Burden of infectious waterborne disease in the United States

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UNC Water and Health Conference
October 31, 2018
Overview

- Water work at CDC
- Snapshot of infectious waterborne disease in a high income country
- General strategy for developing a comprehensive burden estimate
- Results
- How we can use the burden estimate?
Waterborne Disease Prevention Branch

The lead epidemiology unit for U.S. water-related infectious disease at CDC

Mission: Tracking and investigating waterborne disease and outbreaks, building waterborne disease prevention capability in state and local health departments, and developing effective prevention strategies to improve health.
Water related work at CDC

- **Infectious diseases**
  - Surveillance for cases and outbreaks
  - Subject matter expertise for parasites, bacteria, viruses
  - Subject matter expertise for hospital-associated water related infections

- **Office of Preparedness and Public Health Response**
  - Preparedness and planning; emergency response

- **Non-Infectious and Environmental diseases**
  - Chemicals, toxins, private wells
  - Public Health Tracking
  - Injuries (e.g., drownings)

- **Occupational Health**
  - Indoor air quality
Drinking Water History in the United States

- 1900: ~100 cases typhoid fever per 100,000
- 1908: First filtration and disinfection of a US public water supply (New Jersey)
- 1910-1920: Thousands of US cities begin disinfecting drinking water
- 2006: ~0.1 cases of typhoid fever per 100,000

No cholera, No typhoid
No waterborne disease?
Safe, reliable water supply leads to increasing use of water in complex ways

A new paradigm: waterborne disease in high income countries
Complicated plumbing, heating and cooling systems in large buildings
Water parks, splash pads and complex recreational water venues
Food production
Medical uses
Methods
Burden of Waterborne Disease Estimate

- 20 selected pathogens/conditions
- Modeling approach
  - Used by colleagues in foodborne group (Scallan, et al, 2011)
- Data inputs are surveillance data, administrative data, or literature estimates
- Multipliers for under-reporting/under-diagnosis/under-ascertainment
- Include updated attribution estimates
  - Structured Expert Judgment project
  - Estimates across all potential modes of transmission
Short List of Waterborne Diseases

Primarily Waterborne
Cryptosporidiosis
Giardiasis
Acute Otitis Externa
Legionnaires’ Disease
Non-Tuberculous *Mycobacterium* (NTM) infection

Partially Waterborne
Campylobacteriosis
*E. coli* infection (*shiga* toxin-producing)
Shigellosis
Salmonellosis
Hepatitis A infection
Vibriosis
*Pseudomonas* pneumonia
*Pseudomonas* septicemia
Norovirus infection

*Chemicals in Future?*
(Very) Simplified Overview

\[
\text{Case counts} \times \text{Under-reporting multiplier} \times \text{Under-diagnosis multiplier} \times \text{Hospitalization/Death multiplier} \times \text{Travel multiplier} = \text{Total number of cases, domestically acquired}
\]

\[
\text{Total number of cases, domestically acquired} \times \% \text{ Waterborne multiplier} = \text{Total number of cases, domestically acquired, attributed to waterborne transmission}
\]
Modeling approach: Use distributions instead of point estimates

Figure 2: Model distributions for Campylobacter illnesses. The histogram of observed laboratory-confirmed illnesses reflects annual counts from each of the 10 sites in the FoodNet catchment from 2005 to 2008.

- Observed laboratory-confirmed illnesses
  - Mean: 580

- Projected US laboratory-confirmed illnesses
  - Mean: 44,000

- Under-diagnosis multiplier
  - Mean: 30

- Percent domestically acquired
  - Mean: 85%

- Estimated annual domestically acquired illnesses
  - Mean: 1,100,000
  - 90% CrI: 20,000 – 2,000,000

- Percent foodborne
  - Mean: 80%

- Estimated annual foodborne illnesses
  - Mean: 856,000
  - 90% CrI: 340,000 – 1,500,000
What did we estimate?

- For the selected pathogens/conditions, modeled estimates and 95% credibility intervals of
  - Number of illnesses annually
  - Number of emergency department visits
  - Number of hospitalizations
  - Number of deaths
- Cost of emergency department visits and hospitalizations, in 2014 US dollars (as measured by insurance payments)
Results
Short List of Waterborne Diseases

- Campylobacteriosis
- Cryptosporidiosis
- Giardiasis
- Norovirus infection
- Shigellosis
- Salmonellosis
Short List of Waterborne Diseases

- Campylobacteriosis
- Cryptosporidiosis
- Giardiasis
- Norovirus infection
- Shigellosis
- Salmonellosis

Acute Otitis Externa
Short List of Waterborne Diseases

- Campylobacteriosis
- Cryptosporidiosis
- Giardiasis
- Norovirus infection
- Shigellosis
- Salmonellosis
- Acute Otitis Externa
- Legionnaires’ Disease
- Non-Tuberculous *Mycobacterium* (NTM) infection
- *Pseudomonas* pneumonia
Short List of Waterborne Diseases

- Campylobacteriosis
- Cryptosporidiosis
- Giardiasis
- Norovirus infection
- Shigellosis
- Salmonellosis
- Acute Otitis Externa

Legionnaires’ Disease
Non-Tuberculous *Mycobacterium* (NTM) infection
*Pseudomonas* pneumonia

*E. coli* infection (*shiga* toxin-producing)
Hepatitis A infection
Vibriosis
*Pseudomonas* septicemia
Results: Illnesses

- 7.2 million (95% CrI 3.9–12.0 million)
Illnesses by category

- Enteric: 29%
- Ear: 65%
- Other: 6%
7.2 million illnesses

- Otitis Externa: 65%
- Norovirus: 19%
- Giardiasis: 6%
- Cryptosporidiosis: 4%
- Other: 6%
Results: Emergency Department Visits

- 600,000 visits (95% CrI 365,000–865,000)
ED visits by category

Ear: 94%
Enteric: 4%
Otitis externa: 94%

Norovirus: 4%

NTM Infection: 1%

Other: 1%

600,000 ED visits
Results: Hospitalizations

- 120,000 hospitalizations (95% CrI 85,000–150,000)
Hospitalizations by category

- Respiratory: 63%
- Ear: 19%
- Other: 10%
- Enteric: 11%
NTM Infection 43%
Otitis Externa 19%
Pseudomonas pneumonia 13%
Legionnaires' disease 8%
Other 18%
120,000 Hospitalizations
Results: Deaths

- 6,600 (95% CrI 4,400–8,900)
Deaths by category

- Respiratory: 82%
- Ear: 3%
- Other: 12%
NTM infections: 58%
Legionnaires' Disease: 13%
Pseudomonas pneumonia: 11%
Pseudomonas septicemia: 11%
Other: 7%

6,000 Deaths
Results: Direct Healthcare Costs

- 3.3 billion in 2014 U.S. dollars for hospitalizations and emergency department visits
Respiratory: 70%
Ear: 17%
Other: 13%
NTM Infections 45%
Otitis externa 17%
Pseudomonas pneumonia 14%
Legionnaires’ Disease 11%
Enterics 5%

3.3 billion $US
Infectious waterborne disease in the United States

- 7.2 million illnesses
- 600,000 ED visits
- 120,000 hospitalizations
- 6,000 deaths

3.3 billion $US
Conclusions
Conclusions

- First measures of the burden of infectious waterborne disease from all types of water uses in the United States
- Did not include considerable disease burden from chemicals and toxins
- Does not break down waterborne transmission by type of water (drinking, recreational, etc)
Conclusions

- We’ve made tremendous strides
- But the work is not done!
- 7 million cases of illness each year
- Shift from enteric to respiratory disease/biofilm-associated pathogens
Conclusions

- Increased investment in our water system infrastructure needed
  - Drinking water systems, private wells, aquatic facilities, buildings, cooling towers, and healthcare facilities
- Support for waterborne disease-focused public health capacity essential for illness prevention
  - Capacity to routinely and regularly detect and investigate infectious waterborne disease
Next Steps

- CDC clearance and journal submission
- Target is publication in 2019
- Communication and release plan
  - Continue working with communications and policy offices, internal and external partners
  - A comprehensive burden estimate will be a tool for policy makers to support investments
Questions?
Thoughts?
Ideas?
### Annual deaths, hospitalizations, ED visits, and doctor’s office visits for selected diseases in the United States

<table>
<thead>
<tr>
<th>Outcome</th>
<th>Count</th>
<th>Estimated total annual US cost</th>
<th>Citation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Deaths</td>
<td>6,940</td>
<td>not calculated</td>
<td>Gargano, et al. 2017</td>
</tr>
<tr>
<td>Hospitalizations</td>
<td>90,000</td>
<td>$3.6 billion</td>
<td>Collier, et al. 2012 Adam, et al. 2017</td>
</tr>
<tr>
<td>Emergency Department Visits (treat-and-release)</td>
<td>376,000</td>
<td>$194 million</td>
<td>Adam, et al. 2017</td>
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- No attribution included in these publications