			
			Process failure	Human error	Equipment failure	Unmanaged external change
Senior living facility	Potable water	Temperatures in optimal range for <i>Legionella</i> growth [†] in hot potable water because of reduction of hot water heater from original temperature set by the building's contractors Excessive sediment in potable water system because of new construction** Broken water main [‡] during construction**		✓		✓
Senior living facility	Potable water	Temperatures in optimal range for <i>Legionella</i> growth [†] in hot potable water Inadequate disinfectant in potable water Failure to follow manufacturer's recommendations for periodic draining of hot water heaters to remove sediment Water temperature in hot water heater lower than indicated on thermostat Maintenance of water main [‡] resulting in pressure disruptions	✓	✓	✓	✓
Workplace	Cooling tower	Lack of start-up and shutdown procedures for cooling tower Lack of staff training on operation and maintenance of cooling tower Cooling tower dysfunction, prompting opening of windows Heavy rainfall, high humidity, and warm temperatures preceded onset of cases ^{††}		✓		✓
		cooling tower Cooling tower dysfunction, prompting opening of windows Heavy rainfall, high humidity, and warm temperatures preceded onset of cases ^{††}				
Total			15	12	8	8



LB Knowledge is Needed to...

- Assess and Address Legionellosis Risk
- Develop Legionellosis Risk and Water Management Programs
- Manage Buildings, Facilities and Water System Devices to Prevent Legionellosis

Prevent a Preventable Disease!



SUMMARY

- ***Legionella*** is a common bacteria in man-built water systems;
- **Disease Causation is Not Simple** – involves many factors:
 - Favorable conditions for LB growth & amplification
 - Means of transmitting water aerosols containing LB
 - Exposure route to Susceptible persons
- **Cooling Water & Potable Water Systems** must be considered
- **ANSI/ASHRAE Standard 188-2015**
 - Responsibility lies with Owners/managers—as well as design engineers
 - Identify minimum legionellosis risk requirements
 - Must establish a water management program