Water Testing During Foodborne, Waterborne, and Zoonotic Disease Outbreak Investigations

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OutbreakNet Meeting
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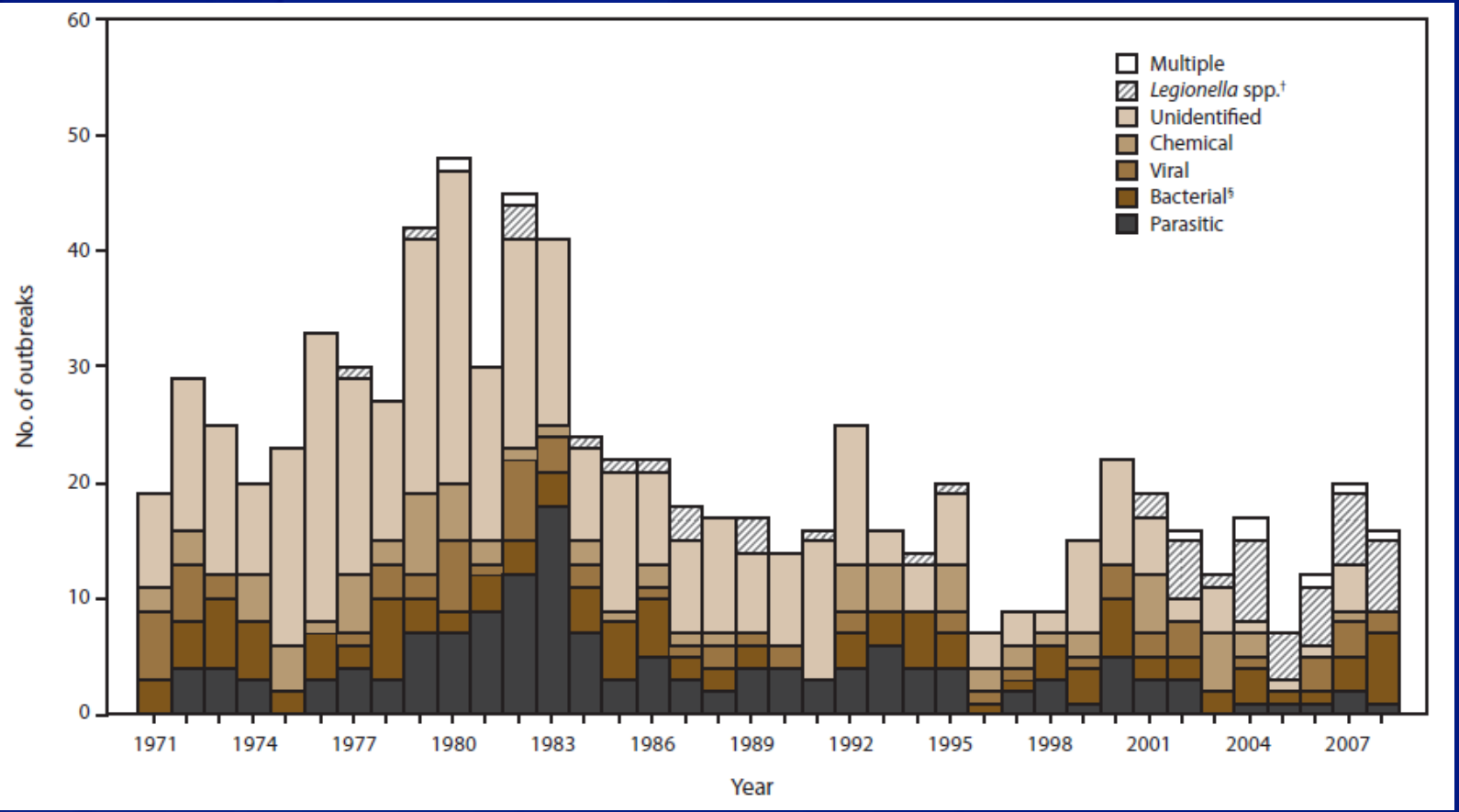
National Center for Emerging and Zoonotic Infectious Diseases
Division of Foodborne, Waterborne, and Environmental Diseases

We contact water every day

Water testing is an investigative tool

- **Water testing can be an effective component of epidemiological investigations**
  - Confirming water source associated with an outbreak
  - Identifying source of fecal contamination
  - Identifying system deficiencies contributing to an outbreak
  - Adding confidence to the conclusions of an epidemiological investigation

Effective investigations need effective methods



Number of waterborne disease outbreaks associated with drinking water, United States, 1971-2008
[Brunkard JM et al (2011) *MMWR*, 60(12):38-75]

CDC Capabilities for Collaborative Investigations

- **Sampling**
- **Sample processing**
- **Rapid pathogen testing via real-time PCR**
- **General water quality testing (e.g., *E. coli*)**
- **Molecular epidemiology testing**
  - PFGE (from culture isolates)
  - Sequencing (pathogen identification, subtyping)

Sampling

- **Grab samples**
  - 100 - 300 mL → water quality testing, microbial indicators
  - 1 - 4 L → swimming pool backflush samples
- **Large-volume filtration**
  - Pre-2004, used microfilter cartridges for viruses and parasites
  - Currently, use ultrafiltration
    - Hollow-fiber ultrafilters (dialysis filters)
    - Dead-end ultrafiltration
    - Performed in field, ultrafilters shipped to lab

Ultrafilter

Local preparedness facilitates rapid response

- **Epidemiology and Laboratory Capacity in Infectious Disease (ELC) Program**
- **2011-2012: Assisted 5 states to develop "Water Sampling Kits"**
  - Peristaltic pump
  - Chlorine test kit
  - Coolers and supplies
    - Ultrafiltration (filters, tubing, connectors)
    - Grab sample bottles
    - Sodium thiosulfate
    - Gloves, scissors, ice packs, ziploc bags, markers, data sheets

Sample processing: linking collection to analysis

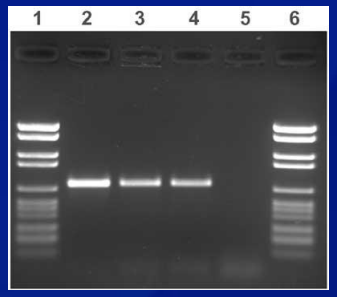
- Membrane filtration → bacteria

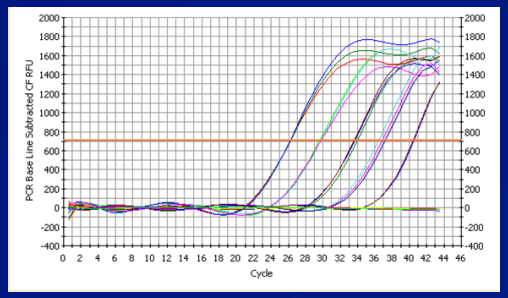
- Centrifugation → parasites

- Precipitation → viruses
- DNA/RNA extraction → PCR/RT-PCR

Rapid screening using real-time PCR

- **Faster turnaround times vs. conventional PCR**





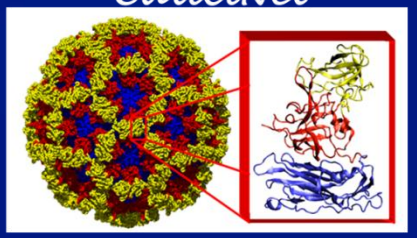
- **Potentially enables quantitation ("qPCR")**
- **Bacteria → culture first, then PCR**
- **Viruses → direct analysis by RT-qPCR**
- **Parasites → direct analysis by qPCR**
  - For *Cryptosporidium* and *Giardia*, can also perform fluorescence microscopy for confirmation, quantitation

Supporting molecular epidemiology

- Bacteria → match PFGE patterns (PulseNet)
- Viruses → match nucleic acid sequences (CaliciNet)
- Parasites → compare sequences, subtypes (CryptoNet)

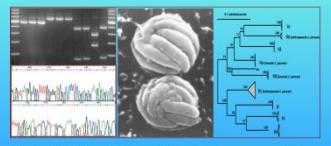
PulseNet USA
The National Molecular Subtyping Network for Foodborne Disease Surveillance
CDC

CaliciNet



National Norovirus Outbreak Network

CryptoNet USA



National Molecular Surveillance for Cryptosporidium
CDC

Water testing: supporting public health response

- **Milwaukee (1993)**
  - Human "*C. parvum*" genotype (later named *C. hominis*) identified in patient stools in 1998 and in Milwaukee wastewater in 2000, confirming that waste source was primarily from sewage system
  - Spurred improvements in filtration and disinfection (ozonation); also Milwaukee's water treatment plant intake pipe was extended 4,200 ft further into Lake Michigan
- **Oklahoma (2008)**
  - Norovirus GI.4 identified in stool samples and a water sample from the well that served a condominium complex.
  - The complex was eventually connected to the public water supply
- **Alamosa, CO (2008)**
  - *Salmonella* Typhimurium detected throughout non-disinfected public water supply system
  - System shut down until new chlorination plant brought online
- **Louisiana (2011): Water testing confirmed presence of *Naegleria fowleri* in tap water used by cases for nasal rinsing**

Working together to investigate WBDOs

- Support for outbreak investigations
- Training (e.g., sampling)
- Technology transfer (e.g., molecular testing)
- Surveillance: CryptoNet

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NOTE: The findings and conclusions in this report are those of the authors and do not necessarily represent the official position of the Centers for Disease Control and Prevention.

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