Leveraging Partnerships and Advanced Molecular Detection in Healthcare Environmental Investigations

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OUTLINE

- Introduction
- Partnerships in Environmental Outbreak Investigations
- Partnerships in Metagenomic Work
- Next steps and Future Collaborations
Who Performs Environmental Investigations at CDC?

- **National Center for Emerging and Zoonotic Infectious Diseases**
  - Division of Healthcare Quality Promotion
    - Healthcare environmental surfaces
    - Healthcare building water system
    - Other water sources, e.g., hydrotherapy tubs, hemodialysis systems, dental water systems
  - Division of Foodborne, Waterborne, and Environmental Diseases
    - Waterborne Disease Prevention Branch: drinking water; recreational water, oceans/lakes/rivers

- **National Center for Immunization and Respiratory Diseases**
  - Division of Bacterial Disease
    - *Legionella*
    - Drinking water systems, cooling towers, water features

- **National Center for Environmental Health**
  - Non-infectious contaminants in drinking water
Division of Healthcare Quality Promotion (DHQP)

- **Priorities**
  - Protect patients
  - Protect healthcare personnel
  - Promote safety, quality, and value in both national and international healthcare delivery systems
DHQP Priorities: Sooner, Faster, Better

- Accuracy / Precision
- Sensitivity
- Specificity
- More data

Sooner
Faster
Better

Containment

- Early Signal
- Improve turnaround
What is the Healthcare Environment?

- **Dry environment**
  - Examples: Bedrails, bedside tables, IV poles
  - Transiently contaminated by patients and healthcare workers

- **Wet environment**
  - Examples: Premise plumbing, sink drains
  - Biofilm formation in water system may serve as a reservoir for pathogens and antibiotic resistant genetic elements, e.g., plasmids

- **Medical devices**
  - Examples: Heater-cooler units, duodenoscopes
  - Dry, wet, or aerosol-generating
  - Ubiquitous in healthcare, can be multiple-use with inherent difficulties to clean and disinfect or retain moisture
Water Environment: Emerging Role in the Healthcare Infections

- **Supply:**
  - Contaminated premise plumbing combined with water usage near at-risk patients can lead to transmission
  - *Legionella*, nontuberculous mycobacteria, Gram negative bacteria

- **Use:**
  - Patient exposure to water is diverse
  - Typical potable use (drinking, bathing) and non-potable (decorative fountains)
  - Healthcare specific: hydrotherapy (physical therapy), dialysis
  - Wetness/moisture: medical devices (bronchoscopes, heater-cooler units), splash zones, aerosol-generation, showers, ice machines

- **Waste:**
  - Several outbreak investigations have detected organism (or plasmid) of interest from sink drains of patient rooms
  - Biofilms in plumbing could serve as a reservoir for resistant Gram negative infections (e.g., carbapenemase-producing Enterobacteriaceae)

- **However, causality is difficult to prove**
How CDC Helps Resolve Outbreaks in Healthcare Facilities
Milestones in an Epi-Aid Investigation

1. CDC receives a call or e-mail from a facility or health department

2. CDC epidemiologist gathers initial information and provides consultation on case finding, lab testing and infection control

3. Health department extends a formal invitation for CDC to help lead an on-site team

4. CDC Epidemic Intelligence Service Officers arrive on-site and help gather additional information from interviews, case/chart reviews, observations and environmental sampling

5. The team analyzes this information to identify risk factors for infection and help develop control measures

6. CDC recommends new or revised measures and steps to prevent more patients from becoming infected or harmed

7. Health department and facility implement recommendations and check to ensure the control measures are working

8. Following the conclusion of the on-site investigation, group communications continue to review what has worked and make adjustments as needed

9. CDC reviews the situation for lessons learned and takes steps to prevent similar outbreaks

Laboratory support of healthcare outbreak responses

- Provide expertise and support to state and regional public health partners and federal agencies (e.g., FDA)
- Unique capacity at CDC to develop and deploy sampling and testing of the patient care environment, medical devices and products
- Testing capacity includes, but not limited to
  - Patient surveillance samples and isolates
  - Implanted and reusable medical devices
  - Intravenous and compounded medications
  - Water, plumbing fixtures
  - Other: Soil, medicinal leeches, human remains, breast milk, cosmetics, other complex matrices
- Characterize isolates
  - Species identification
  - Antimicrobial resistance mechanism testing, phenotypic testing (AST)
  - Genotyping by whole genome sequencing and pulsed-field gel electrophoresis
Laboratory support of healthcare outbreak responses

- Provide supporting data for
  - Determination of transmission pathways
  - Implementation of potential control measures
  - Interventions to protect patients

- Support hypothesis development based on epidemiological findings in the field and at Atlanta headquarters
 Council for Outbreak Response: Healthcare-Associated Infections and Antimicrobial Resistant Pathogens (CORHA)
Building Capacity for Public Health and Healthcare to Improve Outbreak Detection, Response, and Prevention

**Background**
Healthcare-associated Infections (HAI) including antimicrobial resistant (AR) pathogens cause hundreds of thousands of illnesses and deaths among U.S. patients each year. Despite significant progress, patients are still experiencing preventable harms related to outbreaks and other adverse events from delayed recognition of infectious diseases with the potential for healthcare transmission, unsafe healthcare practices, contaminated drugs, and medical device risks. Consistent and coordinated approaches are needed to:

- **Speed-up detection of emerging threats**
- Develop tools to support outbreak investigations
- Prevent outbreaks from spreading
- Better inform prevention activities.

To address these needs, the Council for Outbreak Response (CORHA) was created.

CORHA will function as a multidisciplinary collective representing the interests of healthcare consumers, the medical community, state, local and territorial public health authorities, professional associations, and federal agencies.

**Mission**
To improve practices and policies at the local, state, and national levels for detection, investigation, control and prevention of HAI/AR outbreaks across the healthcare continuum, including emerging infections and other risks with potential for healthcare transmission.

**Vision**
Public health and healthcare collaborating effectively to protect patients and prevent harms from HAI/AR outbreaks.

High-level outputs will include:
- **Best practices for improved detection of potential outbreaks using existing data sources**
- Laboratory best practices to support outbreak detection and investigations
- Suggestions for improving data management for outbreak investigation and response activity tracking
- Suits of event-specific reference tools

**Workgroup activities** – focus on tasks to develop products that address strategic priorities

**CORHA Next Steps**

**Leverage and complement related activities and investments** – Help collective efforts to improve HAI/AR response activities nationally, making them more consistent and effective

**Detailed and comprehensive reference tools** – identify gaps in current evidence, develop additional evidence, and implement recommendations

**Organizational Structure**

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**Organizational Structure**
Advanced Molecular Detection (AMD) and Outbreaks

- Environment is integral component of healthcare

- Without brilliant collaboration between SPHL, healthcare facilities, and CDC, some point sources would never be found

- Next generation sequencing provides additional, more granular data in outbreak investigations

- Improving detection of pathogens in the environment

  - Standard Methods: 8 weeks or more
  - Sequencing: 4 weeks
Carbapenem-resistant Enterobacteriaceae (CRE) Kentucky 2015

- Facility identified a cluster of Carbapenem-resistant Enterobacteriaceae (CRE)
- Verona integron-encoded metallo-β-lactamase (VIM)
  - Plasmid-mediated carbapenemase
  - Most commonly found in Mediterranean region
  - Rare in United States
- Traditional typing and whole genome sequencing performed

MMWR- https://www.cdc.gov/mmwr/volumes/65/wr/mm6507a5.htm
Carbapenem-resistant Enterobacteriaceae (CRE) Kentucky 2015

De Man and Yaffee 2017 in prep
Mycobacterium wolinskyi
Kentucky 2013

- Outbreak of post-surgical rapidly-growing mycobacteria infections.
### Mycobacterium wolinskyi
**Kentucky 2013**

#### Tree scale: 0.001

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PARTNERSHIPS IN ENVIRONMENTAL METAGENOMIC WORK
Innovations to Slow Antibiotic Resistance: Environmental Microbiome

- CDC’s Antibiotic Resistance Solutions Initiative
- National Action Plan for Combating Antibiotic-Resistant Bacteria
- Research
  - Discover and develop new approaches for preventing antibiotic-resistant infections and their spread
  - Improve our ability to leverage the microbiome to improve patient safety and public health
- Academic partnerships
  - Broad Agency Announcements (BAA)
  - Prevention Epicenters Program
BAA: Applied Research and Innovations on Antibiotic Resistance Across Healthcare and the Community

- Tracking and detecting antibiotic resistance and antibiotic resistant pathogens in the environment
- Preventing the dissemination of antibiotic resistant bacteria into surface water from healthcare effluent
- Unlocking the microbial ecology of environmental antibiotic resistance
- Assessing spread of antibiotic resistant bacteria from contaminated premise plumbing
Assessment of the Overall and Multidrug-Resistant Organism Bioburden on Environmental Surfaces in Healthcare Facilities

Alicia M. Shams, MPH; Laura J. Rose, MS; Jonathan R. Edwards, MStat; Salvatore Cali, MPH; Anthony D. Harris, MD, MPH; Jess T. Jacob, MD; Anna LaFue, MPH; Lisa L. Pines, MA; Kerri A. Thom, MD, MS; Lloyd C. McDonald, MD; Matthew J. Arluino, DrPH; Judith A. Noble-Wang, PhD

Community Analysis of Environmental Healthcare Surfaces using Next Generation Sequencing

X. Allison Perry, Tom de Man, Allison Lauer-Holjes, and Judith Noble-Wang

Centers for Disease Control and Prevention: Division of Healthcare Quality Promotion: Atlanta, Georgia, USA

Introduction

- Healthcare-associated infections (HAIs) are a significant cause of morbidity and mortality in the United States.
- Up to 2% of inpatients develop HAIs each year, resulting in increased healthcare costs, extended hospital stays, and reduced patient outcomes.
- HAIs are often acquired through contact with contaminated environmental surfaces.
- CDC recommends routine surface disinfection to reduce the risk of HAIs.

Methods and Materials

Sample Collection

- Samples were collected from 10 healthcare facilities across the United States.
- Samples included high-touch surfaces in patient rooms, bathrooms, and common areas.

Library Preparation and Sequencing

- DNA was extracted from the samples and sequenced using Next Generation Sequencing (NGS).
- The sequencing data were analyzed to identify bacterial species and resistance patterns.

Results

- The study found high levels of multidrug-resistant bacteria on environmental surfaces.
- The most common organisms identified were Staphylococcus aureus and Enterococcus faecalis.
- Resistance was observed to multiple classes of antibiotics, including beta-lactams, aminoglycosides, and fluoroquinolones.

Conclusions

- Routine surface cleaning and disinfection are essential to reduce the bioburden of multidrug-resistant organisms.
- Improved infection control practices, including enhanced disinfection protocols, are needed to reduce the risk of HAIs.

References

Prevention Epicenters program

https://www.cdc.gov/hai/epicenters/index.html
Prevention Epicenter
Granular Model of Transmission in Healthcare

University of Utah, Salt Lake City VA
- Develop a granular model of organism movement between patients, environment and healthcare workers
- Model the impact of interventions on transmission events
- Extensive patient, environment and healthcare worker sampling for several weeks in intensive care units
- Clinical data and healthcare worker movement sensor data
- Performing:
  - Culture
  - Whole genome sequencing
  - Metagenomic sequencing
NEXT STEPS AND FUTURE COLLABORATIONS
AMD Partnerships and Collaboration

STATE, COUNTY and LOCAL PUBLIC HEALTH DEPARTMENTS

* Does not imply endorsement by CDC or HHS.
Looking Ahead

- **Improving our ability to leverage new sequencing technology**
  - Better understand environmental microbiome
  - Improve public health response
    - Rapid pathogen detection from environment and clinical diagnostics

- **Partnering with regional/state/local health departments**
  - Building capacity
    - ARLN
    - FDA-CDC AR Isolate Bank

- **Partnering with industry**
  - Applied Maths
    - Develop wgMLST schemes

https://www.cdc.gov/drugresistance/resistance-bank/index.html
In Summary

- Partnerships are critical to:
  - Environmental outbreak investigations
    - Without accurate and complete epidemiological data, interpretation of sequencing data is impossible
  - Advancing environmental research

- We will continue to engage and interact with SPHL and healthcare facilities to promote the use of AMD for HAI pathogens

- Improve public health response, infection control, patient safety
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• Kathy Seiber

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• David Lonsway
• Maria Karlsson
Thank you!

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