

Waterborne Pathogens of Greatest Health Risk to PLWHA

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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

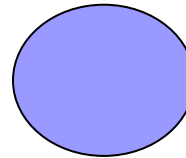


Largest

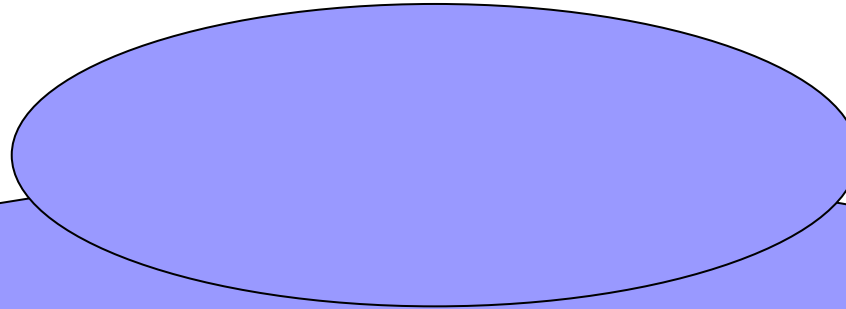
- Virus
- Bacteria
- Protozoa
- Helminth



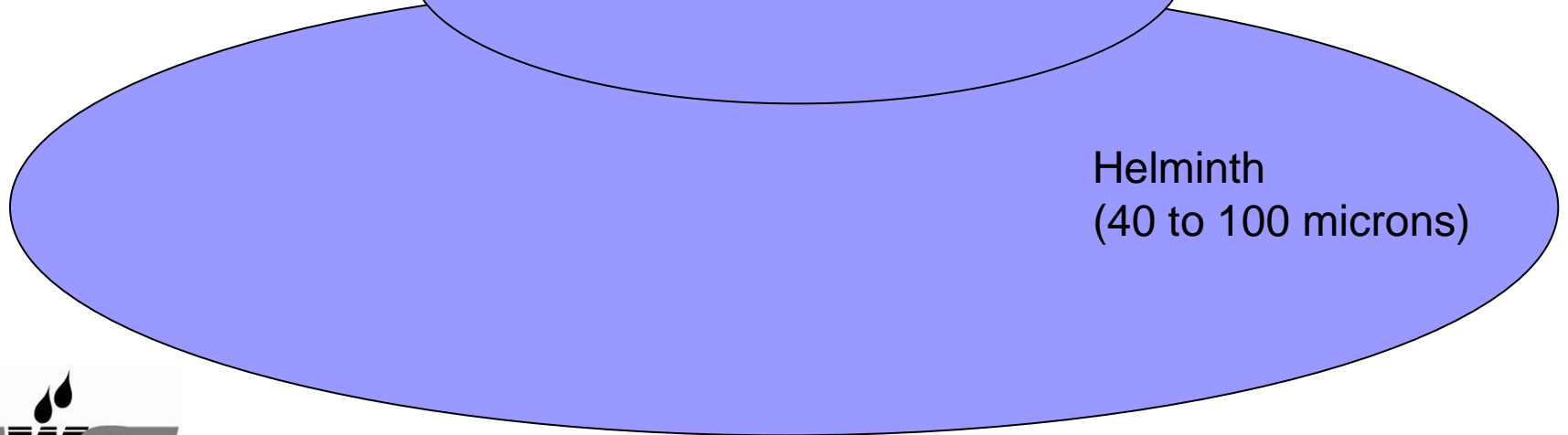
Virus (0.02 to 0.2 micron)



Bacteria (0.2 to 5 microns)



Protozoa
(4 to 20 microns)

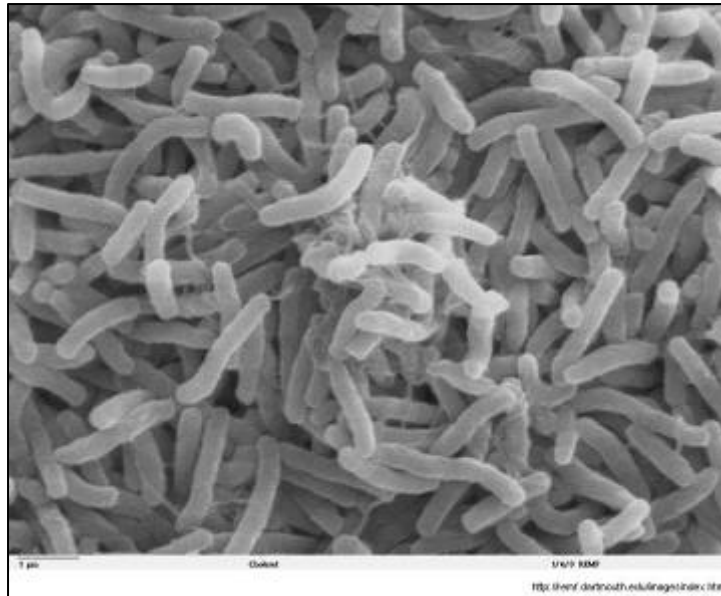


Helminth
(40 to 100 microns)



Bacteria

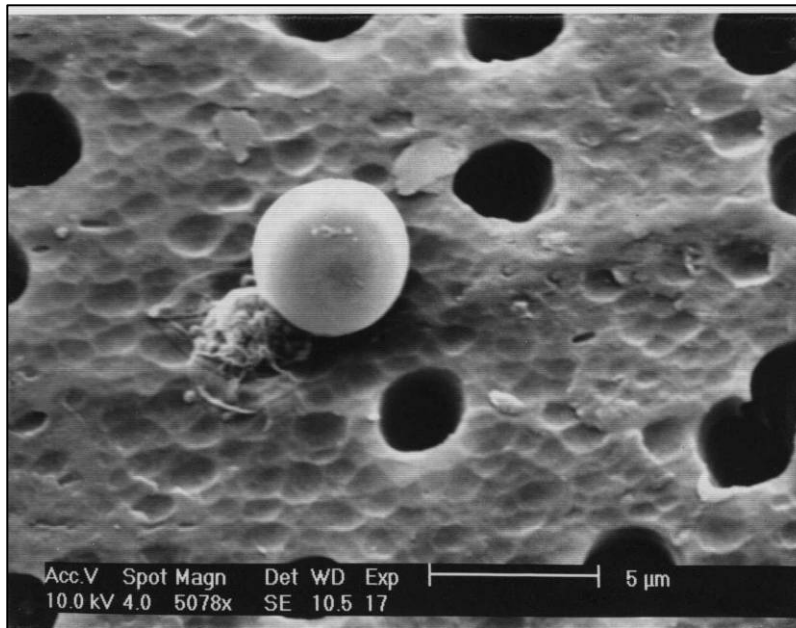
- Waterborne examples: *Salmonella*, *Mycobacteria*
- Simplest, most diverse and most common microorganism
- Abundant in feces (1 gram of feces = billions of bacteria)



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

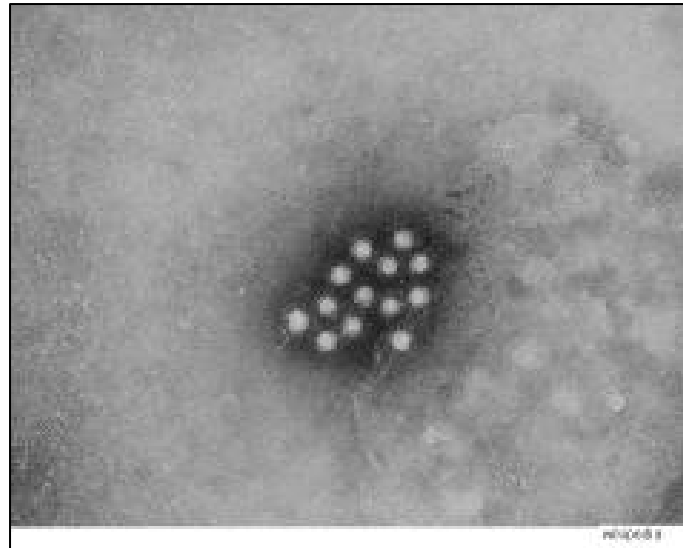


Electron microscope image of a single *Cryptosporidium* oocyst

(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

Any CD4 count	CD4 <200 cells/mm ³
<ul style="list-style-type: none"> • <i>Mycobacterium tuberculosis</i> • Enteric viruses • <i>Salmonella spp</i> • <i>Shigella spp</i> • <i>Campylobacter spp</i> • <i>Escherichia coli</i> • <i>Clostridium difficile</i> • <i>Giardia lamblia</i> • <i>Entamoeba histolytica</i> • <i>Strongyloides stercoralis</i> • Any systemic illness, e.g., TB and malaria, especially in children 	<ul style="list-style-type: none"> • <i>Mycobacterium tuberculosis</i> • <i>Mycobacterium avium complex</i> • <i>Cryptosporidium parvum</i> • <i>Cyclospora cayetanensis</i> • <i>Isospora belli</i> (CD4 <100 cells/mm³) • <i>Microsporidia spp</i> (CD4 <50 cells/mm³) • Cytomegalovirus (CD4 <50 cells/mm³)

Source (Tables 3.4-3.6): Sande MA, Volberding PA, eds. *The medical management of AIDS*. 5th ed. Philadelphia, PA: W.B. Saunders and Company, 1997.

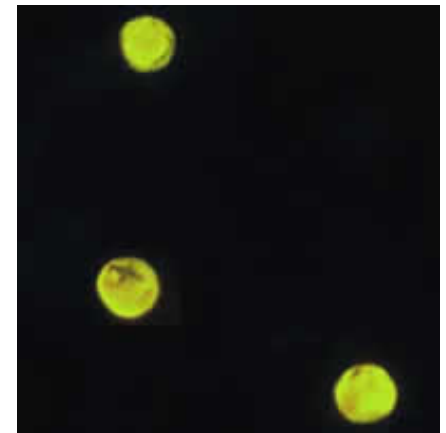
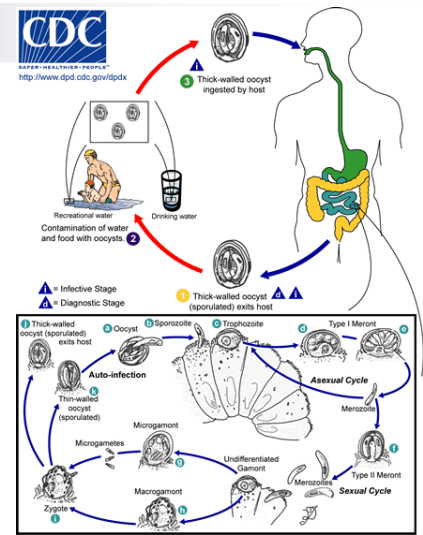
(Partners in Health, 2008)

= significant potential for waterborne transmission



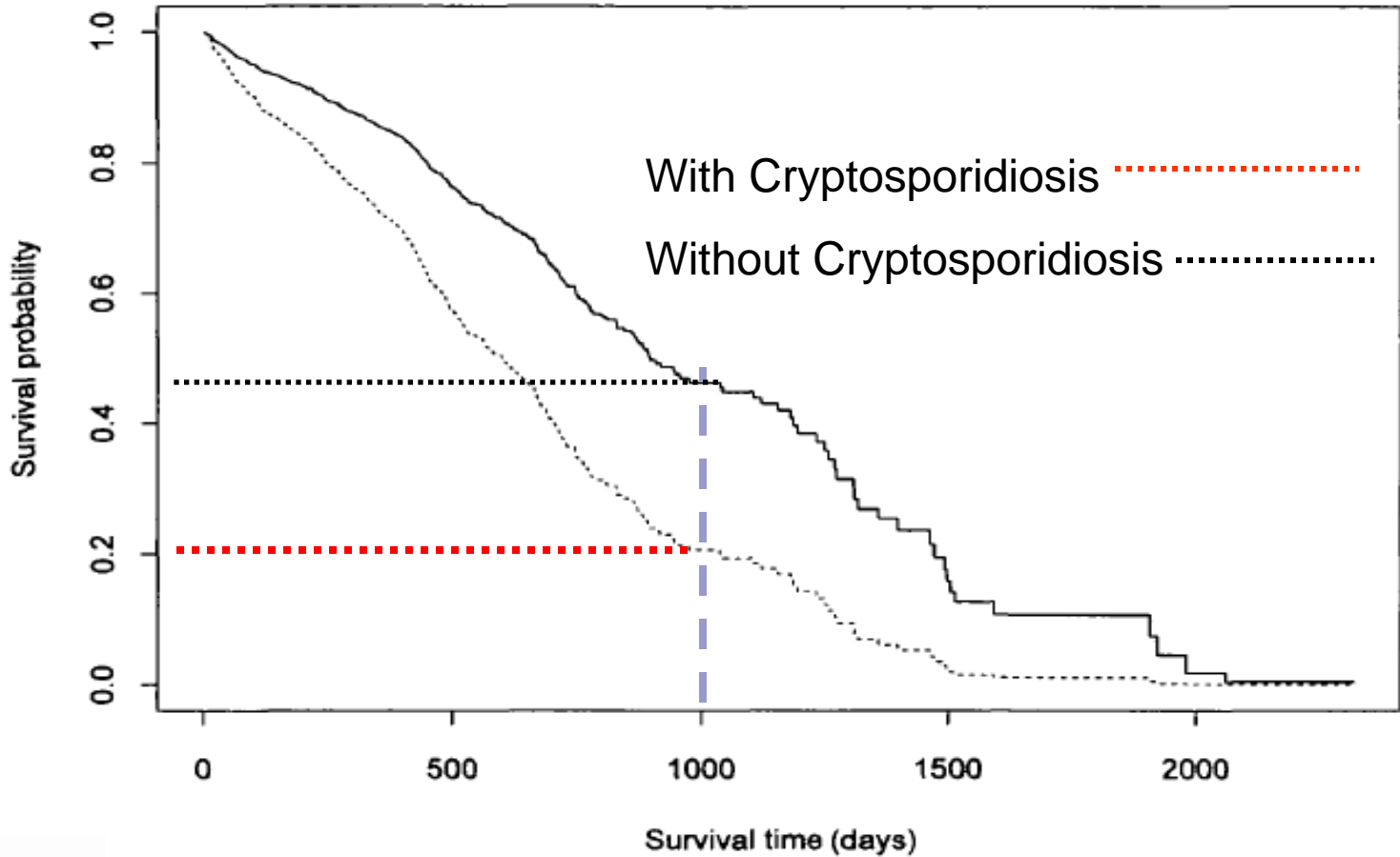
Cryptosporidium

- 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



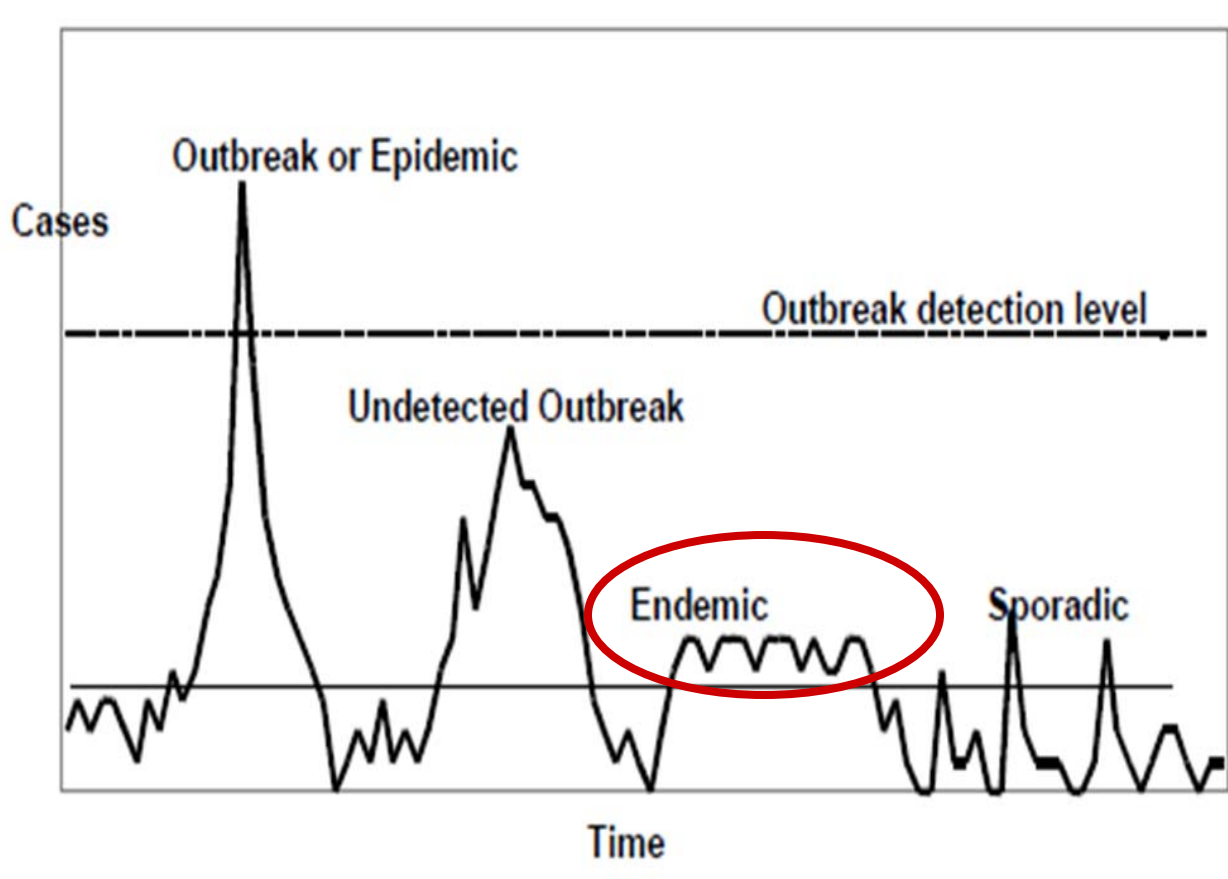
Fluorescent stain of *Cryptosporidium*
 (http://www.dpd.cdc.gov/dpdx/HTML/ImageLibrary/Cryptosporidiosis_il.htm)

% Survival of AIDS Patients and Cryptosporidiosis



Cryptosporidiosis

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



Rainfall & *Cryptosporidium*

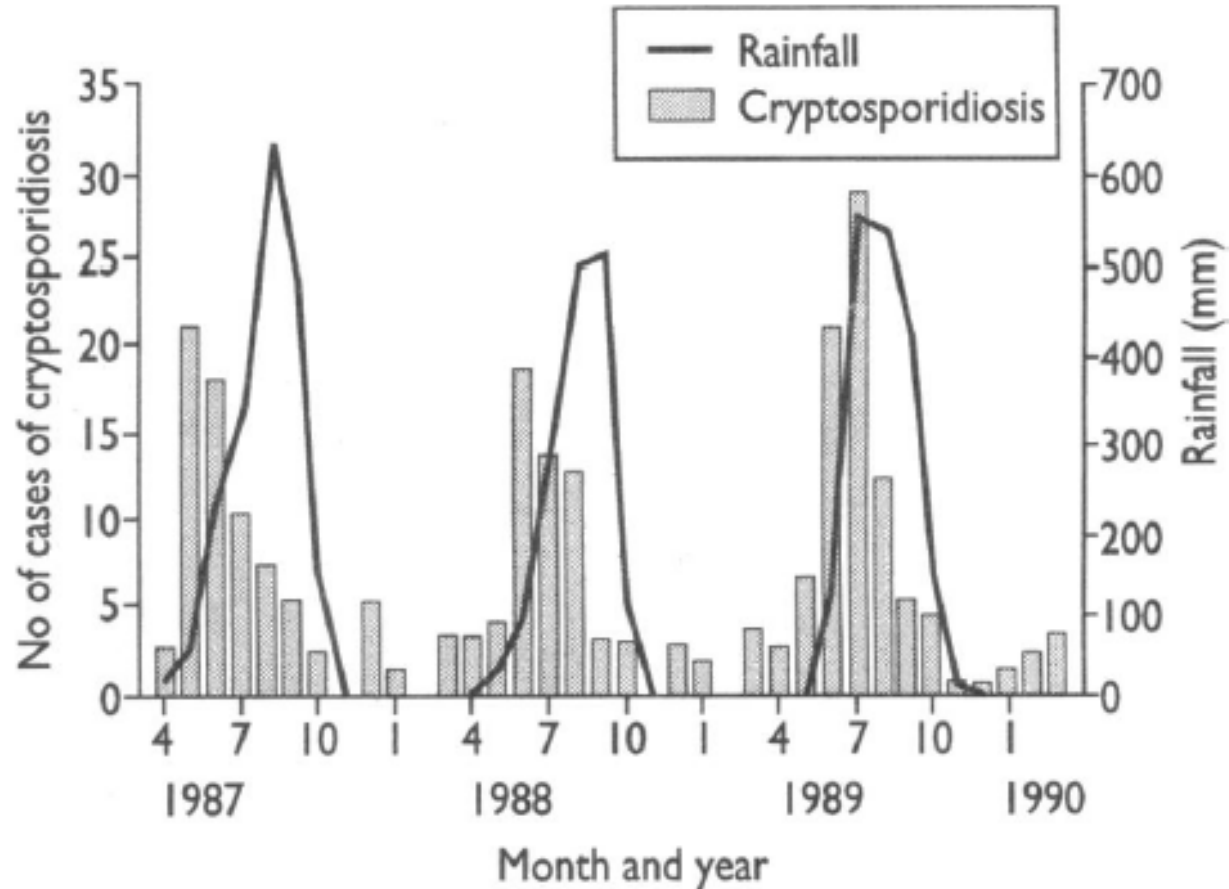


FIG 1—Monthly rainfall (Institute of Meterology, Bissau) and number of episodes of cryptosporidium diarrhoea among 3215 episodes of diarrhoea in children in Bissau, Guinea Bissau, West Africa

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

(Mukhopadhyay et al. (2007) *Southeast Asian J Trop Med Public Health*. Jan;38(1):13-9



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



(Ghimire et al., 2004. Cryptosporidiosis: Opportunistic Infection in HIV/AIDS Patients in Nepal" *J Trop Med Parasitol* 2004;27:7-10)

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

(Ghimire et al., 2004. Cryptosporidiosis: Opportunistic Infection in HIV/AIDS Patients in Nepal" *J Trop Med Parasitol* 2004;27:7-10)



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.”

(Ghimire et al., 2004. Cryptosporidiosis: Opportunistic Infection in HIV/AIDS Patients in Nepal” *J Trop Med Parasitol* 2004;27:7-10)



Pathogens and Type of Diarrhea for PLWHA

Parasites isolated	CD4 cells < 200 cells/ μ l		CD4 cells 200–350 cells/ μ l		CD4 cells 350–500 cells/ μ l	
	Acute cases n = 57	Chronic cases n = 179	Acute cases n = 34	Chronic cases n = 42	Acute cases n = 21	Chronic cases n = 33
<i>Cryptosporidium</i> spp.	38/57 (66.6%)	56/179 (31.2%)	11/34 (32.3%)	20/42 (47.6%)	8/21 (38%)	13/33 (39.3%)
<i>Microsporidia</i> spp.	15/57 (26.3%)	68/179 (37.9%)	5/34 (14.7%)	7/42 (16.6%)	3/21 (14.2%)	--
<i>Cyclospora</i> spp.	4/57 (7.0%)	43/179 (24.0%)	3/34 (8.8%)	28/42 (66.6%)	5/21 (23.8%)	5/33 (15.5%)
<i>Giardia</i> spp.	11/57 (19.3%)	7/179 (3.91%)	8/34 (23.5%)	4/42 (9.5%)	4/21 (19.5%)	3/33 (9.5%)

(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...”

(Nissapatorn V. 2008. Lessons Learned about Opportunistic Infections in Southeast Asia. *Southeast Asian J Trop Med Public Health*)



Pathogen Persistence in Water

Pathogen	Associated health burden			Difficulty to control		
	Health symptoms	Incidence of illness	Outbreaks through water supply	Persistence in environment	Resistance to chemical disinfection	Size (µm)
Faecal-oral transmission						
<i>Entamoeba histolytica</i>	Asymptomatic to severe	Common	Many	Moderate	High	10 - 16
<i>Giardia lamblia</i>	Moderate	Common	Many	Moderate	High	9 - 14
<i>Cryptosporidium</i>	Moderate	Common	Many	Long	Very high	4 - 6

(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

(Murdoch et al., 2004. The Etiology of Febrile Illness in Adults Presenting to Patan Hospital in Kathmandu, Nepal. *Am. J. Trop. Med. Hyg.*, 70(6), 2004, pp. 670–675)

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.”

(Graham, S.M. 2002. Salmonellosis in Children in Developing and Developed Countries and Populations” *Curr Opin Infect Dis.* 2002 Oct;15(5):507-12)



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.”

(Graham, S.M. 2002. Salmonellosis in Children in Developing and Developed Countries and Populations” *Curr Opin Infect Dis.* 2002 Oct;15(5):507-12)



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?