Multi-barrier approach and Havelock North in August 2016

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The Future of Our Water
Peak Vision Church, Havelock North
Micro-organisms

TOPICS
- Pathogens
- Sources
- Drinking Water
- Outbreaks
- Groundwater

0.001 mm
1/1,000 mm

0.000005 - 0.0003 mm
1/10,000 mm
THE HUMAN MICROBIOME

Bacteria, fungi, and viruses outnumber human cells in the body by a factor of 10 to one. The microbes synthesize key nutrients, fend off pathogens and impact everything from weight gain to perhaps even brain development. The Human Microbiome Project is doing a census of the microbes and sequencing the genomes of many. The total body count is not in but it's believed over 1,000 different species live in and on the body.

25 SPECIES
in the stomach include:
- Helicobacter pylori
- Streptococcus thermophilus

500-1,000 SPECIES
in the intestines include:
- Lactobacillus casei
- Lactobacillus reuteri
- Lactobacillus gasseri
- Escherichia coli
- Bacteroides fragilis
- Bacteroides thetaiotaomicron
- Lactobacillus rhamnosus
- Clostridium difficile

600+ SPECIES
in the mouth, pharynx and respiratory system include:
- Streptococcus viridans
- Neisseria s incluso
- Candida albicans
- Streptococcus salivarius

1,000 SPECIES
in the skin include:
- Propionibacterium acnes
- Staphylococcus epidermidis
- Corynebacterium jeikeium
- Trichosporon
- Staphylococcus hominis

60 SPECIES
in the urogenital tract include:
- Ureaplasma parvum
- Corynebacterium auris
- Neisseria gonorrhoeae

Image sources: Unsplash - Human Microbiome, Nicola S. - The Human Microbiome Project.
Pathogens

• Viruses
  – Norovirus
  – Enterovirus
  – Rotovirus

• Bacteria
  – Campylobacter
  – Salmonella
  – E. coli O157

• Protozoa
  – Giardia
  – Cryptosporidium
## Notified Diseases in New Zealand (Selected)

<table>
<thead>
<tr>
<th>Disease</th>
<th>2016 Cases</th>
<th>NZ 2016/17</th>
<th>Current Rate per 100 000</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>NZ</td>
<td>Hawkes Bay</td>
</tr>
<tr>
<td>Campylobacteriosis</td>
<td>7457</td>
<td>159.2</td>
<td>817.8</td>
</tr>
<tr>
<td>Cryptosporidiosis</td>
<td>1061</td>
<td>22.6</td>
<td>41.1</td>
</tr>
<tr>
<td>Giardiasis</td>
<td>1615</td>
<td>32.4</td>
<td>40.3</td>
</tr>
<tr>
<td>Legionellosis</td>
<td>243</td>
<td>5.1</td>
<td>1.2</td>
</tr>
<tr>
<td>Leptospirosis</td>
<td>93</td>
<td>2.4</td>
<td>2.1</td>
</tr>
<tr>
<td>Listeriosis</td>
<td>37</td>
<td>0.5</td>
<td>0.6</td>
</tr>
<tr>
<td>Salmonellosis</td>
<td>1097</td>
<td>22.7</td>
<td>22.3</td>
</tr>
<tr>
<td>Shigellosis</td>
<td>174</td>
<td>4.1</td>
<td>2.5</td>
</tr>
<tr>
<td>VTEC/STEC infection</td>
<td>422</td>
<td>9.2</td>
<td>7.4</td>
</tr>
<tr>
<td>Yersiniosis</td>
<td>858</td>
<td>19.2</td>
<td>14.3</td>
</tr>
</tbody>
</table>

Higher reported recreational water contact [www.surv.esr.cri.nz](http://www.surv.esr.cri.nz)
Campylobacteriosis

*Campylobacter jejuni*

- Illness onset 1 to 10 days following ingestion of the bacteria.
- Diarrhoea, severe abdominal pain, vomiting, fever, nausea
- Reactive arthritis, guillain barre syndrome
"E. coli O157 (STEC/VTEC)"

- Illness onset 3 to 9 days (mean 4 days) following ingestion of the bacteria.
- Bloody diarrhoea, severe abdominal pain, vomiting, no fever
- 10% of children infected develop *Haemolytic Uraemic Syndrome (HUS)*
  - Renal failure leading to kidney dysfunction, seizures, coma,
- 1% of STEC cases result in death.
Cryptosporidium

• Incubation period 1–14 days, with an average of 7 days
• Copious watery non-bloody diarrhoea, vomiting, anorexia, fever, malaise, and abdominal cramping for up to 2 weeks
• Resistant to chlorine
• Survive for months
• Found 155 mammals
Sources of pathogenic micro-organisms

- **Humans**
  - Viruses, Bacteria & Protozoa

- **Animals**
  - Bacteria & Protozoa

Excrete 10,000,000,000 cysts per day
Lamb faeces (105 samples)

- **Campylobacter**
  - 81% samples positive
  - 1 – 4,600,000 cfu/g
- **Cryptosporidium** spp.
  - 37% samples positive
  - 1 – 73,882 oocysts/g
- **Giardia** spp.
  - 28% samples positive
  - 1 – 733 cysts/g
- **STEC**
  - 3.8% positive
- **Salmonella**
  - 1.9% positive

Multi-barrier Approach to Safe Drinking Water

• Protection of source of the water
• Water treatment
  – Remove Particles
  – Inactivate organisms
• Secure Distribution system
• Monitor water quality
• Response to adverse water test results
Outbreaks due to contamination surface water

<table>
<thead>
<tr>
<th>Year of Outbreak</th>
<th>Location</th>
<th>Pathogens</th>
<th>Cases Confirmed</th>
<th>Total Cases Estimated</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>2001</td>
<td>North Battleford, SK, Canada</td>
<td><em>Cryptosporidium parvum</em> type 1</td>
<td>375</td>
<td>5,800–7,100</td>
<td>Sewage discharges upstream drinking water intake</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(human)</td>
<td></td>
<td>50 hospitalised</td>
<td></td>
</tr>
<tr>
<td>2010</td>
<td>Östersund, Sweden</td>
<td><em>Cryptosporidium</em></td>
<td>&gt;29</td>
<td>27,000</td>
<td>270 hospitalised</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2001</td>
<td>Te Aute, College, Hawkes Bay, NZ</td>
<td><em>Campylobacter jejuni</em></td>
<td></td>
<td>95–185</td>
<td>Cattle</td>
</tr>
<tr>
<td>2012</td>
<td>Darfield, NZ</td>
<td><em>Campylobacter jejuni</em></td>
<td>29</td>
<td>138</td>
<td>Sheep Rainfall</td>
</tr>
</tbody>
</table>

Dr. Steve E. Hrudey, *Converting Hindsight into Foresight*
Outbreaks due to contamination ground water sources

<table>
<thead>
<tr>
<th>Year</th>
<th>Location</th>
<th>Pathogens</th>
<th>Cases Confirmed</th>
<th>Total Cases Estimated</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>2000</td>
<td>Walkerton, ON, Canada</td>
<td><em>Escherichia coli</em> O157:H7, <em>Campylobacter</em></td>
<td>163 (E)</td>
<td>2,300</td>
<td>Cattle manure Rainfall Treatment failure</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>105 (C)</td>
<td>27 HUS 7 deaths</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>12 both</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2000–01</td>
<td>Asikkala, Finland</td>
<td><em>Campylobacter jejuni</em></td>
<td>71</td>
<td>1450</td>
<td>Rainfall No treatment</td>
</tr>
<tr>
<td>2002</td>
<td>Transtrand, Sweden</td>
<td>Norwalk-like virus</td>
<td>4</td>
<td>~500</td>
<td>Leaking sewer pipe near bore No treatment</td>
</tr>
</tbody>
</table>
# Outbreaks due to contamination in reticulation

<table>
<thead>
<tr>
<th>Year</th>
<th>Location</th>
<th>Pathogens</th>
<th>Cases Confirmed</th>
<th>Cases Estimated</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>2007</td>
<td>Nokia, Finland</td>
<td><em>Campylobacter</em> spp., Norovirus, <em>Giardia</em>, <em>Salmonella</em> spp. <em>Clostridium difficile</em>, Rotavirus</td>
<td>2 deaths</td>
<td>6,500</td>
<td>cross-connection at sewage treatment plant</td>
</tr>
<tr>
<td>2008</td>
<td>Alamosa, CO, USA</td>
<td><em>Salmonella</em></td>
<td>124 1 death</td>
<td>1300</td>
<td>vermin contamination of water storage tank</td>
</tr>
<tr>
<td>2008</td>
<td>Adliswil, Switzerland</td>
<td>pathogens not identified</td>
<td>-</td>
<td>180</td>
<td>cross-connection at sewage treatment plant</td>
</tr>
<tr>
<td>2008</td>
<td>Northampton, England</td>
<td><em>Cryptosporidium cuniculus</em></td>
<td>22</td>
<td>422</td>
<td>Rabbit in backwash tank</td>
</tr>
</tbody>
</table>

*Dr. Steve E. Hrudey, *Converting Hindsight into Foresight*
## Documented waterborne outbreaks in New Zealand, 2005–2013

<table>
<thead>
<tr>
<th>Year</th>
<th>Incident</th>
<th>Causal agent</th>
<th>Cases</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td><strong>Confirmed</strong></td>
<td><strong>Probable</strong></td>
</tr>
<tr>
<td>2005</td>
<td>Bridge Valley camp</td>
<td>Campylobacter</td>
<td>3</td>
</tr>
<tr>
<td>2005</td>
<td>Hawke’s Bay school camp</td>
<td>Campylobacter</td>
<td>6</td>
</tr>
<tr>
<td>2005</td>
<td>Med student camp, Canterbury</td>
<td>Campylobacter</td>
<td>13</td>
</tr>
<tr>
<td>2005</td>
<td>Otago bowling tournament</td>
<td>Campylobacter</td>
<td>8</td>
</tr>
<tr>
<td>2006</td>
<td>Cardrona Skifield</td>
<td>Norovirus</td>
<td>218</td>
</tr>
<tr>
<td>2006</td>
<td>School camp, Te Kuiti</td>
<td>Campylobacter</td>
<td>2</td>
</tr>
<tr>
<td>2007</td>
<td>School camp, Wellington</td>
<td>Gastro – unknown cause</td>
<td>96</td>
</tr>
<tr>
<td>2007</td>
<td>Northland school</td>
<td>Gastro – viral unknown cause</td>
<td>17</td>
</tr>
<tr>
<td>2008</td>
<td>Springton</td>
<td>Campylobacter</td>
<td>5</td>
</tr>
<tr>
<td>2008</td>
<td>South Canterbury youth camp</td>
<td>Campylobacter</td>
<td>2</td>
</tr>
<tr>
<td>2010</td>
<td>Waiouru Commanders’ Course</td>
<td>Campylobacter</td>
<td>1</td>
</tr>
<tr>
<td>2011</td>
<td>Runanga drinking-water supply</td>
<td>Campylobacter</td>
<td>4</td>
</tr>
<tr>
<td>2012</td>
<td>Darfield drinking-water supply</td>
<td>Campylobacter</td>
<td>29</td>
</tr>
<tr>
<td>2012</td>
<td>Hawke’s Bay camping ground drinking-water</td>
<td>Campylobacter</td>
<td>28</td>
</tr>
<tr>
<td>2012</td>
<td>Cardrona Hotel &amp; water supplies</td>
<td>Norovirus</td>
<td>48</td>
</tr>
<tr>
<td>2013</td>
<td>Nelson Lakes Scout camp</td>
<td>Gastro – unknown cause</td>
<td>13</td>
</tr>
</tbody>
</table>
Figure 3: Brookvale Water Supply Bore: Maximum flood extents for flood depths over 10 mm over the simulation period with flood volumes.

Runoff volume from 6-8 August 2016 for a scenario with 125mm of rainfall.
Mangateretere Stream Pond
Alluvial gravel aquifer

- Three main textures
  - Sandy gravel
  - Sand
  - Open frameworks
Stygofauna

Aquifer ecosystems

- Organic matter from surface
- Bacterial/fungal biofilm
- Grazers/detritivores
- Scavengers
- Predators

Microbial Inactivation & Removal
- Filtration
- Predation
- Starvation

Increase transport times and matrices
- Sunlight
- Desiccation

Avoid direct deposition

Courtesy Dr Louise Weaver, ESR
Multi-barrier Approach to Safe Drinking Water

• Protection of source of the water

• Water treatment
  — Remove Particles
  — Inactivate organisms

• Secure Distribution system

• Monitor water quality

• Response to adverse water test results
Conclusions

• Microorganisms are everywhere – both good & bad
• Human sewage/faeces is biggest risk
• Animal faeces likely to contain pathogens
  – but may differ in quantity and types
• Drinking water needs a multiple barrier approach
  – Weakness/absence of any one stage needs to recognised and either fixed or compensated for by enhancing other barriers
• Reduce pathogenic risk in recreational/source waters by increasing opportunities for inactivation or removal of microorganisms
Government Inquiry into Havelock North Drinking Water

Overview

On 12 September 2016, the Government announced that an Inquiry into the Havelock North water supply contamination incident would be held.

The Inquiry members appointed are Hon Lyn Stevens QC (chair), Dr Karen Poutasi CNZM and Anthony Wilson ED.

The Inquiry follows the widespread outbreak of gastroenteritis in Havelock North in August 2016, with more than 5000 people falling ill, following the confirmation of the presence of E. coli in the water supply. Testing through the health system led the Hastings District Council and the Hawke’s Bay District Health Board staff to suspect that Campylobacter was the primary infectious agent.

Drinking water supplies across New Zealand rely on different methods of take and treatment, depending on the nature and security of the water source. Drinking water supplies are regulated under the Health Act 1956 and the source of drinking water is regulated under the Resource Management Act and National Environmental Standards for sources of drinking water. The National Environmental Standards are given effect to by the Hawke’s Bay Regional Council.

In previous inquiries, the Department of Internal Affairs has expressed its expectation that water supplied to their homes and businesses for drinking purposes will be safe to