Legionella in Building Water Systems: Controlling the Risk

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"With wine comes wisdom,
with beer comes freedom,
with water comes bacteria."
-- Benjamin Franklin
Especially Legionella bacteria!

Today’s Agenda

- Share with you the results of our research
- Legionella in residential water systems; who is at risk?
- Legionella in water systems; flow matters
- Legionella prevention; what works and what doesn’t

Important Facts about Legionnaires’ Disease?

- Legionella pneumonia is a severe form of bacterial pneumonia
- Patients are more likely to be admitted to the ICU
- Empiric antibiotic selection may be ineffective
- High mortality (20-40%)
- Approximately 20,000 cases annually

Who Gets Legionnaires’ Disease?
Data from 487 cases in Allegheny Co., PA

<table>
<thead>
<tr>
<th>Factor</th>
<th>Percentage</th>
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<tbody>
<tr>
<td>Male</td>
<td>60%</td>
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<tr>
<td>Mean age</td>
<td>61</td>
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<tr>
<td>Underlying Cancer</td>
<td>21%</td>
</tr>
<tr>
<td>Transplant</td>
<td>3%</td>
</tr>
<tr>
<td>Dialysis</td>
<td>4%</td>
</tr>
<tr>
<td>Steroids</td>
<td>24%</td>
</tr>
<tr>
<td>Other Immunosuppressives</td>
<td>13%</td>
</tr>
<tr>
<td>Diabetes</td>
<td>19%</td>
</tr>
<tr>
<td>Smoker</td>
<td>39%</td>
</tr>
<tr>
<td>None of the above</td>
<td>26%</td>
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Legionella Species

- Gram negative bacterium – rod shaped
- >50 species, over 60 serogroups
- *L. pneumophila*, serogroup 1 causes approx. 80% of cases (Most virulent)
L. pneumophila, serogroup 1 is the Black Sheep of the Family!

Legionella – Is Elusive

- Free living amoebae (Hartmanella, Naegleria, Acanthamoeba) are abundant in water.
- They feed on Legionella and other bacteria by phagocytosis.
- Ingested Legionella are not destroyed; they survive, multiply and are released.

Hundreds of Legionella from a single Amoeba (acanthamoeba polyphaga)

Risk of Acquiring Legionnaires’ Disease is Multi-factorial

Legionella in water (reservoir) + Transmission to the host (exposure) + Susceptible Host

Modes of Transmission of Legionnaires’ disease

- Aerosolization
- Aspiration
- Direct instillation into the patient (tap water rinsing of Nasogastric tubes, respiratory tubing, etc)

Facts or Folklore?

- Legionella bacteria are everywhere (ubiquitous) – even in homes?
- Stagnation is a key for Legionella growth in water systems
- Showering is a major mode of transmission
Legionella in Residential Water Systems

- The Environmental Protection Agency (EPA) funded this study of community-acquired Legionnaires’ disease.
- 35 cases of Legionnaires’ disease were identified in Ohio and Pennsylvania.
- If the identical strain of Legionella that infected the patient was found in the home water system = home water was the source of infection.

Results

- *Legionella pneumophila* was the disease-causing species for all cases.
- And was isolated from the home water systems of 24% (5/21) of cases.
- Molecular typing matched infecting strains to environmental strains.
- Electric hot water heaters were more likely to be positive vs. gas (43% vs. 12%).
- Electric hot water tank temperatures were significantly lower than gas (37.3°C vs. 50.9°C).
- Legionella positivity associated with lower temperature.

Remediation: Heat & Flush

- Increase hot water tank temperature to maximum setting (140°F).
- Flush outlets for 20-30 min.
- Outlet positivity reduced (100% to 0%) in most homes.
- Duration of effect unknown, but expected to be transient.

Conclusions

- Most homes are negative for Legionella – Legionella is not everywhere!
- Legionnaires’ disease can be acquired from residential water systems.
- Case patients had health conditions that increased risk of disease, i.e., cancer, advanced age, immunosuppression.
True or False?
- Stagnation is a key requirement for Legionella growth in water systems

Flow Dynamics and Legionella

Effect of flow regimes on the presence of Legionella within the biofilm of a model plumbing system

Liu et al. 2006 J Appl Microbiol

Higher counts recovered in biofilm of turbulent flow

Results & Conclusions
- Results failed to show that stagnation promoted growth
- Increasing flow velocity leads to higher biofilm density due to mass transfer
- Higher transfer rate results in greater particle deposition
Legionella and Biofilm

- Legionella adheres to surfaces in water
- Warm temperatures promote growth
- Legionella is amplified by growth in and with other microorganisms such as amoebae

Scientific Evidence Debunks Long-Held Beliefs

- Stagnation is NOT a key requirement for Legionella growth in water systems
- But what about Showering...is it a major mode of transmission?

Case Report

- “The patient did not bath or shower during his stay. Nurses reported, however, that the patient had ingested tap water from an unprotected faucet in his room during a period of highly impaired cell-mediated immunity”
  - Mathys W. 1999. J. Hosp Infection

Most studies have not linked showering with Legionnaires’ disease

<table>
<thead>
<tr>
<th>Author</th>
<th>Organization</th>
<th>Year</th>
<th>Study Type</th>
<th>Link to showering?</th>
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<td>1981</td>
<td>Anecdotal case-control</td>
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<td>Ezzedine</td>
<td>Belgium</td>
<td>1983</td>
<td>Observational</td>
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<td>Shands</td>
<td>CDC</td>
<td>1985</td>
<td>Case-control</td>
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<td>Breiman</td>
<td>CDC</td>
<td>1990</td>
<td>Case-control</td>
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<tr>
<td>Blatt</td>
<td>TX</td>
<td>1993</td>
<td>Case-control</td>
<td>No, p&lt;.05</td>
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<td>Koel</td>
<td>CDC</td>
<td>1998</td>
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Legionella: It's hard to kill

- Chemical biocides are effective in the right combination
- Potable water disinfection is still a challenge
- New technologies under evaluation
**Legionella Disinfection Methods: Status of Evaluation Criteria**

### State-of-the-Art Disinfection Methods:
- Copper-silver ionization (continuous).
- Thermal shock treatment (heat & flush).
- Shock chlorination (>10 mg/L residual), may require water tanks to be 20-50 mg/L.
- Continuous supplemental chlorination (2-4 mg/L).
- New Technology – Chlorine Dioxide (ClO₂).
- Point-of-use filtration.

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**Thermal Eradication (Heat & Flush): Not a Simple Solution**

- **Advantages:**
  - Quick and effective
- **Disadvantages:**
  - 30 min. flush at 71°C (160°F)
  - Scald potential
  - Rapid recolonization

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**Guideline Says….thermal eradication**

- Temperature at the taps do not fall below 60°C; run water at least 5 minutes.
  - Health & Safety Commission (HSC)
- Raise temperature to 71°C-77°C (160-170°F) and flush each outlet for a minimum of 5 minutes.
  - Optimal flush time is not known and longer times may be required.
  - Centers for Disease Control & Prevention (CDC)

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**Problems Encountered with Thermal Disinfection**

- Shorter duration of flush times resulted in failure to significantly reduce Legionella colonization
- Temperature raised to 80°C and all outlets flushed for 5 min.
  - Outcome = Legionella concentrations remained the same as before disinfection!

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**Others Have Experienced the Same Lack of Efficacy**

- Failure of Superheat-and-flush and Disinfecting Taps in Controlling Legionella Colonization in a Hospital Water System
- Flushed 3000 outlets for 5 min. with 60°C water, disinfected taps and showerheads.

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**Results**

- Legionella in ICU distal outlets reduced from 80% to 25%, but increased 2 months later to 93% positive.
- Conclusion: Abandoned this method for an alternative disinfection approach.

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Guideline says …for routine storage and distribution

- Hot water should be stored above 60°C (140°F) and circulated with a minimum return temperature of 51°C (124°F).
  - Am Soc. Heating, Refrigeration and Air-conditioning Engineers (ASHRAE Guideline 12P)

Efficacy of Elevated Recirculation Temperatures in Controlling Legionella

- Kusnetsov tested the efficacy of elevated recirculation temperatures (60-80°C) on distal outlet (taps) positivity
  - From Kusnetsov J., Perola O., et al. 2003. Efficacy of elevated recirculation temperatures on colonization of hospital water systems by Legionellae, mycobacteria and other heterotrophic bacteria potentially hazardous to risk group patients. APMIS

Results

- Peripheral sites remained heavily colonized
- “Keeping hot water temperatures temporarily or constantly high is no more than a good start in the prevention of pathogens in water systems”

Overview of U.S. Legionella Guidance Documents

- Centers for Disease Control and Prevention (CDC)
- Environmental Protection Agency (EPA)
- Cooling Technology Institute (CTI)
- Joint Commission for Accreditation of Hospitals
- Occupational Safety and Health Administration (OSHA)
- American Society for Heating, Refrigerating, and Air Conditioning Engineers (ASHRAE)
- Allegheny Co. Health Department (Pittsburgh)
- NY & MD State Dept.’s of Health
- Veterans Healthcare System

In 2010 a New ASHRAE Legionella Standard…Ready or Not

ASHRAE Legionella Guideline 12 Will be a STANDARD!

- Key Elements of Standard 188
  - Requirement for Hazard Analysis (HACCP)
  - Documentation of water systems and operation & maintenance as relates to reducing/controlling Legionella
  - Verification that the controls are “in range”
  - Validation that the hazard (Legionella) is under control – culturing is the only way to accurately validate effectiveness of the program
See ASHRAE Journal Article on www.legionella.org

Our Current Research

ASHRAE Project 1361-RP:
Biological Control in Cooling Water Systems
Using Non-Chemical Water Treatment Devices

Dr. Radisav Vidic (Principal Investigator)
Dr. Janet Stout (Co-Investigator)
Scott Duda (Graduate Student Researcher)

University of Pittsburgh
Department of Civil & Environmental Engineering

Evaluation of Non-chemical Treatment Devices

- Magnetic fields
- Electric fields
  - pulsed
  - and static
- Ultrasonic radiation
- Cavitation ( acoustic and hydrodynamic)

Presentation at ASHRAE Meeting
June 27, 2010

This Presentation is Available – send your request to info@specialpathogenslab.com

Informational Website (FAQ’s)
www.legionella.org

www.specialpathogenslab.com
412-281-5335
Legionella...a worthy opponent!

Thank You!