Legionella and Public Health: Importance of Water Management Approach

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2018 SHL Lab Symposium
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Presentation Overview Topics

- *Legionella* bacteria and illness
- *Legionella* ecology and transmission
- *Legionella* growth factors
- *Legionella* outbreaks; lessons learned
- Water management team approach
- *Legionella* environmental sampling and testing
Legionella Cases Increasing

- *Legionella* cases increasing (~4-fold in US; ~3-fold in Europe)
- *Legionella* causes the most outbreaks in community water systems
  - 2007-2008: 60%
  - 2009-2010: 76%
  - 2011-12: 84%

Fig 1. Cases of legionellosis per 100,000 population, by year US

Surveillance for Waterborne Disease Outbreaks, MMWR 64 (31):842-848
Healthcare-associated Outbreaks

- LTCF second most frequent outbreak setting (27 CDC investigations, 2000-2014)
  - Hotels/motels – most frequent
- Healthcare-associated *Legionella* cases accounted for 85% of outbreak associated deaths (27 CDC investigations, 2000-2014)
- Illustrates disproportionate disease burden among hospitalized persons
- More likely to have risk factors of acquiring legionellosis

LEGIONNAIRES’ DISEASE IN NURSING HOMES AND LONG-TERM CARE FACILITIES: AN EMERGING CATASTROPHE

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Abstract: Outbreaks of Legionnaires’ diseases in nursing homes and longterm care facilities have become increasingly cited in newspaper and television reports especially when deaths are involved. News reports can lead to unsubstantiated rumors and widespread disruption of services. A sense of panic can lead to adoption by the facility of expensive, short-term measures that are unscientific and expensive. The worst case scenario is that the measures will also be found to be useless. We present an evidence-based approach that has been successful and cost-effective in longterm care facilities. Environmental cultures of the drinking water for Legionella within the nursing home and longterm care facility is a necessary first step. Infection control personnel should make the key decisions in management of the outbreak. Healthcare facility managers and outside water treatment consultants often make costly and expensive recommendations that will be proven ineffective over time.
New CMS Guidelines: Focus on Water Management

- CMS S&C *Legionella* Memo June 2017
- Requirement to reduce *Legionella* risk in health-care facility water systems to prevent cases and outbreak of Legionnaires Disease

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**Memo:**

**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)

***Revised to Clarify Provider Types Affected***

**Memorandum Summary**

- **Legionella Infections:** The bacterium *Legionella* can cause a serious type of pneumonia called LD in persons at risk. Those at risk include persons who are at least 50 years old, smokers, or those with underlying medical conditions such as chronic lung disease or immunosuppression. Outbreaks have been linked to poorly maintained water systems in buildings with large or complex water systems including hospitals and long-term care facilities. Transmission can occur via aerosols from devices such as showerheads, cooling towers, hot tubs, and decorative fountains.

- **Facility Requirements to Prevent Legionella Infections:** Facilities must develop and adhere to policies and procedures that inhibit microbial growth in building water systems that reduce the risk of growth and spread of *legionella* and other opportunistic pathogens in water.

- **This policy memorandum applies to Hospitals, Critical Access Hospitals (CAHs) and Long-Term Care (LTC). However, this policy memorandum is also intended to provide general awareness for all healthcare organizations.**
Legionellosis

- Illness caused by *Legionella* bacteria
- Two forms
  - Legionnaires Disease: severe form of pneumonia
    - Frequently leads to hospitalization
    - 25% fatality rate when health-care related
  - Pontiac fever: self-limiting, flu-like symptoms
- Incubation period 2-10 days
Signs and Symptoms

- Cough, shortness of breath, fever, headache, lethargy, confusion, muscle aches, nausea, diarrhea, abnormal chest x-ray
- Not unique for LD; must test to confirm

Legionnaires’ disease symptoms

- Headache
- Confusion
- Fever
- Chills
- Tiredness
- Cough
- Shortness of breath
- Muscle or body aches
- Nausea
- Vomiting
- Diarrhea
Legionellosis Transmission Pathway

- Not your classic waterborne pathogen
- Inhalation/aspiration of aerosolized droplets of water contaminated with *Legionella* from man-made water systems

Legionnaires’ disease, a type of severe pneumonia, is caused by breathing in small droplets of water that contain *Legionella*. 
Legionellosis Risk Factors

- Risk factors: >50 years age, underlying medical conditions: chronic lung or immunosuppression, travel, smoking
  - Residents in LTCFs have many of these risk factors
- Person to person transmission v rare (one case)
- 3 transmission classifications: healthcare associated, travel-related or community-acquired
Legionella Reservoir

- Commonly found in soil and water
- **Ubiquitous** in our freshwater environment worldwide; lakes, rivers, streams
- Exposure in this natural setting does not cause illness
Where *Legionella* Can Grow

*Legionella* can live and grow in these manmade devices:

- Water Distribution systems
- Water heaters, hot and cold water storage tanks, showerheads and hoses, water filters, etc.
- Cooling Towers
- Decorative Fountains
- Whirlpool spas
- Ice Machines
- Humidifiers

1. **Legionella Source/Manmade device**
   (water system, cooling tower or spa)

2. **Amplification**
   (e.g. heat)

3. **Aerosolization**
   (mist, v. small droplet size)

4. **Susceptible Host**
   (immunosuppression)

5. **Disease**
   (legionellosis)
Survival Mechanisms in the Environment
Association with Biofilms

- Survives within biofilms
- Biofilm offers shelter and nutrients
- Evades biocide treatment

Control of biofilms – best control measure to prevent legionellosis

Biofilm Concept

• group of microorganisms that stick to each other and onto a surface
• cells become embedded within a slimy extracellular matrix
• three dimensional structure
• represent a community lifestyle (“cities for microbes”)
• very resistant to disinfectants (and antibiotics)
Legionella Colonization

Legionella bacteria introduction

Heavy colonization and slime layer

Disinfectant levels must be CONSISTANTLY maintained to limit amplification
Factors that lead to \textit{Legionella} Growth

Man-made Aquatic Devices

- Ideal warm temperature
  - Optimum growth range: 25-42 °C (77-108°F)
  - Survives 50-55 °C (124°F)
  - Death: >60 °C (140°F)
- Inadequate disinfect levels
- Water stagnation
- Scale and sediment
- Biofilm
- Construction/main breaks
- Changes in water quality
Association with Amoebae

- Survives as intracellular parasites of free-living protozoa
- Ability to multiply intracellularly
- Explains how survives in environment
- Evades biocides
Legionella Taxonomy

- Family: Legionellaceae
- Genus: Legionella
- Species: ~60
  - *Legionella pneumophila* Serogroup 1 – accounts 80-90% reported cases in US
  - The name “*Legionella*” was derived from original outbreak at the 1976 American Legion Convention in Philadelphia; in Greek “pneumophila” means lung-loving
- Opportunistic pathogen
Legionella Outbreaks CDC 2000-2014


Potable Water: 56%

27 Outbreaks:
56% Healthcare
44% Hotels
Outbreak Deficiencies CDC 2000-2014

- Most frequent deficiencies
  - Process failures (65%)
    - 70% inadequate water disinfectant levels
    - 53% water temperatures in optimal Legionella growth range
- Multiple common preventable maintenance deficiencies identified
- Highlights importance of comprehensive water management programs for water systems

Legionella
Air Conditioning Systems

- Bellevue-Stratford Hotel, Philadelphia, PA
- August 1976 –thought possibly BT event
- Exposure to lobby
- 221 cases/ 34 deaths
- Epi data suggests air conditioning but scheduled for renovation – no samples available
Legionella

Cooling Towers

- Transmission source for legionellosis since the 70’s
- *Legionella* cultured in up to ~50% of towers (PCR+ 84%)
- Many of the largest LD outbreaks assoc. w/ CT
  - 2015 New York Bronx (138 cases; 55 CTs; 16 deaths; medically vuln community)
  - Improper maintenance
  - New law governing operation and maintenance of NY CTs

Legionella
Potable Water Distribution System Outbreaks
(Three Large Hospitals)

<table>
<thead>
<tr>
<th>Location</th>
<th>Period</th>
<th>Cases</th>
</tr>
</thead>
<tbody>
<tr>
<td>Los Angeles, CA</td>
<td>1977-80</td>
<td>175+</td>
</tr>
<tr>
<td>Pittsburgh, PA</td>
<td>1979-81</td>
<td>100+</td>
</tr>
<tr>
<td>Iowa City, IA</td>
<td>1981</td>
<td>24</td>
</tr>
</tbody>
</table>

UIHC Cases in new hematology-oncology unit.

*Lpn1* isolated from one 2,000 gallon hot water storage tank and numerous water taps in unit.
Slovenia Nursing Home Outbreak 2010

- First case detected Aug 19; UA+ (Lpn1)
- Upon investigation, 9 residents had symptoms prior to Aug 19; none tested for LD
- LD confirmed in 10 patients
- Various *Legionella* species isolated from 64 enviro samples
  - Numerous closed pipes, no flow


<table>
<thead>
<tr>
<th>Symptoms</th>
<th># Cases</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fever</td>
<td>10</td>
</tr>
<tr>
<td>Cough</td>
<td>7</td>
</tr>
<tr>
<td>Diarrhea</td>
<td>3</td>
</tr>
<tr>
<td>Confusion</td>
<td>3</td>
</tr>
<tr>
<td>Pneum x-ray</td>
<td>5</td>
</tr>
</tbody>
</table>
### Legionella Whirlpool Major Outbreaks

<table>
<thead>
<tr>
<th>Location</th>
<th>Period</th>
<th>Cases/ Deaths</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cruise Ship</td>
<td>1994</td>
<td>50/0</td>
</tr>
<tr>
<td>Netherlands (indoor flower exhibition-whirlpool display)</td>
<td>1999</td>
<td>200/28</td>
</tr>
</tbody>
</table>
Source in Whirlpool

- *Legionella* was isolated from outbreak whirlpools
- Exposure to spas associated with disease
- Clinical and environmental isolates exact fingerprint match – confirmed source
- Filters not properly maintained
  - Low disinfectant levels
  - *Legionella* biofilm growth in filter
General *Legionella* in Water

Prevention Strategies

- Prevent amplification in manmade aquatic systems
  - Keep hot water hot (and cold water cold)
  - Keep water moving
  - Ensure adequate disinfection and temperatures correct
  - Maintain equipment (e.g. periodic sediment removal in tanks)

Maintenance and Monitoring
How to meet the standards and regulations
DATE: June 02, 2017

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First Legionella standard in US; ASHRAE 188-2015
ASHRAE Standard 188-2015

- Only available through membership or purchase
- **Purpose**: establish minimum Legionellosis risk management requirements for building water systems
- **Scope**: design, construction, commissioning, operation maintenance, repair, replacement, expansion of new and existing building water systems.
- **Describes principles of a water management program**
- All elements are outlined in CDC Toolkit
Toolkit Bottom Line

Water Management Program Steps

• Identify building systems when *Legionella* control measures are needed
• Assess risk of the hazardous conditions
• Apply control measures to reduce hazardous condition (prevent *Legionella* growth and spread)
• Make sure program is running as designed and effective
Per CDC Toolkit:

DEVELOPING A LEGIONELLA WATER MANAGEMENT PROGRAM

Identifying Buildings at Increased Risk

Survey your building (or property) to determine if you need a water management program to reduce the risk of Legionella growth and spread.

If you answer YES to any of questions 1 through 4, you should have a water management program for that building’s hot and cold water distribution system.

<table>
<thead>
<tr>
<th>Healthcare Facilities</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yes ___ No ___ 1. Is your building a healthcare facility where patients stay overnight or does your building house or treat people who have chronic and acute medical problems† or weakened immune systems?</td>
</tr>
<tr>
<td>Yes ___ No ___ 2. Does your building primarily house people older than 65 years (like a retirement home or assisted-living facility)?</td>
</tr>
<tr>
<td>Yes ___ No ___ 3. Does your building have multiple housing units and a centralized hot water system (like a hotel or high-rise apartment complex)?</td>
</tr>
<tr>
<td>Yes ___ No ___ 4. Does your building have more than 10 stories (including basement levels)?</td>
</tr>
</tbody>
</table>
Water Management Program Steps

1. Establish a water management program team
2. Describe the building water systems using text and flow diagrams
3. Identify areas where Legionella could grow and spread
4. Decide where control measures should be applied and how to monitor them
5. Establish ways to intervene when control limits are not met
6. Make sure the program is running as designed and is effective
7. Document and communicate all the activities
Build a team

- Building owner or building manager/administrator
- Maintenance or engineering employees
- Contractors/consultants (e.g., water treatment professionals)
- Infection Preventionist
- Risk/Quality Management /Safety Officers and Accreditation specialist
- Consider Person with specific experience in *Legionella* bacteria in building water systems

In some cases, you may need to train your in-house personnel or hire professionals with *Legionella* experience.
Describe Water System

- Develop a written description of the building or water distribution system(s)
- Develop a process flow diagram (keep it simple)
Identify Problem Areas: Control Points

- Where *Legionella* could grow and spread
- Identify areas where hazards could occur
  - Stagnation
  - Ideal temperature
  - Low or no disinfectant
  - Conditions for spread
    - water aerosolization- showers whirlpools, water features
  - External Hazards
Develop Control Measures, Limits and Corrective Actions

- Includes controls for each control point to reduce the risk of *Legionella* growth

**SUCH AS:**

- physical controls
- temperature management
- disinfectant level control
- visual inspections
- environmental testing for pathogens.
Chlorine Sample Procedure


IDNR YouTube video; how to measure chlorine residuals
Control Measures Examples

Make sure changes that may lead to Legionella growth are not occurring

- System water quality (e.g. chlorine residuals) measured throughout system
  - No drop in chlorine levels
- Water heaters
  - maintained at appropriate temperatures.
- Decorative fountains
  - kept free of debris and biofilm.
- Cooling towers and hot tubs
  - Continuously maintained and regularly monitored.
  - Surfaces with any visible biofilm (i.e., slime) should be cleaned
Corrective Actions

Establish corrective actions when control limits are not met; examples below:

- Biofilm growth seen in decorative fountain
  - Plan states to shut off fountain, drain, scrub with detergent; follow start up procedure and check disinfectant levels; document activities

- Unoccupied floor or wing
  - Plan states daily flushing of sinks at end of the hall; increases frequency of temp and chlorine monitoring (from weekly to daily); document activities
Do you need to test for *Legionella*?

- Is CMS requiring routine environmental *Legionella* testing? **NO**
- But consider testing if:
  - Difficulty maintaining the building water systems within control limits
  - *Legionnaires’* disease associated with the building water systems
Laboratory Testing

- If testing is chosen to validate the effectiveness of the water management program
  - Laboratory should have environmental testing accreditation (e.g. TNI (The Nelac Institute) or ISO/IEC 17025:2005)
  - Laboratory demonstrate proficiency
    - CDC ELITE (Environmental *Legionella* Isolation Techniques Evaluation Program); two sets of proficiency samples/year; WSLH $500/set
    - SHL has environmental testing accreditation and has been an ELITE member since its inception 2008
Sampling Compared to Coliform Collection (Drinking water)

Similarities

- Method of sample collection can dramatically affect the results!
- Same sterile collection bottles containing 10% sodium thiosulfate for chlorine neutralizing
- Surveillance samples are collected from where you drink the water
- Trouble shooting similar: after positive; recommend strategic sampling
Sampling Compared to Coliform Collection (Drinking water) Differences

**Coliform**
- Sample volume: 100mL
- Cold water
- FLUSH for 2 min; evaluating distribution system lines; NOT distal end
- Remove aerator

**Legionella**
- 1000 mL for drinking water and 100 mL for cooling tower or decorative fountains
- Hot water
- Flush and/or no flush; depends what you are evaluating; line or distal end
  - CDC: collect biofilm swab then flush
  - U of Pittsburg: no flush, first 1000 mL
Legionella Biofilm at Periphery
Sampling Procedure and Potential Sampling Sites

Protocol for collecting environmental samples for *Legionella* culture during a cluster or outbreak investigation or when cases of disease may be associated with a facility.

Sampling should only be performed after a thorough environmental assessment has been done and a sampling plan has been made. This protocol describes how to take standard biofilm swab, bulk water, and filter samples from commonly sampled sites. This protocol may be used in conjunction with the following tools:

- **LEGIONELLA ENVIRONMENTAL ASSESSMENT FORM**
- **SAMPLE DATA SHEET**
- **LEGIONELLOSIS OUTBREAK INVESTIGATION VIDEOS:**
  - Legionella Ecology and an Introduction to Environmental Health and Engineering
  - Conducting and Interpreting the Environmental Assessment
  - How to Make a Sampling Plan
  - How to Sample Potable Water
  - How to Sample Cooling Towers
  - How to Sample Spas and Fountains

Legionella detection

- Filtration and culture-CFU/mL (CDC or SM9260J)
  - All species
- Filtration and PCR-detection or no detection
  - Lpn or *Legionella* sp screen
- IDEXX Legiolert-MPN/100mL
  - Only Lpn1
IDEXX Legiolert™

- Similar to colilert technology; defined substrate packets

- Differences
  - Temp: 39° C; inc 7 days
  - Different QT; must use QT Sealer PLUS
  - Humidity in incubator required
  - Positive: brown or turbidity
Legionella Speciation/Serogrouping

- Required for all VA Hospital positive samples
- Extremely important in health care setting for epi purposes; will guide diagnostic testing
- SHL Legionella speciation: Bruker MALDI-TOF MS
  - Lp serogrouping: DFA Microscopy

SHL MALDI-TOF MS
WGS study of *Legionella pneumophila* strain diversity over time in hospital premise plumbing: Wes Hottel, Valerie Reeb, Nancy Hall and Lucy DesJardin in collaboration with Brian Raphael, CDC

- Results: all strains from two facilities appeared to be genetically stable over time; one cluster of Lpn belonged to ST36 group, known to be assoc. with various outbreaks in US
References

Standard

Standard 188—Legionellosis: Risk Management for Building Water Systems (ANSI Approved)
ASHRAE
Published 2015
www.techstreet.com/ashrae/products/1897561

Guidelines

Guideline 12—Minimizing the Risk of Legionellosis Associated with Building Water Systems
ASHRAE
Published 2000
www.techstreet.com/ashrae/products/232891
(currently under revision)

Legionellosis Guideline: Best Practices for Control of Legionella
Cooling Technology Institute
Published 2008

Model Aquatic Health Code Guidance
Centers for Disease Control and Prevention
Published 2014
www.cdc.gov/mahc/index.html

Laboratory Resources

ELITE Program
Centers for Disease Control and Prevention and Wisconsin State Laboratory of Hygiene
www.cdc.gov/ELITE/Public/Elitel-ome.aspx
In Summary

- Legionellosis is on the rise and presents a serious risk of legionellosis in health-care facilities, esp LTC
  - Residents with many risk factors, legionellae ubiquitous in our water environment, grow and spread in man-made water systems
- CDC Tool Kit is a great tool.
  - Develop a team, assess hazard, develop/implement plan, evaluate/validate plan using CDC tool kit
In Summary (continued)

- Remember preventing *Legionella* is like food safety
  - Keep the hot water hot and the cold water cold
  - Regularly monitor temperature (and disinfectant)
  - Attention to maintenance (of water systems)
- Implementing good management plans at health care facilities will reduce the risk of *Legionella* growth and ultimately reduce disease
In Summary (continued)

- If *Legionella* testing necessary, SHL can help
  - either by performing the testing OR
  - if you are performing the testing, SHL can perform speciation/serogrouping
- In addition, DNA fingerprinting is available for source tracking and confirmation
Any Questions?