The changing epidemiology of waterborne disease outbreaks in the United States: Implications for system infrastructure and future planning

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Outline

• Epidemiology and trends in waterborne disease outbreaks in U.S.
  • Five take-home messages
• Unknown disease burden
• Emerging challenges
  • Aging water infrastructure
  • Extreme weather events/climate change
  • Drought
    • Water reuse
  • Recreational water risks
• Future thoughts
Epidemiology and Trends of Waterborne Disease Outbreaks in U.S.

Waterborne Disease and Outbreak Surveillance System (WBDOSS): The primary source of data concerning the scope and effects of waterborne-disease and outbreaks in the United States

1971

1978
Five WBDOSS Trends for Drinking Water
Decreasing Outbreaks in Public Water Systems

Positive Impact of National Drinking Water Regulations and Water System Practices

Includes outbreaks from pathogens and chemicals

Surface Water vs. Ground Water

Impact of Surface Water Treatment Rule and Water System Practices

Percent of WBDOs in Public Systems (CWS + NCWS) Associated with Untreated or Improperly Treated Source Water by Year

- Surface Water with Def 1 or 3
- Ground Water with Def 2 or 3

SWTR 1989
Decreasing Outbreaks in Public Water Systems

Positive Impact of National Drinking Water Regulations and Water System Practices

Public (Regulated) Systems vs. Individual (Unregulated)

Positive Impact of National Drinking Water Regulations and Water System Practices

~45 million people served by individual systems
2005-2006 is first time in history of surveillance system that gastrointestinal illness does not represent a majority of outbreak illnesses

Premise plumbing

- **Legionella**: 50.0%
- **AGI**: 45.0%
- **Hepatitis A**: 5.0%
Number of Waterborne-Disease Outbreaks Associated with Drinking Water (n = 814), by Year and Etiologic Agent — United States, 1971–2006

Decreasing “unidentified” etiologies
Legionella added in 2001

Unregulated Deficiencies Outside the Jurisdiction of a Water Utility

Majority of Deficiencies Occur After Water Meter/Property Line

- No Water Utility Jurisdiction or at Point of Use: 52.2% (12)
- Deficiencies in Source Water, Treatment, or Distribution: 43.5% (10)
- Unknown: 4.3% (1)

2005-2006
Unknown Endemic Disease Burden: WBDOSS Data Are NOT an Indicator of Magnitude of Problem

- Limitations of WBDO Surveillance Data
- Data represents a portion of the burden of illness associated with water exposure
  - Passive surveillance
  - Lack of sensitivity
  - Inconsistent environmental health data
- Data doesn’t include of endemic waterborne disease
- No reliable estimates of the number of unrecognized WBDOs and associated cases of illness are available
- Estimated 4-33 million cases AGI/yr from PWS
  - Misses Non-PWS, Non-Drinking uses, all diseases
Spectrum of Waterborne Disease in the U.S.

- Acute gastroenteritis
  - Cryptosporidium, toxigenic E. coli, Giardia, Shigella, norovirus, chemicals

- Skin infections
  - Pseudomonas dermatitis/folliculitis, fungal infections

- Ear infections – Pseudomonas

- Eye infections and irritation
  - Adenoviruses, chloramines

- Respiratory infections
  - Legionella, Mycobacterium, chloramines, chemicals

- Neurologic infections – Echovirus, Naegleria

- Wound infections – Vibrio

- Hepatitis – HAV

- Other - Leptospirosis

- Urinary tract infections – Pseudomonas
Drinking Water Distribution Systems

- 1 million miles in U.S.
  - Pipes, pumps, valves, storage tanks, reservoirs, meters, fittings
- 34 billion gallons of water produced daily in U.S. by PWS
- Serve populations of 25 people to millions
- Most of DS pipes will reach end of expected lifespan in 30 years

Source: National Research Council 2006
Aging Water Infrastructure

• Pipes and Water treatment plants 50-100 years old in much of US

• EPA estimates nearly $300 billion (some estimate $1 trillion) investment needed over next 20 years

• Increased risk for contamination of drinking water in distribution systems if infrastructure not replaced (NRC, 2006)

• 100’s of water advisories annually due to mains breaks
Distribution System Deficiencies

- Outbreaks caused by distribution system deficiencies in PWS continue to persist
  - 1970s: 13%
  - 1980s: 13%
  - 1990s: 17%
  - 2000–2006: 13%
National Research Council Assessment of Drinking Water Distribution Systems
Public Health Findings

- DS is the remaining component of public water supplies yet to be adequately addressed in national efforts to eradicate waterborne disease
  - TCR revision ongoing
- DS ecology is poorly understood, making risk assessment via pathogen occurrence measurements difficult
- Epidemiologic studies that specifically target the DS component of waterborne disease needed
  - Neigard study in Norway (RR = 1.58 for AGI assoc with mains breaks)

Source: National Research Council 2006
EPA Research Priorities for Distribution Systems: Proposed Total Coliform Rule Revision

- Cross-connections and backflow
- Storage facility design, operation, or maintenance
- Mains installation, repair or rehabilitation practices;
- Intrusion due to pressure conditions and physical gaps in DS infrastructure
- Significance/control of biofilm and microbial growth
- Nitrification issues that lead to public health effects
- Accumulation and release DS scales and sediments

- DOES NOT address premise plumbing, individual systems, Legionella
Severe Weather Events, Climate Change, and Water Availability/Quality

Source: IPCC Climate Change 2007 Synthesis Report
Mechanisms and Impacts on Water Systems and Quality in the Arctic Occurring Now

- Melting permafrost
- Coastal erosion
- Sea level rise
- Floods, droughts, severe weather
- Northward movement of animals

- Damaged water and wastewater infrastructure-lagoon containment
- Increased nutrient loads – surface and groundwater sources
- Saltwater intrusion
- Zoonotic diseases such as giardiasis
Today’s News in Alaska

- 2000 - Storm surge spread sewage lagoon waste throughout Kipnuk
- 2004 - Saline intrusion after storm surge in Nunam Iqua
- 2005 - Community water source disappears in Kwigillingok
- 2005 - Flooding of Juneau septic systems
- 2005 - Warm-weather warning (shell fish poisoning due to warmer ocean temperatures)
- 2006 – Beavers sited around Nome
Extreme Weather Events

- Hurricanes Gustav and Ike
- Millions without electricity
- Pumping stations and lift stations with no power
  - Drinking water and wastewater treatment impacted
- Flooded wells
- Boil water advisories
- 1993 Midwest flood well data
  - 9 states, widespread contamination, long-term water quality issues with wells
Drought

- Current
  - Colorado basin
  - Atlanta, GA
- Drinking water quality and quantity
- Decreasing recreational water quality
- Indirect effects
  - Air quality, mental health, hygiene
- Need to reuse water
Water Reuse

- **Indirect Potable Reuse**
  aka “Toilet-to-Tap”---indirect potable water re-use
  - Orange County, CA: 70 mgd
    - Salt water intrusion
  - Gwinnet County, GA: 60 mgd
    - Drought affecting reservoir

- **Grey Water**
  - Tucson, AZ
  - Australia

- **Aquifer depletion**
  - Land subsidence (San Joaquin Valley, CA)
  - Direct pumping of water back into aquifers (Tucson, AZ)
Gastroenteritis Outbreaks, United States, 1978-2006
Summary

• Changing Epidemiology
  • Decreasing surface water outbreaks
  • Increasing importance of outbreaks associated with groundwater and private systems
  • Increasing importance of Legionella (effect on aging population)
  • Increasing importance of system components beyond current regulatory emphasis (i.e., premise plumbing)

• New Challenges
  • Aging drinking water distribution systems
  • Weather effects
  • Water re-use
  • Recreational water use Food production, chemical contaminants
One Water: The Universe of Water-Related Disease

- Domestic
  - Drinking
  - Recreational
  - Other uses
- Security & Response
- International
  - Water, Sanitation, Hygiene
- Wastewater
WaterNET
Prevention platform for public health issues arising from drinking, recreational, and other water uses

Identify emerging public health issues
Answer water-specific health research questions
Develop recommendations for decreasing waterborne illness

Strategic Partnerships
Sustained Funding

Expertise
Epidemiology
Laboratory Science
Environmental Health
Behavioral Science
Communications
Engineering

Research
Investigation
Health Promotion
Program
Surveillance-Tracking
Monitoring Evaluation

Identify emerging public health issues
Answer water-specific health research questions
Develop recommendations for decreasing waterborne illness
Future Needs

- Investment in drinking water infrastructure
  - $300 billion (up to 1 trillion) over next 20 years
  - Health effects studies on distribution systems risks
- Health effects from small systems, premise plumbing
- Health effects resulting from adaptive strategies to water scarcity
  - Water conservation
  - Different types of water use (agriculture, municipal, environmental, and industry)
  - Water reuse (reclamation and gray water)
- Prevention platform to address future needs—WaterNet
  - Improved detection/investigation/reporting—WBDOs
  - Accurate burden estimate for all waterborne disease
Questions