Recreational Water: The Risks, the Effects, and Climate Change

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Outline

• Trends in recreational water-associated waterborne disease outbreaks in U.S.
• Potential climate change impact
  • Drought, floods, temperature
• Changes in reporting of Cryptosporidium
• Future thoughts
One Water: The Universe of Water-Related Disease

- Wastewater
  - Domestic
    - Drinking
    - Recreational
    - Other uses
  - International
    - Security & Response
    - Water, Sanitation, Hygiene
Water Use in the U.S.

- Electricity: 48%
- Irrigation: 34%
- Public Use: 11%
- Industrial: 5%
- Other: 2%

USGS, 2000
Diarrhea is Common

- ~8% of general public had diarrhea in past month\(^1\)

- 0.1–3.5 cases of diarrhea/person/year (higher for young children)\(^2\)

- > 2% fecal incontinence (FI) in Wisconsin Family Health survey\(^3\)
  - 70% with FI <65 years old

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Fecal Contamination of Recreational Water is Common

- Heavy use by diapered and toddler-aged children: swimmer to swimmer
- Fecal accidents common
  - 293 formed stools, 47 pools\(^1\)
- \(\sim 0.14g\) of feces on peri-anal surface/person
  - range: 0.01g (adults)–10g (children)\(^2\)

Fecal Contamination of Fresh Water/Recreational Water is Common

- Environmental contamination
  - animal--urban/pastureland/forestland runoff

- Wastewater effluent
  - CSO, SSO

- Untreated dumping -- pleasure craft, houseboats, failing septic systems

- Most surface water in U.S. contaminated with pathogens
Exposure to Recreational Water is Common: Americans swim...a lot

• Swimming is the 2nd most popular exercise activity in the United States
  • ~ 350 million swimming visits each year¹
    • Underestimate
      • ≥7 years of age
      • Swim ≥6 times in last year

Spectrum of Waterborne Disease in the U.S.

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

- **Skin infections and irritation**
  - *Pseudomonas* dermatitis/folliculitis, fungal infections, chloramines

- **Ear infections** – *Pseudomonas*

- **Eye infections and irritation**
  - Adenoviruses, chloramines

- **Respiratory infections**
  - *Legionella*, *Mycobacterium*, chloramines, chemicals

- **Neurologic infections** – *Echovirus*, *Naegleria*

- **Wound infections** – *Vibrio*

- **Hepatitis** – HAV

- **Urinary tract infections** – *Pseudomonas*

- **Other** – Leptospira, HAB’s
Tracking RWIs/Surveillance Data

What Do We Know About Outbreaks?
RWI Outbreaks, United States, 1978–2006

Gastroenteritis Outbreaks, United States, 1978-2006

Gastroenteritis Outbreaks, United States, 1978-2006

RWI Outbreaks, United States, 1997-2006; Gastroenteritis

Fresh Water
- E. coli* 19.0%
- Crypto 12.7%
- Shigella 12.7%
- Giardia 4.8%
- Norovirus 20.6%
- Unidentified 25.4%

Chlorinated Water
- Cryptosporidium 68.3%
- Other* 3.8%
- E. coli O157:H7 2.9%
- Giardia 2.9%
- Shigella 6.7%
- Norovirus 6.7%

* Includes E. coli O157:H7, O26:NM, O121:H19
* Includes Campylobacter, Salmonella

N=63
N=104

* Includes Salmonella, Campylobacter, Plesiomonas, mixed pathogens
Recreational Water: Natural Waters

- Only one reported Great Lakes-associated outbreak since 1978
- No ocean-related outbreaks reported in US since 1978
- If you do prospective health effects studies you generally find GI illness associated with swimming
Illness Incidence and Adjusted Cumulative Incidence Ratios (aCIR) Comparing Swimmers With Nonswimmers

<table>
<thead>
<tr>
<th>Illness</th>
<th>aCIR (95% CI)</th>
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<tbody>
<tr>
<td>GI</td>
<td>1.4 (1.3-1.6)</td>
</tr>
<tr>
<td>Rash</td>
<td>1.4 (1.1-1.7)</td>
</tr>
<tr>
<td>Earache</td>
<td>1.6 (1.2-2.2)</td>
</tr>
</tbody>
</table>

Four Great Lakes Beaches. 21,015 interviews
Wade et al., Epidemiol 2008;19: 375–383
Extreme Weather Events, Climate Change, and Water Availability/Quality

Source: IPCC Climate Change 2007 Synthesis Report
Climate Change
Water Impacts

- Increased water availability in moist tropics and high latitudes
- Decreased water availability and increasing drought in mid-latitudes and semi-arid low latitudes
- Water stress for hundreds of millions
- Extreme weather events
  - Droughts
  - Floods
  - Increased temperatures

Source: IPCC
Water and Climate Change: Challenges

Water quality

Cholera, cryptosporidiosis, campylobacter, shigellosis, giardiasis, *Naegleria*, leptospirosis, vibriosis, HABs, chemicals

Water quantity
Drought

- Current problems
  - Colorado basin
  - Tucson, AZ
  - Atlanta, GA
- Drinking and recreational water quality and quantity decreasing
- Surface water
  - Concentration of contaminants
  - Decreased dilution factor in outflows
  - Increased risk for swimmers?
Drought

- Groundwater
  - Increasing need for groundwater recharge
  - Surface water sources used
  - Saltwater intrusion into groundwater

- Collateral damage
  - Air quality, mental health, poor hygiene, fires, crop loss

- Water quantity
  - First act in GA was to try and shut all pools
  - Need to replace water more often
Other Uses of Water: Challenges

• Food production
  • Agriculture: production and processing is one of the major uses of water in the world
    • Eat the food and drink the water from around the world
    • Water suspected in Cyclospora outbreaks 1995+
    • Spinach and E coli O157:H7, 2007
  • Drawing from decreasing water resource that may be more prone to contamination

• Increasing re-use of wastewater & grey water
U.S. Wastewater Issues

- On-site waste water system failures
- Reuse/recycle inevitabilities
  - Focus on wastewater/greywater
  - Sludge disposal
    - Farmers encouraged to use as fertilizer
    - Pathogens, chemicals, drugs, hormones, heavy metals
  - Use/management of animal waste
- GA 2007: Farmer got “free” fertilizer from city which contained industrial sewage
  - Grass and > 100 cows killed---contained heavy metals, PCB’s, rat poison
Water Reuse

- Indirect Potable Reuse
  aka “Toilet-to-Tap”---indirect potable water re-use
  - Orange County, CA: 70 mgd
    - Salt water intrusion
  - Gwinnett 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)
Flooding

- Midwest 2007/8, post-hurricane, tsunami
  - extreme precipitation
- Collateral damage
  - Injuries, mental health, crop loss
- Mold growth
- Potential infrastructure failures for drinking/ wastewater treatment
- Drinking and recreational water quality issues
Floods

- Sewer overflows (combined and sanitary)
  - >1 trillion gal of sewage & storm water discharged annually during CSO’s
- Agricultural and livestock areas rinsed into surface water—”first flush”
- Water quality
  - Surface & ground water contamination w/ pathogens, chemicals
Extreme Precipitation and Waterborne Disease Outbreaks in the United States, 1948-1994

- 67% of WBDO preceded by precipitation above the 80th percentile, $p < 0.001$
- 51% of WBDO’s preceded by precipitation above the 90th percentile, $p < 0.002$
  - Surface water-related outbreaks 1 month after extreme precipitation
  - Groundwater-related outbreaks 2 months after extreme precipitation.

Curriero et al. AJPH 2001:91;1194-1199.
Higher Temperatures

- Increasing water temperatures and/or nutrients
  - Movement of pathogens to more northern regions
    - *Vibrio paraheamolyticus* in Alaska
  - Enhanced growth of pathogens
    - *Naegleria*, *Vibrio*, harmful algal blooms, *Pseudomonas*
  - Recreational water climate change indicators
  - Increased infections, health effects
Higher Temperatures

- Increasing recreational water activities
  - Ambient waters
  - Swimming pools
- Increased pathogen transmission
  - Already seeing now at pools
What is Happening with Cryptosporidiosis Reporting?
Cryptosporidium Seasonality: United States, 2003-2005

Chlorine resistant, largest cause of rec. water outbreaks

Week of Onset

Number of Case Reports

N= 15,406 total case reports
N=15,276 have onset dates

Cryptosporidiosis Non-Outbreak Case Reports: United States, 1994-2007*

143% increase since 2004
Est. 750,000 cases/year

Recreational Water–Associated Outbreaks of Cryptosporidiosis, by Water Treatment United States, 1988–2007*

- Treated: Pool, water parks, interactive fountains
- Untreated: Lakes, oceans, rivers


Number of Outbreaks: 0, 2, 4, 6, 9, 10, 10

2007 data preliminarily based on CDC Logs, not verified by states
Crypto is in Our Community. 
Is it in Our Pools? Yes.

<table>
<thead>
<tr>
<th>Country</th>
<th>Crypto Positive</th>
<th>Giardia Positive</th>
</tr>
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<tbody>
<tr>
<td></td>
<td>% (n)</td>
<td>% (n)</td>
</tr>
<tr>
<td>United States¹</td>
<td>1.9% (3/160)</td>
<td>6.9% (11/160)</td>
</tr>
<tr>
<td>Netherlands²*</td>
<td>5.9% (9/153)</td>
<td>7.2% (9/153)</td>
</tr>
<tr>
<td>France³*</td>
<td>2.1% (1/48)</td>
<td>0.0% (0/48)</td>
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<tr>
<td>Italy⁴*</td>
<td>38.1% (8/21)</td>
<td>28.6% (6/21)</td>
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Yellow font in table indicates backwash samples.
* Indicates serial samples for given pools.

Hypotheses

- Real increase in transmission
- Improved surveillance
- Improved awareness about cryptosporidiosis and pool exposures
- Changing healthcare testing practices
  - 2002: New children’s formulation of drug approved (only drug ever approved)
  - 2004: adult formulation approved
- Combination of all of the above
Future Needs

- Increased stressors on freshwater quality
- Health effects resulting from adaptive strategies to water scarcity and quality
  - Water conservation and reuse (waste & grey water)
  - Different types of water use (agriculture, municipal, environmental, and industry)
  - More swimming
- Intervention includes:
  - Conservation (re-use, cutting use)
  - Technological (improved treatment)
  - Behavioral/education (reduce contamination)
  - Regulatory (collect & use data to enforce compliance with what system can bear)
- Partnerships and resources/commitment
Acknowledgements

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(Please Interpret as You See Fit)

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Questions