The Crossroads of Waterborne Infectious Disease Transmission

Society

Environment

Infectious

Enteric microbes

Kelly Baker, PhD, kelly-k-baker@uiowa.edu
College of Public Health, Department of Occupational & Environmental Health
The University of Iowa
Epidemiology of global infectious disease

Deaths from unsafe water, sanitation and hygiene

http://cherq.org/images/diarrheaarticle/figure1.jpg
Comparative ecology of fecal-transmission pathways

Reservoirs: wildlife, agriculture

Human exposure: Swimming, Agriculture, floods
Feces to water to food exposure pathways in Accra, Ghana

- Fecal sources in urban low-income environments
  - Prolific open defecation
  - At-scale dumping of untreated human waste
  - Free-roaming domestic animals

- Water access for agriculture and fishing
  - River and coastal waters impacted by high density populations
  - Economics of irrigation water
    - Perception of quality of water
    - Cost of piped water unaffordable for agriculture
  - Farming and fishing occupational hazards

- Farm to market
  - Unregulated industry – limited protection for customers
  - Market-related hazards
<table>
<thead>
<tr>
<th>Disease</th>
<th>Specific Agent</th>
<th>Reservoir</th>
<th>Symptoms in Brief</th>
</tr>
</thead>
<tbody>
<tr>
<td>Enteropathogenic E. coli</td>
<td><em>Escherichia coli</em> O157:H7, ETEC LT, ETEC ST/LT, EAE, EPEC, EHEC</td>
<td>Intestines of animals and infected persons</td>
<td>Cramping, vomiting, diarrhea (occasionally bloody), fever, dehydration</td>
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<tr>
<td>Salmonellosis</td>
<td><em>Salmonella typhimurium</em></td>
<td>Animals and eggs</td>
<td>Abdominal pain, diarrhea, chills, fever, vomiting and nausea</td>
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<tr>
<td>Typhoid Fever</td>
<td><em>Salmonella typhosa or typhi</em></td>
<td>Feces and urine of typhoid carrier or patient</td>
<td>Fever, usually rose spots on the trunk, diarrheal disturbances</td>
</tr>
<tr>
<td>Paratyphoid Fever</td>
<td><em>Salmonella paratyphi</em> (ABC)</td>
<td>Feces and urine of carrier or patient</td>
<td>Fever, diarrheal disturbances, sometimes rose spots on trunk, other symptoms</td>
</tr>
<tr>
<td>Shigellosis (Bacillary dysentery)</td>
<td><em>Shigella</em></td>
<td>Feces of carrier and infected persons</td>
<td>Acute onset diarrhea, fever, tenesmus, frequent stools containing blood and mucus</td>
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<tr>
<td>Campylobacter Enteritis</td>
<td><em>Campylobacter Jejuni</em></td>
<td>Chickens, swine, dogs, cats, human, raw milk, contaminated water</td>
<td>Watery diarrhea, abdominal pain, fever chills, nausea, vomiting, blood in stool</td>
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<tr>
<td>Cholera</td>
<td><em>Vibrio cholerae, Vibrio comma</em></td>
<td>Feces, vomitus; carriers</td>
<td>Diarrhea, rice–water stools, vomiting, thirst, pain, coma</td>
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<td>Protozoa</td>
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<td>Amebiasis (Amebic dysentery)</td>
<td><em>Entamoeba histolytica</em></td>
<td>Bowel discharges of carrier, and infected person; possibly also rats</td>
<td>Diarrhea or constipation, or neither; loss of appetite, abdominal discomfort; blood, mucus in stool</td>
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<td>Cryptosporidiosis</td>
<td><em>Cryptosporidium</em></td>
<td>Farm animals, human, fowl, cats, dogs, mice</td>
<td>Mild flu-like symptoms, diarrhea, vomiting, nausea, stomach pain</td>
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<tr>
<td>Giardiasis</td>
<td><em>Giardia lamblia</em></td>
<td>Bowel discharges of carrier and infected persons; dog, beaver</td>
<td>Prolonged diarrhea, abdominal cramps, severe weight loss, fatigue, nausea, gas, fever is unusual</td>
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<td>Viruses</td>
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<tr>
<td>Viral gastroenteritis</td>
<td>Rotaviruses, Norwalk agent, Norovirus GI and GII, Adenovirus, Sapovirus, Astrovirus, Enterovirus</td>
<td>Human, feces, or sewage</td>
<td>Nausea, vomiting, diarrhea, abdominal pain, low fever</td>
</tr>
<tr>
<td>Infectious Hepatitis</td>
<td>Hepatitis A</td>
<td>Feces from infected persons</td>
<td>Fever, nausea, loss of appetite; possibly vomiting, fatigue, headache, jaundice</td>
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<td>Helminths</td>
<td></td>
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<td>Schist</td>
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Read more: [http://www.waterencyclopedia.com/Ge-Hy/Human-Health-and-Water.html#ixzz3Si8NgC5C](http://www.waterencyclopedia.com/Ge-Hy/Human-Health-and-Water.html#ixzz3Si8NgC5C)
Environmental influences on transmission dynamics

Giardia from contaminated pool


Difference in spatial–temporal complexity, etiology, and magnitude of exposure

Giardia, ETEC  ETEC, Cryptosporidium, Adenovirus  Vibrio cholerae  Rotavirus

Current indicators for measuring risk from disease in food and water perform poorly.
Systems-level risk assessment for fecally-transmitted disease using a rapid, microfluidic qPCR system


INFORMATICS SCIENCE (Sen Gupta)

MOLECULAR EPIDEMIOLOGY (Dreeszen)
Applications of microbial systems science to global food and waterborne risk assessment

- **Methodology** –
  - What (how many) indicators should be used in risk assessment?
  - Are there informational gains from treating exposure as an ecological system of microbial hazards vs single target?
  - Distinguish host origin/hazard

- **Policy and Practice**
  - Consideration of geographical context in methodology
  - Improved accuracy of fecal source tracking, QMRA disease prediction models, and evaluation of ecological interventions
  - Pinpointing specific transmission pathways
  - Fundamental understandings of spatial-temporal fate and transport of microbes

*FIGURE 1. Superimposed sanitation fingerprint pathway map and ecosystems map*
Due to population growth, climate change, investment and management shortfalls, and inefficient use of existing resources, half of the world will live in conditions of water stress by 2025, 1.8 billion in regions with absolute water scarcity.