Waterborne Pathogens of Greatest Health Risk to PLWHA

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Kathmandu, Nepal, April 28, 2010
Water Quality

- Biological
  - Viruses, bacteria, protozoa, helminths (worms)
- Chemical
  - Arsenic, fluoride, iron, manganese
- Physical
  - Turbidity, colour, taste, smell and temperature
Microbiological Contaminants

1. **Viruses** – Smallest and most complex, requires a host cell to replicate

2. **Bacteria** – Simplest and most common microorganism

3. **Protozoa** – May be able to form cysts/oocysts that can stay alive without hosts and in harsh environments.
Size Comparison

**Smallest**
- Virus (0.02 to 0.2 micron)
- Bacteria (0.2 to 5 microns)
- Protozoa (4 to 20 microns)
- Helminth (40 to 100 microns)

**Largest**
Bacteria

- Waterborne examples: *Salmonella, Mycobacteria*
- Simplest, most diverse and most common microorganism
- Abundant in feces (1 gram of feces = billions of bacteria)

Cholera
Protozoa

- Water borne examples: Cryptosporidium, Giardia, Isospora, Cyclospora, Entamoeba hystolytica
- Able to form cysts/oocysts which let them stay alive without a host and survive in harsh environments

Electron microscope image of a single Cryptosporidium oocyst

(Credit: Australian Flow Cytometry Group and Macquarie University)
Viruses

- Water borne examples: *Rotavirus, Hepatitis*
- Depend on host cells to replicate
- Some viruses can remain viable outside of a host for long periods, also in dry conditions
- Difficult to analyze in laboratory

Hepatitis A
Major Water Borne Diseases Caused by Pathogens

- Diarrhea
  - Bacteria, virus or protozoa
- Cholera
  - Bacteria
- Typhoid
  - Bacteria
- Cryptosporidiosis
  - Protozoa
Discussion Question 1

- Which waterborne pathogens are common in PLWHA at the clinics/hospitals/offices that you work with?
### Table 3.4 Differential Diagnosis of Diarrhea by CD4 Count

<table>
<thead>
<tr>
<th>Any CD4 count</th>
<th>CD4 &lt; 200 cells/mm³</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Mycobacterium tuberculosis</td>
<td>• Mycobacterium tuberculosis</td>
</tr>
<tr>
<td>• Enteric viruses</td>
<td>• Mycobacterium avium complex</td>
</tr>
<tr>
<td>• Salmonella spp</td>
<td>• Cryptosporidium parvum</td>
</tr>
<tr>
<td>• Shigella spp</td>
<td>• Cyclospora cayetanensis</td>
</tr>
<tr>
<td>• Campylobacter spp</td>
<td>• Isospora belli (CD4 &lt; 100 cells/mm³)</td>
</tr>
<tr>
<td>• Escherichia coli</td>
<td>• Microsporidia spp (CD4 &lt; 50 cells/mm³)</td>
</tr>
<tr>
<td>• Clostridium difficile</td>
<td>• Cytomegalovirus (CD4 &lt; 50 cells/mm³)</td>
</tr>
<tr>
<td>• Giardia lamblia</td>
<td></td>
</tr>
<tr>
<td>• Entamoeba histolytica</td>
<td></td>
</tr>
<tr>
<td>• Strongyloides stercoralis</td>
<td></td>
</tr>
<tr>
<td>• Any systemic illness, e.g., TB and malaria, especially in children</td>
<td></td>
</tr>
</tbody>
</table>


= significant potential for waterborne transmission
**Cryptosporidium**

- Causes the disease cryptosporidiosis

- Severe and chronic dehydrating diarrhea with massive fluid losses for AIDS patients which can result in death
  - Risk of infection increases with lower CD4 levels

- Diarrhea is usually acute, but can be chronic with relapsing illness

- Watery diarrhea which is similar to cholera

Fluorescent stain of *Cryptosporidium* ([link](http://www.dpd.cdc.gov/dpdx/HTML/ImageLibrary/Cryptosporidiosis_il.htm))
% Survival of AIDS Patients and Cryptosporidiosis

(Colford et al.)
Cryptosporidiosis

“Cryptosporidiosis is endemic to most tropical countries”
(Centers for Disease Control, USA)
Rainfall & Cryptosporidium

FIG 1—Monthly rainfall (Institute of Meterology, Bissau) and number of episodes of cryptosporidium diarrhoea among 3215 episodes of diarrhoea in children in Bissau, Guinea Bissau, West Africa
HIV, *Cyclospora* and *Cryptosporidium* in Nepal

- Study of protozoa and persistent diarrhea in children age 5 from western Nepal

- Of 253 children with persistent diarrhea
  - 36% had protozoa infections
  - 13% had bacteriological infections

- HIV infection and severe malnutrition were associated with *Cyclospora* and *Cryptosporidium* causing persistent diarrhea

Nepal HIV/AIDS Study

- November 2002 to July 2003

- 148 stool specimens were collected from 75 HIV/AIDS patients from Maiti Nepal, Kathmandu and HOSPICE, Jhapa (NGOs with hostels for HIV/AIDS women) and from patients visiting Sukra Raj Tropical Disease Hospital, Kathmandu

- Samples were analyzed at a research laboratory at Tribhuvan University, Kirtipur

Results from Nepal Study

- 7% of HIV+ patients and 31% of AIDS patients were found infected with Cryptosporidium
- All patients with Cryptosporidium had diarrhea
- All 4 AIDS patients with Cryptosporidium had chronic watery diarrhea of more than one month’s duration

Conclusions from Nepal Study

- “Cryptosporidium is one of the most important prevalent agent of diarrhea in Nepalese HIV/AIDS patients, and considering the severe and untreatable nature of cryptosporidiosis in such patients, it is rather essential that control measures be taken to achieve improved management among HIV/AIDS population.”

- “In conclusion, Cryptosporidium is probably the most prevalent parasitic pathogen found in patients with diarrhea in HIV/AIDS individuals.”

Pathogens and Type of Diarrhea for PLWHA

<table>
<thead>
<tr>
<th>Parasites isolated</th>
<th>CD4 cells &lt; 200 cells/μl</th>
<th>CD4 cells 200–350 cells/μl</th>
<th>CD4 cells 350–500 cells/μl</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Acute cases</td>
<td>Chronic cases</td>
<td>Acute cases</td>
</tr>
<tr>
<td>Cryptosporidium spp.</td>
<td>38/57 (66.6%)</td>
<td>56/179 (31.2%)</td>
<td>11/34 (32.3%)</td>
</tr>
<tr>
<td>Microsporidia spp.</td>
<td>15/57 (26.3%)</td>
<td>68/179 (37.9%)</td>
<td>5/34 (14.7%)</td>
</tr>
<tr>
<td>Cyclospora spp.</td>
<td>4/57 (7.0%)</td>
<td>43/179 (24.0%)</td>
<td>3/34 (8.8%)</td>
</tr>
<tr>
<td>Giardia spp.</td>
<td>11/57 (19.3%)</td>
<td>7/179 (3.91%)</td>
<td>8/34 (23.5%)</td>
</tr>
</tbody>
</table>

(Tuli et al., 2008. Correlation between CD4 counts of HIV patients and Enteric Protozoan in Different Seasons – An experience of a tertiary Care Hospital in Varanasi (India) *BMC Gastroenterol.* 2008; 8:36)
HIV, *Cryptosporidium* and Children

“Opportunistic infections play a major role in children with severe immune impairment, with *Cryptosporidium* being the leading agent of severe diarrhea.”

(Guarino et al., 2004. Management of Gastrointestinal Disorders in Children with HIV Infection. *Paediatr Drugs*)
Cryptosporidiosis in Southeast Asia

“Among parasitic infections, cryptosporidiosis is the most common intestinal protozoan infection relating to diarrhea in AIDS patients…”

Pathogen Persistence in Water

<table>
<thead>
<tr>
<th>Pathogen</th>
<th>Associated health burden</th>
<th>Difficulty to control</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Health symptoms</td>
<td>Incidence of illness</td>
</tr>
<tr>
<td></td>
<td>Outbreaks through water supply</td>
<td>Persistence in environment</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Resistance to chemical disinfection</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Faecal-oral transmission</th>
<th></th>
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</thead>
<tbody>
<tr>
<td><strong>Entamoeba histolytica</strong></td>
<td>Asymptomatic to severe</td>
<td>Common</td>
<td>Many</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Moderate</td>
<td>High</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>10 - 16</td>
</tr>
<tr>
<td><strong>Giardia lamblia</strong></td>
<td>Moderate</td>
<td>Common</td>
<td>Many</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Moderate</td>
<td>High</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>9 - 14</td>
</tr>
<tr>
<td><strong>Cryptosporidium</strong></td>
<td>Moderate</td>
<td>Common</td>
<td>Many</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Long</td>
<td>Very high</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>4 - 6</td>
</tr>
</tbody>
</table>

(Adapted from WHO)
Bacteria of Particular Importance

- Non-typhoid *Salmonella*
- *Mycobacterium avium*
Blood Based Infections

“Among populations with high rates of HIV infection, bloodstream infection were two to three times higher, and included a relatively heavy burden of opportunistic pathogens.”

Such infections can originate from contaminated water and/or food

Non-typhoid Salmonella

- Non-typhoid Salmonella (NTS) is a major cause of bloodstream bacteria infections.

- “HIV infection is the major risk factor for invasive NTS disease in African adults, with the most recent large study from the region showing that 92% of 164 adults with NTS bacteraemia were HIV seropositive.”

Non-typhoid *Salmonella*

- Some *Salmonella* strains are resistant to many antibiotics

- Prevention of initial infection is important
  - Safe water and hygiene

- “It is likely that...the food chain is less responsible than is ...contaminated water ...in communities with poor hygiene and sanitation.”

Mycobacterium avium

- Opportunistic waterborne pathogen that can spread through the body and cause infections in AIDS patients

- As many as 40% of patients with advanced AIDS may develop *Mycobacterium* infection
CAWST Literature Review

Summary

- Comprehensive literature review relative to waterborne pathogen infection rates for PLWHA

- Indicated that a variety of waterborne pathogens infections are associated with PLWHA
  - *Cryptosporidium* and other protozoa, as well as certain bacteria appear to be particularly common
Discussion Question 2

How would you describe the ability of hospitals in Nepal to analyze stool samples for different waterborne pathogens?
Key Messages

- A variety of waterborne pathogens are associated with PLWHA
- *Cryptosporidium* and other protozoa, as well as certain bacteria (e.g. non-typhoid *Salmonella* and *Mycobacteria*) appear to be particularly common in PLWHA
**Key Messages**

- *Cryptosporidium* is very common once HIV has progressed to AIDS
- *Cryptosporidium* is an important pathogen because it...
  - Survives longer in water than many pathogens
  - Can cause severe chronic life threatening in AIDS patients
  - Is very resistant to water treatment with chlorine
Key Messages

- Certain bacteria (non-typhoid *Salmonella* and *Mycobacteria*) ingested with drinking water can potentially spread through the body in AIDS patients leading to high mortality rates.
Any Questions?