Legionella Risk Management for Safety Professionals

Joint ChABSA / AIHA Meeting - January 15 2020

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Who am I?

Research microbiologist –
35 years medical faculty at Johns Hopkins Medicine [retired], University of Maryland Medicine & Medical College of Pennsylvania (Drexel University Medicine)

Presented / published 61 microbiology / biosafety papers cited 379 times & read 9,474 times on ResearchGate
I’ll cover:

Legionnaires’ disease
*Legionella* bacterium & Dx
Transmission sources
Risk reduction
Decontamination

Legionnaires’ disease
43-years & counting
Legionellosis

Legionnaires’ disease - LD
atypical pneumonia with rapid onset
high fever, myalgia, cough, atypical
radiogram – often misdiagnosed

Pontiac fever – mild – no pneumonia

https://www.cdc.gov/legionella/health-depts/surv-reporting/case-definitions.html

Legionnaires’ disease - LD

Airborne aerosol transmission to lungs

Incubation 2 to *10 days
Attack rate 5% of population
Pneumonia 100%, Rapid onset
Course 15% to 40% fatal
Legionnaires’ disease risk factors

Age ≥ 50 years
Smoking (current or historical)
Chronic lung disease  
(such as emphysema or COPD)
Immune system disorders due to  
disease or medication
Systemic malignancy

Legionnaires’ disease risk factors

Underlying illness such as diabetes,  
renal failure, or hepatic failure
*Recent travel with an overnight stay  
outside of the home, including stay  
in a healthcare facility
*Exposure to hot tub aerosol
*Exposure to cooling tower drift
Legionnaires’ disease

Limited sputum production
Limited consolidation [no dark shadow]
Limited alveolar exudate
Small white blood cell count increase
IV Antibiotic therapy essential at onset

Radiograph – not remarkable
**Legionella** grow in macrophages

**Legionella** contact lung alveolar [air sack] macrophages [wbc] & transduce a signal to change phagosome movement. Alveolar macrophages engulf the bacteria into vacuoles where the bacteria multiply to high numbers & produce fluid that prevents air exchange [Drowning]
### Legionnaires’ disease - LD

Many serogroups of *L. pneumophila*  
Serogroup 1 most common Dx in US  
15 other *Legionella* species clinically associated with LD  
15-30% of pneumonia patients admitted to intensive care units may have LD  
50,000 to 70,000 cases in US/yr *NAS2019*

### Trigger Outbreak  
Philadelphia  
1976
1976 – Bellevue Stratford Hotel
Philadelphia PA

Legionnaires’ [ex-military] Convention

221 cases of serious pneumonia of
*Unknown Etiology [Neg lab Dx]
34 deaths

Source – untreated roof cooling tower
[Personal knowledge of CT & 1980’s Senate hearing]

National Enquirer – Dec. 6, 1977

Top Doctors Claim ‘Climate of Fear’ Created by Gov’t.
LEGIONNAIRES DISEASE
– THE GREAT HOAX
Legionella bacterium – CDC 1977

*Legionella* [new bacterial genus named by CDC]
61 *Legionella* species as of October 2019

First cultured in embryonated eggs with tissue from a Guinea pig with a fever

Guinea pig had been injected with blood from a deceased Philadelphia Legionnaires’ Conventioneer
My lab started working with *Legionella* in 1978

**Cytochrome spectra of *Legionella pneumophila***

Paul L. Kronick and Richard W. Gilpin
Franklin Research Center, Philadelphia, Pennsylvania 19103, U.S.A.
Department of Microbiology, The Medical College of Pennsylvania, Philadelphia 19129, U.S.A.


**Legionella bozemanii**

Still Another Cause of Pneumonia

Jack D. Sobel, MD; Richard Krieger, MD; Richard Gilpin, PhD; Linda Grioka, MD; Pasha Aparwal, MD

*JAMA*, July 15, 1983—Vol 250, No. 3

Legionella bozemanii Pneumonia—Sobel et al 383
1985 Our first paper on cooling tower testing

Biological, chemical and physical parameters of a large cooling tower. Samples were tested on the indicated days during the summer months. Cooling degree days (Degree d) were calculated from a base temperature of 18°C. Viable counts of bacteria from (●) pool water (CFU ml⁻¹) and (□) slats (CFU mm⁻²); DFA-positive bacteria (▲) in pool water (number ml⁻¹) dissolved solids (mg ml⁻¹) calculated by multiplying conductivity measurements µmho cm⁻² by a factor of 0.75; chromate and phosphate concentrations are µg/ml. Temperature is °C. Arrows indicate increased (↑) or decreased (↓) blowdown.
1995 * The Analyst * Assoc Water Technol

2014 * Applied Biosafety * ABSA Vol 19 #2

Articles

Quantitative Measurement of Legionella pneumophila Counts in Routinely Maintained Commercial and Industrial Cooling Towers

Richard W. Gilpin1,2 and Adele M. Kaplan Gilpin2

1Richard W. Gilpin, Ph.D., Ltd., Baltimore, Maryland and 2University of Maryland School of Medicine, Baltimore, Maryland
Legionella bacterium & Dx

First CDC Symposium – 1978  I was there
CDC Publications 1978 & 1979

1978 CDC Lab Dx Methods

Indirect fluorescent antibody test

*Direct fluorescent antibody test — 1st Dx method

Original culture in Mueller-Hinton agar containing 1% hemoglobin & 1% IsoVitalex in a candle jar @ 35°C

Later grown on Feeley-Gorman agar

Much later - Buffered Charcoal Yeast Extract (BCYE) agar
**Direct Fluorescent Antibody [DFA] Test**
Fluorescein-conjugated IgG attaches to bacterial cell wall

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**Legionella on BCYE Agar**
**Legionella Colonies on BCYE Agar**

**Legionella Bacterium**

- Gram negative rod (stains poorly)
- Rod morphology (long rods in old culture)
- Strict aerobe – requires aeration
- Facultative intracellular parasite
- Grown on medium with reduced free radicals [no growth on usual Dx media]
- Grows in amoebae within biofilms
Legionella [green] in Biofilm


Legionella can live and grow in biofilm

- Water
- Pipe wall
- Biofilm-associated bacteria
- Free-floating bacteria
- Secreted slime

Cross section of pipe

Weakly Staining Gram Negative Rod
Current CDC Lab Confirmation
Culture on BCYE agar:

Isolation of any *Legionella* organism from respiratory secretions, lung tissue, pleural fluid, or other normally sterile fluid

https://www.cdc.gov/legionella/clinicians/diagnostic-testing.html#preferred-tests

Transmission sources
Transmission by Aerosol Inhalation

Mechanical Aerosol Sources

Cooling towers*
Evaporative condensers
Showers
Spas*
Hot tubs*
Grocery store & Outdoor misters
Mechanical Water Sources

Fountains*
Warm water pipes/fixtures
Vehicle wash facilities
Ice machines
Water-containing dental equipment
Cooling Towers Showing Water Drift

How Cooling Towers Work

Hot Tub Aerosol

Domestic Water Supply
Risk reduction

What do we know about LD?  Heard it’s no longer a problem
“Industrial hygienists follow the practice of anticipation, recognition, evaluation, and control of hazards and potential hazards in workplace settings”

What do you do next?
Source of the case report?
Response chain of command – safety?
Facilities/Operations/Maintenance?
Water treatment consulting company?
Legal Department?
Test / Not test?
Press release?
June 2019 testing began after WSU employee and two contractors were diagnosed with Legionnaires' disease.

*Legionella* bacteria were discovered in rooftop cooling towers at several campus buildings.
Wayne State University Plan
Constant monitoring [biocides, pH, testing]
Aggressive decontamination when bacterial numbers rise

**Water Safety Team:**
Infectious Disease specialists
EHS
Facilities
Planning & Management
October 2019 - NC Officials Traced 124 Legionnaires’ disease cases to a Hot Tub display at a State Fair

**One week AFTER State Fair closed**, NC Division of Public Health found sudden spike in Legionnaires’ disease cases
ASHRAE Standard 188 - 2018

Legionellosis: Risk Management for Building Water Systems

The presence of Legionella bacteria in building water systems is not in itself a sufficient cause. Environmental conditions promoting Legionella growth must be present. Aerosol generation must be present to transmit LD. Exposure of susceptible persons to colonized water by inhalation or aspiration into lungs.

Ashrae 188-2018

Legionella bacteria are not transmitted person-to-person or by normal (non-aspirated) ingestion of Legionella contaminated water.

Develop risk analysis plans for site review to identify and monitor water containing valves, tanks, boilers, heat rejection equipment, and aerosol producing equipment that may be associated with Legionella growth.
ASHRAE Site Review Factors

*Cooling towers / Evaporative condensers
*Whirlpools / Hot tubs / Spas
*Ornamental fountains, Misters, Air washers, Humidifiers

Centralized water heaters in multiple unit buildings
Buildings more than 10 stories high
Buildings where at risk people stay
[disease, diabetes, immunocompromised]
Buildings where people over 65 years of age stay

Sources of Information

AIHA American Industrial Hygiene Association
APIC Association for Professionals in Infection Control and Epidemiology
ASHRAE American Society of Heating, Refrigerating and Air-Conditioning Engineers
AWT Association of Water Technologies
CMS Centers for Medicare & Medicaid Services
CTI Cooling Technology Institute
EPA US Environmental Protection Agency
NSF National Science Foundation
NSF NSF International – equipment certification
OSHA US Occupational Safety and Health Administration
VA US Department of Veterans Affairs
Sources of Information - CDC


Potable Water Treatment

Chlorine vs Monochloramine*
Chlorine dioxide
Copper-silver ionization
Hot water temperature above 140 °F*
Ozone

Flannery, et al., 2006, Emerg Infect Dis 12:588-596
Cooling Tower Treatment – Many choices

- Bromine - oxidizing biocide*
  - continuously or several hours/day
  - or 3 times/week to get a 0.5 to 1.0 ppm bromine
- Non-oxidizing microbiocides alone not effective
- Chlorine dioxide - oxidizing biocide
  - 4 timed slug feed dosages of 3-5 ppm chlorine dioxide/day
- THPS - tetrakis(hydroxymethyl)phosphonium sulfate (Richard D. Miller, et al., AWT Annual Convention 2011)

Our Legionella Testing
Our DFA Routine Testing

The highest number of *Legionella* we found in a water sample was 150,000/ml of CT water

1980’s - 7% of the tower samples tested by our laboratory had *Legionella* counts greater than 200/ml of tower water – Now about 1% or less

Water line samples are usually negative

Highest recent counts from hospital water samples have come from decorative fountains

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Our Remedial Action Criteria

< 0.2 to 1 CFU/ml

- This is the most common test result
- This does not require remedial action
- Obtain another test of this site in a month to check for evidence of increasing numbers of *Legionella*
- Some operators perform routine monitoring monthly, many operators monitor quarterly
Our Remedial Action Criteria

> 1 to 10 CFU/ml

- This is the second most common test result
- The decision to disinfect the system should be made by considering the numbers of *Legionella*, the location of the system, and the type of employee, patient or visitor population
- If the system is not disinfected, obtain another test within a few weeks to check for evidence of increased numbers of *Legionella*

> 10 CFU/ml

- This is the least likely test result
- This result represents a public health concern
- Disinfection of the system is indicated
- If greater than 100 CFU/ml, take action immediately
- Obtain another test within a few weeks to check for evidence of increased numbers of *Legionella*
Decontamination

Cooling Tower Decontamination

State of Wisconsin Department of Health and Social Services “Control of *Legionella* in Cooling Towers, Rev. 8/87, POH4242”; ASHRAE; or CTI

Cooling tower shock treatment with 50 ppm free residual chlorine with a non-sudsing detergent. Maintain 10 ppm free residual chlorine for 24 hours following the initial shock dose. Repeat once. Flush & return to service
Water Line Decontamination

Heat hot water systems to 160 °F (71 °C) - 170 °F (77 °C) for one hour and measure that temperature at each tap – May not remove biofilms

The American Water Works Association hyper-chlorination method: 50 ppm for 1 hour - Labor intensive - More effective*

GTS Legionella Testing Lab - since 1981 -

www.legionella.com

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Thank you

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Biosafety Training – Legionella Testing