Microbiological Safety of Drinking Water: To Your Health

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Health Canada
Introduction

- What are the pathogens?
- Why should we be concerned?
- How do they enter treated water?
- How do we measure microbiological safety?
- How do we reduce the risks?
What are the pathogens?

• human viruses
  • enteric - Norwalk, Hepatitis A
• bacteria
  • enteric - Campylobacter, Shigella, Salmonella, E. coli O157
  • respiratory - Legionella
• protozoa
  • enteric - Giardia, Cryptosporidium
  • systemic - Toxoplasma
How do they differ?

- **Size/Filterability**
  - protozoa > bacteria > viruses
- **Chlorine resistance**
  - protozoa > viruses > bacteria
- **Obligate parasites**
  - viruses and protozoa +, bacteria -
- **Survivability outside host**
  - viruses and protozoa > bacteria
- **Ease of detection**
  - bacteria > protozoa > viruses
What are the acute health effects?

• DIARRHEA! DIARRHEA! DIARRHEA!
  – Norwalk - mild
  – Campylobacter - acute (profuse, watery or bloody)
  – Shigella - acute (mucous or bloody)
  – E. coli O157 - acute (bloody)
  – Salmonella - sudden (watery)
  – Giardia - acute (explosive, pale)
  – Cryptosporidium - acute (profuse and watery)
## More acute health effects

<table>
<thead>
<tr>
<th>Organism</th>
<th>Inf. Dose</th>
<th>Symptoms</th>
<th>Duration</th>
</tr>
</thead>
<tbody>
<tr>
<td>Norwalk</td>
<td>Low</td>
<td>V, C, F, H, N</td>
<td>12-48 h</td>
</tr>
<tr>
<td>Campy.</td>
<td>Med</td>
<td>C, F, N, V</td>
<td>2-3 d</td>
</tr>
<tr>
<td>Shig./O157</td>
<td>Low - Med</td>
<td>F, N, V, C</td>
<td>4-7 d</td>
</tr>
<tr>
<td>Salmonella</td>
<td>High</td>
<td>F, C</td>
<td>2-5 d</td>
</tr>
<tr>
<td>Giardia</td>
<td>Low</td>
<td>C, G, V</td>
<td>2 -12 w</td>
</tr>
<tr>
<td>Crypto.</td>
<td>Low</td>
<td>C, N, F</td>
<td>10-15 d</td>
</tr>
</tbody>
</table>
Acute effects other than the “d” word

- **Toxoplasma gondii**
  - fever, pharyngitis (infectious mononucleosis)
  - persists days to weeks

- **Hepatitis A**
  - nausea, vomiting, jaundice
  - persists 1-2 weeks

- **Legionella**
  - Legionnaires’ disease (pneumonia, often fatal)
  - Pontiac fever (non-infectious flu-like illness, self-limiting)
<table>
<thead>
<tr>
<th>Organism</th>
<th>Disease</th>
</tr>
</thead>
<tbody>
<tr>
<td>Helicobacter pylori</td>
<td>ulcers, gastric cancer</td>
</tr>
<tr>
<td>Campylobacter</td>
<td>Guillain-Barré syndrome</td>
</tr>
<tr>
<td>Toxoplasma</td>
<td>blindness, mental illness</td>
</tr>
<tr>
<td>Shigella/E.coli O157</td>
<td>kidney damage</td>
</tr>
<tr>
<td>Salmonella</td>
<td>reactive arthritis</td>
</tr>
</tbody>
</table>
## I Outbreaks 1974-1996

<table>
<thead>
<tr>
<th>Agent</th>
<th>Outbreaks</th>
<th>Known Cases</th>
</tr>
</thead>
<tbody>
<tr>
<td>Viruses</td>
<td>23</td>
<td>1506</td>
</tr>
<tr>
<td>Bacteria</td>
<td>78</td>
<td>3149</td>
</tr>
<tr>
<td>Protozoa</td>
<td>59</td>
<td>1320</td>
</tr>
<tr>
<td>Unknown</td>
<td>43</td>
<td>2678</td>
</tr>
<tr>
<td>All</td>
<td>203</td>
<td>8653</td>
</tr>
</tbody>
</table>
### II Outbreaks 1974-1996

<table>
<thead>
<tr>
<th>Agent</th>
<th>% Outbreaks</th>
<th>% Cases</th>
</tr>
</thead>
<tbody>
<tr>
<td>Viruses</td>
<td>11.3</td>
<td>17.4</td>
</tr>
<tr>
<td>Bacteria</td>
<td>38.4</td>
<td>36.4</td>
</tr>
<tr>
<td>Protozoa</td>
<td>29.1</td>
<td>15.2</td>
</tr>
<tr>
<td>Unknown</td>
<td>21.2</td>
<td>31.0</td>
</tr>
<tr>
<td>Supply</td>
<td>% Outbreaks</td>
<td>% Cases</td>
</tr>
<tr>
<td>---------------</td>
<td>------------</td>
<td>---------</td>
</tr>
<tr>
<td>Public</td>
<td>35</td>
<td>65</td>
</tr>
<tr>
<td>Semi-public</td>
<td>45</td>
<td>32</td>
</tr>
<tr>
<td>Private</td>
<td>20</td>
<td>3</td>
</tr>
<tr>
<td>Category</td>
<td>Details</td>
<td></td>
</tr>
<tr>
<td>------------------------</td>
<td>----------------------------------------------</td>
<td></td>
</tr>
<tr>
<td>Pop’n</td>
<td>1,000,000</td>
<td></td>
</tr>
<tr>
<td>MDs</td>
<td>1,000</td>
<td></td>
</tr>
<tr>
<td>Hospitals</td>
<td>25</td>
<td></td>
</tr>
<tr>
<td>50% attacked</td>
<td>500,000 ill (2 weeks)</td>
<td></td>
</tr>
<tr>
<td>Each week:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1% to MDs</td>
<td>2500 2.5 per MD</td>
<td></td>
</tr>
<tr>
<td>0.01% to Hosp</td>
<td>25 1 per Hosp</td>
<td></td>
</tr>
</tbody>
</table>
Endemic diarrhea

• How often do you have diarrhea?
  – once per year?
  – twice per year?
  – five times per year?
  – ten times per year?

• 0.5 times per year
<table>
<thead>
<tr>
<th>Sources</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Water</td>
<td>30</td>
</tr>
<tr>
<td>Food</td>
<td>30</td>
</tr>
<tr>
<td>Person to person</td>
<td>30</td>
</tr>
<tr>
<td>Other (animal, stress, etc.)</td>
<td>10</td>
</tr>
</tbody>
</table>
## Annual costs of endemic diarrhea

<table>
<thead>
<tr>
<th>Description</th>
<th>Population</th>
<th>Cost per case</th>
<th>Total cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.5 cases/y</td>
<td>15M</td>
<td>$300</td>
<td>$1,500M</td>
</tr>
<tr>
<td>0.30 water</td>
<td>5M</td>
<td>$400</td>
<td>$200M</td>
</tr>
<tr>
<td>0.1 md</td>
<td>0.5M</td>
<td>$4,000</td>
<td>$20M</td>
</tr>
<tr>
<td>0.01 Hos</td>
<td>5,000</td>
<td>$0.5M</td>
<td>$5M</td>
</tr>
<tr>
<td>0.002 RIPs</td>
<td>10</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
How do pathogens enter treated water?

- Insufficient treatment
  - disinfection
    - E. coli O157, Walkerton
    - Crypto, Kelowna
    - Giardia, Botwood
  - filtration
    - Crypto, Milwaukee,
How do pathogens enter treated water?

- Inadequate integrity during storage and distribution
  - infiltration
    - E. coli O157, Cabool MO
  - faulty storage
    - Salmonella, Gideon MO
  - back siphonage
  - faulty construction and repairs
How do we monitor microbiological safety?

• Microbiological quality
• Physical - chemical quality
• Sanitary surveys
• Disease surveillance
Microbiological quality

- Samples must represent true water quality
  - sufficient sampling points
  - adequate sampling frequency
  - proper sample collection and transport
- Optimise recovery in lab.
  - Proper storage
  - Standard media
  - No short cuts
Non-random distribution

<table>
<thead>
<tr>
<th></th>
<th>10</th>
<th>10</th>
<th>0</th>
<th>5</th>
<th>0</th>
</tr>
</thead>
<tbody>
<tr>
<td>10</td>
<td>0</td>
<td>5</td>
<td>10</td>
<td>5</td>
<td></td>
</tr>
</tbody>
</table>

55 bacteria in 10 x 100mL of water, av. 0.5/100mL, range 0-10/100mL
Indicators - the best vs. the rest

- **E. coli**
  - best indicator of recent or substantial contamination
  - simple detection methods available
- **Total & thermotolerant coliforms (in absence of E.coli)**
  - indicates regrowth
  - no health significance
- **HPC**
  - measure of water quality deterioration
  - monitoring changes and trends in system condition
E. coli testing - Making decisions with old data

• Water was unsafe yesterday and maybe even before then so a boil water advisory is being issued today.
• Hope you are feeling well!
• The water may or may not be safe today but we won’t know for sure until tomorrow.
• Stay tuned!
Monitoring Crypto.

- Legal requirement in UK
- Cost - £ 8M per year
- Cases prevented - 1500 per year
- Cost per case prevented - £ 5.3K per year!
- Skewed cost/benefit relationship?
Physical-chemical quality

- Free chlorine residuals
  - 0.2-0.5 mg/L
- Turbidity
  - sudden increases above background
- Total dissolved solids
  - conductivity
Sanitary surveys

- Simple to conduct
- Cost effective
- Should be carried out periodically
- Identify acute and potential problems
- Especially relevant to small systems
Disease surveillance

• Passive
  – MDs and labs. report cases to MOHs
• Enhanced
  – MOHs seek cases from MDs and labs.
    • sentinel physicians and pharmacies
    • clinical lab reports
    • health hot-lines
  – improves detection of outbreaks
  – controls spread of outbreaks
    • timely boil water advisories
How can we reduce the risks?

- Guidelines
- Multi-barrier approach
- Adequate monitoring
- Public education
Guidelines

- F/P/T Drinking Water Subcommittee develops guidelines
- Reduce risk of illness to tolerable levels at reasonable costs
- Reviewed on a continuous basis and revised when necessary
- Provinces and municipalities apply them judiciously
Multi-barrier approach

- Select the best source and protect it
- Proper system design and evaluation
- Effective treatment (in WTP or home)
- Intact storage & distribution system
- based upon Hazard Analysis Critical Control Point framework
HACCP - new approach for safe water

- HACCP developed as a means to ensure food safety for US space programme
- Systematic approach to identify, evaluate and control safety hazards
- Emphasis placed upon failure prevention rather than end-product testing
- Will form basis of new WHO drinking water quality guidelines
HACCP Principles

• Perform hazard analysis
• Identify critical control points (CCPs)
• Establish critical limits for CCPs
• Establish system to monitor CCPs
• Establish corrective actions as needed
• Establish verification procedures
• Establish documentation procedures
In-home disinfection devices

- Effective devices are available and include:
  - 1 micron filter + UV light or Ozone or Chlorine
    - viruses, bacteria and protozoa
    - EPA Guide Standard or NSF Int’l Standard 55
  - 0.1 micron filter (ceramic)
    - bacteria and protozoa
    - EPA Guide Standard
  - 1 micron filter (carbon block or RO)
    - protozoa
    - NSF Int’l Standards 53 or 58
Public education

- Regular monitoring of private supplies and proper waste management practices
- Domestic hygiene
- Compliance with boil water advisories
- Selection and operation of home water treatment devices
Conclusions I

- Waterborne pathogens can cause serious acute and chronic diseases
- Most waterborne outbreaks are never detected
- Waterborne diseases (epidemic and endemic) present significant costs to society
- Caused by faulty treatment, storage and distribution
Conclusions II

• E. coli is the faecal indicator of choice
• But monitoring safety involves more than just testing for E. coli
• Reduce risks through a multi-barrier approach (HACCP)
• Educated public can make informed decisions
To Your Health...