Waterborne Diseases

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Learning Objectives

Upon completion, participants should be able to:

- Describe waterborne diseases
- Discuss when to suspect healthcare-acquired *Legionella*
- Explain methods to control *Legionella* spp in healthcare settings

Outline

- Background on waterborne pathogens
- Case study
- Control and prevention methods for *Legionella*
Background on Waterborne Pathogens

Global Impact

- Waterborne pathogens are among the most common causes of disease worldwide with most diseases due to unsafe drinking water, poor sanitation, sewage and fecal contamination.
- More than 2 million deaths annually are caused by waterborne disease, most in children under age 5.
- Natural disasters such as floods, earthquakes, and hurricanes can cause disruption of drinking water and contamination with sewage.
- Even in the absence of natural disasters, more than 2.5 billion people do not have access to basic sanitation and are at risk of acquiring waterborne diseases.

Waterborne Pathogens

- Cryptosporidium
- Giardia
- Hepatitis A and E
- Legionella
- Naegleria fowleri
- Norovirus
- Salmonella/E. coli/Campylobact/Shigella
- Vibrio

Waterborne Illnesses

- Infection occurs after ingestion or inhalation of water mists OR following exposure of non-intact skin to water contaminated with enteric pathogens
- Water sources include drinking water, water parks, swimming pools, fountains, hot tubs, lakes, rivers, and flood waters after natural disasters
- Contamination usually occurs when sewage containing enteric pathogens comes into contact with water sources
- Food can also become contaminated by enteric pathogens via irrigation methods
- Most waterborne pathogens are generally not healthcare acquired
Symptoms of Waterborne Illnesses

- Diarrhea
- Conjunctivitis/ear infections
- Skin infections
- Hot tub lung

Why Do Outbreaks Occur?

- Some pathogens are chlorine resistant
- Chlorine levels may be inadequate
- Not all water sources are chlorinated
- Water runoff after heavy rain can increase bacterial contamination
Challenges in Monitoring Waterborne Pathogens

- No one system of monitoring currently exists
- Methods that rely on indicator organisms such as *E. coli* may miss other species
- Some organisms are difficult to culture
- Methods used have to be sensitive, specific, easy to perform, and inexpensive

Milwaukee, WI: *Cryptosporidium* Outbreak

- In 1993, Milwaukee experienced the largest outbreak of drinking-water–related *Cryptosporidium* in the US because of ineffective filtration at 1 of 2 municipal water treatment plants
  - More than 400,000 individuals (25% of Milwaukee’s population) became ill
  - Costs exceeded $96 million
- First clues of the outbreak were pharmacies selling out of anti-diarrhea medications and increased ED visits for GI illness
- 69 people died; 93% had underlying HIV infection
- People were sick an average of 9 days with 12 stools per day; 1% were hospitalized
Flint, MI: *Legionella* and *Shigella* Outbreaks

- On 4/25/2014, Flint’s water source was changed from Lake Huron to Flint River, resulting in the corrosion of pipes and increased lead and other contaminants in the water
- Increased lead levels were found in children younger than 6 years
- Residents were advised to not drink the water on 10/15/15
- Water contamination may have contributed to *Legionella* outbreak that resulted in multiple deaths
- Outbreak of *Shigella* occurred because individuals were avoiding bathing in the contaminated water
- Increase in skin rashes, but no clear cause found

Multiple States: Waterborne Pathogen Outbreaks Following Hurricane Katrina

- Skin lesions/rashes and MRSA outbreaks reported in shelters
- Outbreaks of *Vibrio vulnificus* and *Vibrio parahaemolyticus*
  - 18 wound-associated cases, likely due to abrasions and contamination with floodwater
  - 4 non-wound associated cases of Vibrio infection
- More than 1,000 cases of diarrhea reported in adults and children, some due to norovirus, salmonella, and *Vibrio*; all within 3 weeks after evacuation


Case Study

- You are the director of infection prevention at a hospital located in an area with recent flooding after a hurricane; the hospital experienced some flooding in non-patient-care areas, and construction is underway.
- It’s 4:55 pm on Friday afternoon, and you receive a call from a critical care physician concerned about a patient who was readmitted to the hospital with confusion, hyponatremia, and a right lower lobe infiltrate; the patient was discharged the week before after being admitted for an acute COPD exacerbation.
Case Study

- On Monday morning, you look up the lab results on the patient
- The patient’s urine test is positive for the *Legionella* antigen
- What’s your next step?

**Legionella**

- At least 60 species of Legionella, half of which have been associated with human disease
  - Majority of cases caused by *L. pneumophila*
- Bacteria survive as intracellular parasites of amoebae, protozoa, or slime molds and can enter a non-replication state in low-nutrient environments, making them more resistant to biocides
- Water conditions that promote bacterial growth include:
  - Heat (68-122 F)
  - Water stagnation
  - Biofilm
  - Sediment

**Legionella Transmission**

- *Legionella* spp have been found in a wide range of aquatic habitats, including lakes, streams, air conditioning cooling towers, potable water, fountains, and spa baths.
- Colonization in hot-water-distribution systems in hospitals is common.
- Transmission occurs usually by the organism being inhaled from mist or aspirated.
- Exposure to contaminated soil has also been linked to infection.
- One incident of person-to-person transmission reported.

**Legionella Epidemiology**

- Reported *Legionella* cases have been on the rise since 2000.
  - More illnesses in the summer and early fall.
  - Increased rainfall is associated with increased risk.
  - True incidence may be higher due to *Legionella* being underdiagnosed.
- Most outbreaks are community rather than healthcare-associated (nosocomial).
- Cause of atypical CAP in some areas.
Nosocomial *Legionella*

- Nosocomial cases of *Legionella* are underrecognized and even one case may signal an outbreak.

**16 of 21 Jurisdictions Reported Definite Cases of Healthcare-Associated Legionnaires’ Disease (LD) in 2015**

*Alaska had no cases to report.

Reported definite cases of healthcare-associated LD
Did not report a definite case of healthcare-associated LD
Not included in the analysis: jurisdictions reporting less than 90% of *Legionella* infections to SLDSS, which contains information such as healthcare facility exposures.

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People at Increased Risk of *Legionella*

- People 50 years or older
- Current or former smokers
- People with a chronic lung disease
- People with underlying illnesses like diabetes, kidney failure, or liver failure
- People with weak immune systems or those on immunosuppressants
- People with cancer

Factors That Can Lead to *Legionella* Growth

- Changes in water pressure due to construction or water main breaks
  - Can disrupt biofilm and free *Legionella*
- Changes in municipal water quality
- Use of electronic-eye faucets
  - More likely to be contaminated with *Legionella* than manual faucets
- Failure to replace water system filters
  - Allows for build-up of sediment and biofilm
- Water stagnation in rarely used faucets, tubs, or showers


Clinical Signs and Symptoms of *Legionella*

- Symptoms include cough, fever, anorexia, headache, myalgia, nausea, vomiting, diarrhea, mental status changes, seizures, and delirium
  - Cough is purulent in 50% of patients, sputum is usually thin with few WBCs
  - Extra-pulmonary infection can occur but is rare
- Pontiac Fever has symptoms of primarily fever and muscle aches and is a milder infection than Legionnaire’s disease

Diagnosing Legionnaire’s Disease

- Laboratory test findings may be nonspecific and shared with CAPs that mimic Legionnaire’s disease
- Nonspecific laboratory abnormalities associated with Legionnaire’s disease include:
  - Hyponatremia
  - Decreased serum phosphorus
  - Elevated CPK
- CXR shows all types of lung infiltrates

Diagnostic Testing

- Culture of lower respiratory tract secretions, and lung tissue or pleural fluid is definitive, but usually not available in most hospitals
  - Direct comparison between clinical and environmental isolates
  - Positive culture can be determined within 48-72 hours, and the test can stay positive for several weeks or months
  - Negative test doesn’t rule out legionella
  - Sensitivity lower for nosocomial legionella, as those infections are more likely from strains other than L. pneumophila serogroup I
- Paired serology can be used
- Direct fluorescent antibody may be helpful

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<th>Specificity (%)</th>
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<td>Polymerase chain reaction</td>
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Who Should Be Tested for *Legionella*?

- Anyone who has failed outpatient antibiotic therapy for pneumonia
- Anyone admitted to the ICU with pneumonia or severe CAP
- Immunocompromised patients
- Patients with a travel history or an overnight stay in a healthcare facility within 14 days before the illness (10% of cases associated with travel)
- Patients with pneumonia in the setting of an outbreak
- Anyone with pneumonia ≥ 48 hours after admission to healthcare facility


Investigation of Cases

- **Case definition**
  - If ≥1 definite healthcare-acquired (patient spent the entire prior 10 days in healthcare facility) or ≥ 2 possible healthcare-associated cases (patients spent part of prior 10 days in same facility before symptoms began) occurs, conduct an investigation
- Exposure/epidemiologic history
- Environmental sampling

CDC. Guidelines for Preventing Health-Care–Associated Pneumonia. www.cdc.gov.
Control and Prevention Methods for *Legionella*

Facility Requirements to Prevent Legionella Infections

- On June 2, 2017, the Centers for Medicare and Medicaid Services at the Department of Health and Human Services issued a memo stating that:

  *Facilities (hospitals, CAHs, and LTC) 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.*

Immediate Control Methods

- Superheat and flush
- Hyperchlorination
- Point-of-use filtration

Long-Term Control Methods

- Copper-silver ionization (CSI)
  - *Legionella* can develop tolerance to silver ions, and higher concentrations may be needed over time; copper can precipitate at alkaline pH, leading to decrease in efficacy

- Monochloramine
- Chlorine dioxide
  - Useful over a broader range of pH (6.0-8.5)
CSI

- Copper and silver ions are both bactericidal against *Legionella* and other waterborne pathogens
  - Copper ion concentration should be tested weekly with a field colorimeter kit
  - Silver ion concentration testing is more complex and should be done every 2 months
- For a typical 250-bed hospital's hot water recirculating line, the cost of an ionization system is ~$40,000 to $50,000
  - Relatively easy to install and maintain
  - Elevated pH and low ion concentration may compromise efficacy
  - Failures of the ionization system to prevent *L. pneumophila* in hospitals have occurred due to resistant organisms and inadequate ion levels


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Chlorine Dioxide

- Method used in Europe since the 1940s
- Advantages of chlorine dioxide disinfection include:
  - Superior penetration into biofilms compared with chlorine
  - Biocidal action maintained over a wider pH range compared with chlorine and CSI
- Disadvantages include:
  - Prolonged time before significant reductions in *Legionella* positivity rate
  - Reactions with organic material and corrosion scale in piping can produce chlorite and chlorate, which may pose health risks
  - Challenging to maintain effective residual concentration
- Cost varies depending on whether the equipment is purchased or leased

Monochloramine

- This water treatment has not been evaluated as extensively as chlorine dioxide or CSI
- Monochloramine provides a steady residual that penetrates biofilm and has a wider working pH range than chlorine or CSI
- Disadvantages include that it may cause drinking water to take on an ammonia odor, and it may cause an increase in other microorganisms (Mycobacterium species)

Conclusions

- Outbreaks of a number of different waterborne diseases can occur after natural disasters.
- Disruption of water and fluctuations in water pressure can have specific implications for healthcare facilities and can increase the risk of *Legionella*.
- Even one case of healthcare-acquired *Legionella* is concerning and warrants further investigation.
- A water-management policy is an important component of infection prevention.

Additional References

- Emergency Preparedness and Response Preparation and Planning. Centers for Disease Control and Prevention. [emergency.cdc.gov/planning/](emergency.cdc.gov/planning/)