Babies, and Biofilms: An Outbreak of *Pseudomonas aeruginosa* in a neonatal intensive care unit

Division for Healthcare Quality Promotion
Centers for Disease Control and Prevention

TSICP
April 2018
Game Plan

- Pseudomonas basics
- NICU outbreak investigation
- NICU water quality
- Take-home points
**Pseudomonas aeruginosa (PA)**

- An important cause of serious healthcare-associated infections (HAI)
- Water-associated pathogen
- Common in healthcare environments
Water Basics: Biofilms

- Group of microorganisms that stick together
  - Many different organisms
  - Many different strains of the same organism

- Surrounded by a slimy extracellular matrix
  - Protects bugs from antimicrobials
  - Ability to grow at extreme temperatures
  - Require higher levels of disinfectants

- Can form on almost any surface in an aqueous or humid environment
Transmission of PA, March – October 2016

Eight cases of *Pseudomonas aeruginosa* in a neonatal intensive care unit (NICU)

<table>
<thead>
<tr>
<th>Month</th>
<th>Case Count</th>
</tr>
</thead>
<tbody>
<tr>
<td>March</td>
<td>1</td>
</tr>
<tr>
<td>April</td>
<td>1</td>
</tr>
<tr>
<td>May</td>
<td>0</td>
</tr>
<tr>
<td>June</td>
<td>0</td>
</tr>
<tr>
<td>July</td>
<td>2</td>
</tr>
<tr>
<td>August</td>
<td>2</td>
</tr>
<tr>
<td>September</td>
<td>0</td>
</tr>
<tr>
<td>October</td>
<td>2</td>
</tr>
<tr>
<td>November</td>
<td>0</td>
</tr>
</tbody>
</table>

NICU Closure 1
Enhanced Water Treatment

NICU Re-closure
Epi-Aid requested

NICU Reopens
Continuous enhanced water treatment
Welcome to the NICU

- Incubator: protect baby from fluctuations in humidity
- Breast pump: maintain nutrition
Objectives of Investigation

▪ Define outbreak scope

▪ Identify *Pseudomonas transmission risks* related to water exposures

▪ Review *water management practices* and water sampling results

▪ Provide *recommendations* to decrease risk of further transmission
Case Definition

- Clinical or surveillance culture positive for *Pseudomonas aeruginosa*
- Patient receiving care in the NICU at Hospital A at the time of positive culture collection
- March 2016 to October 2016
Records Review and Interviews

- Reviewed laboratory and medical records
- Interviewed
  - Nursing
  - Facilities management
  - Environmental services
  - Respiratory therapy
Hospital Water in the NICU: Management and Use

- Hospital water management
  - Supplemental chlorination
  - Point-of-use filters
  - Water quality testing

- Potential water exposures in the NICU
  - Sink use
  - Breast milk preparation
  - Reprocessing of reusable breast pump equipment
  - Water used in isolette humidifier reservoirs
Laboratory Methods

▪ Targeted environmental sampling of equipment, breast milk, and surfaces

▪ Sampling of post-filter tap water from NICU sinks

▪ Comparison of clinical and environmental isolates using pulsed-field gel electrophoresis (PFGE)
## Case Investigation Results

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>n/N (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Gestational age</strong></td>
<td></td>
</tr>
<tr>
<td>(weeks)</td>
<td>Median (range)</td>
</tr>
<tr>
<td>Female</td>
<td>3/8 (37.5)</td>
</tr>
<tr>
<td>On respiratory support</td>
<td>7/7 (100)</td>
</tr>
<tr>
<td>Breastmilk</td>
<td>2/2 (100)</td>
</tr>
<tr>
<td>Born in Hospital A</td>
<td>7/8 (87.5)</td>
</tr>
<tr>
<td>Infected</td>
<td>4/8 (50)</td>
</tr>
<tr>
<td>Colonized</td>
<td>4/8 (50)</td>
</tr>
<tr>
<td>Deaths</td>
<td>2/8 (25)</td>
</tr>
</tbody>
</table>
## Water Sampling Results

<table>
<thead>
<tr>
<th></th>
<th>Pre-Intervention</th>
<th>Post-Intervention</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>HPC (colony-forming units / mL)</td>
<td>Pseudomonas Identified (n=4 sinks)</td>
</tr>
<tr>
<td>Bulk water</td>
<td>3000-6000</td>
<td>Yes</td>
</tr>
</tbody>
</table>

500 CFU/mL
Infection Prevention and Control Practices and Water Exposures

- Splashing
- Tap water for refilling humidifier reservoirs
- Cleaning reusable breast pump equipment
Potential Transmission Pathways

- Municipal water treatment
- Hospital water supply
- ICU sinks
Conclusions

- NICU outbreak of *Pseudomonas*
  - contamination of hospital water system
  - use of water in the NICU

- Multiple potential transmission pathways identified

- Improved water quality alone did not eliminate transmission
Investigation Challenges

- Highly-charged investigation
- NICU closed
Take-home Points
An Unhappy Combo

Water Supply

Vulnerable Population

Infection Control
Employ a Team Approach

- Building engineers
- Water consultant
- Facilities management

- Infection prevention and control (IPC)
- Hospital epidemiologist
- Laboratory
- Risk management

- Nurses
- Surgeons
- Physicians
- Respiratory therapists
- Occupational health

Water Supply

Infection Control

Vulnerable Population
Infection Control Assessments

- Commonly observed practices:
  - Hand hygiene
  - Surgical procedures
  - Use of contact precautions
  - Medication preparation
  - Respiratory therapy
  - Environmental cleaning

- How could water or its vapor be a source of transmission?
Environmental Assessment

- Don’t jump to this without first exploring epidemiology of the outbreak
- Organism of interest will also guide type of sampling
- Only a snapshot of what is happening
- Understand limitations
  - Most clinical labs are not able to do this
  - Require expertise to execute
  - Expensive

What will you do with the results?
Water Sampling: Microbiology

- Especially helpful with gram-negative rods and nontuberculous mycobacteria
  - Culture
  - Heterotrophic plate counts (HPC)

- Challenges:
  - Biofilm sloughing can cause levels in the water to fluctuate over time
  - Residual disinfectant in tap water can decrease yield
Water Sampling: Biochemical

- Residual disinfectant levels
- Free ammonia
- Nitrite/Nitrates

Chloramines  Ammonia  Nitrites Nitrates

Nitrifying Bacteria
Water Basics: Water Distribution Systems

Levels of:
- Microorganism
- Residual disinfectant

Treatment Plant
Water Basics: Amplification

- Complex systems
- Low Flow
- “Dead legs” or areas with stagnant water
- Water temperature
- Loss of disinfectant residual
Search for Water Exposures
Challenges for Water Sampling & Testing

- Large volume water samples required
- Diversity of microbes in water
- May need to remove competing bacteria
- Multiple species grow within the same biofilm
- Lab samples only a few colonies for identification after isolation
Surface Sampling

- Consider possible transmission pathways
  - Mobile medical equipment?
  - High touch room surfaces?

- Challenges:
  - Surface contamination not uniform
  - Yield can be low at baseline, especially if residual disinfectant on surface
Apply Environmental Testing Judiciously

- Environmental testing driven by epidemiology findings
- Understand the bug
- Interpreting lab results can be challenging
- What to do with a positive result?
Consider Multiple Interventions

- **“Pre-faucet”**
  - Municipal supply
  - Shock treatment
  - Supplemental disinfection
  - Flushing protocols

- **Water filters**
- **Replace sink fixtures**

- **“Post-faucet”**
  - Educate
  - Improve IPC
  - Limit source exposure
  - Aerosol-generating activities
Remaining Questions

- Are existing CDC water management guidelines sufficient or applicable for all water-associated organisms?

- How appropriate is the EPA threshold for municipal water systems for vulnerable healthcare populations?

- How can we better understand the relationship between bacterial contamination levels and risk of transmission in healthcare environments?
Questions?

Thank you:
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State A Health Department

For more information please contact Centers for Disease Control and Prevention

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Visit: www.cdc.gov | Contact CDC at: 1-800-CDC-INFO or www.cdc.gov/info

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