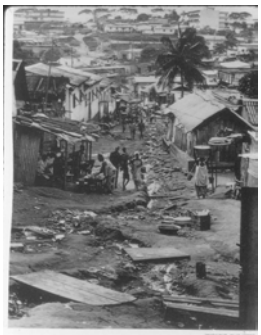
Water and Infectious Disease - Waterborne Disease

- Global distribution of infectious disease
- Transmission cycles
- Water and infectious disease
- Enteric disease in children
- Case studies
  - *E.coli*
  - Cholera (*Vibrio cholerae*)
  - *Cryptosporidium parvum*

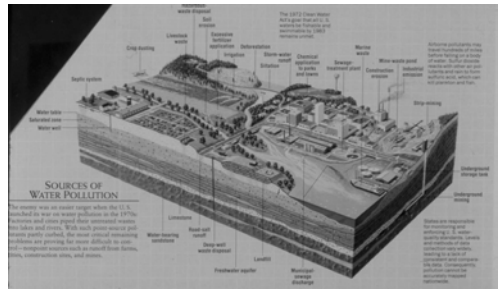


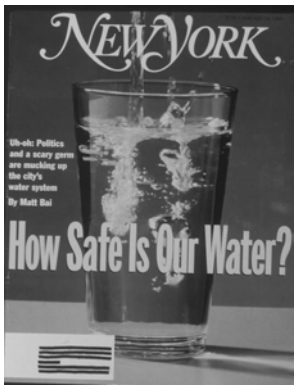
Crowded, makeshift housing and inadequate water and sanitation are associated with increased mortality and morbidity due to communicable diseases, especially gastrointestinal and respiratory diseases.

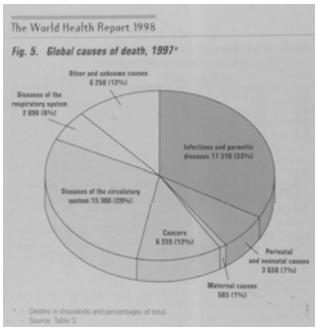
Getting water into households is essential to better health for urban dwellers.

Open drains, a regular feature in low-income urban settlements, represent a major hazard to health.

Delaware Watershed
Catskill Watershed
East of Hudson Watersheds


SOURCES OF WATER POLLUTION


NEW YORK
Uh-oh: Politics and a scary germ are mucking up the city's water system
By Matt Bai
How Safe Is Our Water?


The World Health Report 1998
Fig. 5. Global causes of death, 1997*
Other and unknown causes 6 250 (12%)
Diseases of the respiratory system 2 890 (6%)
Infectious and parasitic diseases 17 310 (33%)
Diseases of the circulatory system 15 380 (29%)
Cancers 6 235 (12%)
Perinatal and neonatal causes 3 630 (7%)
Maternal causes 585 (1%)
* Deaths in thousands and percentages of total.
Source: Table 3.

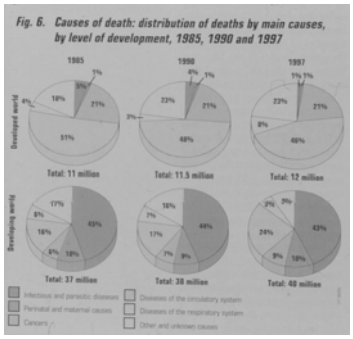
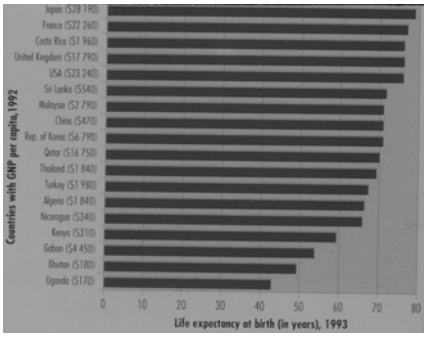
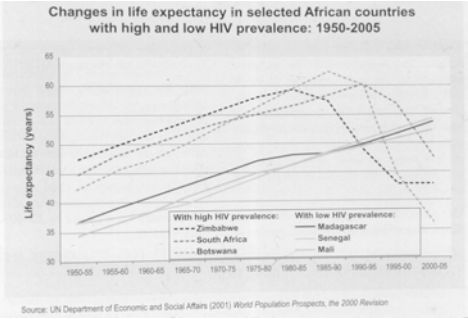
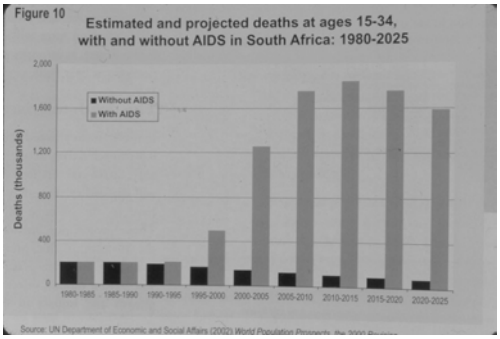
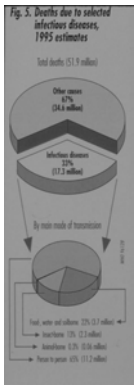


Fig. 6. Causes of death: distribution of deaths by main causes, by level of development, 1985, 1990 and 1997
1985
1990
1997
Developed world
Developing world
Total: 11 million
Total: 11.5 million
Total: 12 million
Total: 37 million
Total: 38 million
Total: 40 million
Infectious and parasitic diseases
Perinatal and maternal causes
Cancers
Diseases of the circulatory system
Diseases of the respiratory system
Other and unknown causes


Japan ($28 190)
France ($22 260)
Costa Rica ($1 960)
United Kingdom ($17 790)
USA ($23 240)
Sri Lanka ($540)
Malaysia ($2 790)
China ($470)
Rep. of Korea ($6 790)
Qatar ($16 750)
Thailand ($1 840)
Turkey ($1 980)
Algeria ($1 840)
Nicaragua ($340)
Kenya ($310)
Gabon ($4 450)
Bhutan ($180)
Uganda ($170)
Countries with GNP per capita, 1992
0
10
20
30
40
50
60
70
80
Life expectancy at birth (in years), 1993







Infections related to water may be classified into four main groups.

Water-borne diseases, where the pathogen is transmitted by ingestion of contaminated water. Cholera and typhoid are often spread this way.

Water-washed diseases involve fecal-oral or other spread from one person to another facilitated by the lack of adequate supplies of water for washing. Many diarrheal diseases as well as infections of the skin and eyes are transmitted this way.

Water-based infections are those caused by pathogenic organisms which spend part of their life cycle in aquatic organisms. The schistosomes and other trematode parasites which parasitize snails, and guinea worm (dracunculiasis), which is spread through minute aquatic crustaceans, are examples.

Water-related insect vectors include those which breed in water, such as the mosquitoes which spread malaria, filariasis, dengue and yellow fever; and black-files which transmit river blindness (onchocerciasis). Also, some of the tsetse flies that transmit sleeping sickness bite preferentially near water.

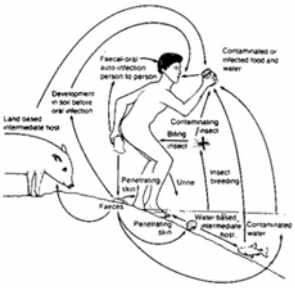
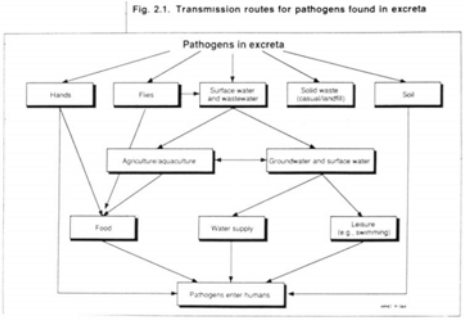
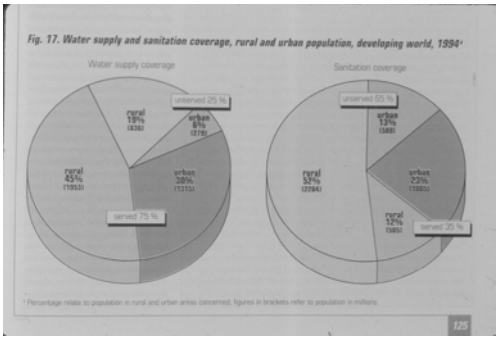
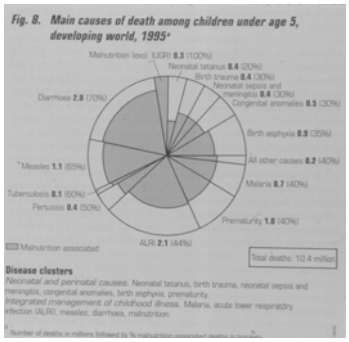


Fig. 5.3. Routes of transmission of the water- and sanitation-related diseases.







1.8 billion

episodes of diarrhea

a year in

children under 5

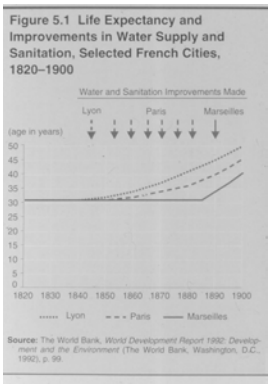
What is needed to control water-borne disease?

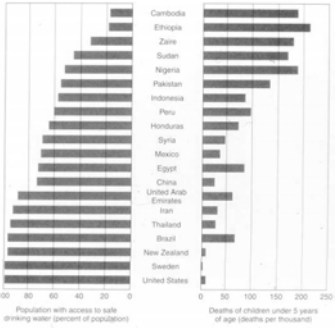
Reduce exposure to excrement

Sanitation - proper disposal of feces

Water - quantity

Water - quality





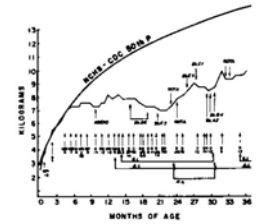


FIG. 1. Enteric infections, diarrheal episodes, and weight curve of cohort male child No. 34. Key URI: upper respiratory infection. D1: diarrhea of 7 days duration. OM: otitis media. BR: bronchitis. BP: bronchopneumonia. G1: Giardia lamblia. A1: Ascaris lumbricoides. H1: Hymenolepis nana. SH.A: Shigella dysenteriae. SH.B: Sh. flexneri. SH.C: Sh. boydii. NOA: Notavirus. ADENO: Adenovirus. This low-birth-weight child was exclusively breast fed for several months. Growth was adequate during the first 5 months of life as compared to the 50th percentile of the NCHS-CDC growth curves. Thereafter, a sequence of periods of growth deceleration, growth arrest, and weight loss in conjunction with diarrhea episodes led to progressive deterioration of the nutritional status and to stunting. Diarrhea episodes were associated, more often than not, with pathogenic enteric infectious agents.

From: Mata et al. Infectious Agents in Acute and Chronic Diarrhea of Childhood. In: Chronic Diarrhea in Children. 1984. E. Lebenthal. Ed

TABLE 1. *Etiologic agents of acute diarrhea*

Rotaviruses, pararotaviruses	*Arizona, Plesiomonas*
Noncultivatable adenoviruses	*Clostridium difficile*
Cultivatable adenoviruses	*Clostridium perfringens*
27-nm agents (Norwalk, Hawaii, Montgomery)	*Staphylococcus aureus*
Enteroviruses (ECHO, Coxsackie)	*Bacillus cereus*
Coronaviruses	*Giardia lamblia*
Astroviruses, caliciviruses (?)	*Dientamoeba fragilis*
Enterotoxigenic *Escherichia coli* (ST, LT)	*Entamoeba histolytica*
Enterophatogenic *Escherichia coli*	*Balantidium coli*
Enteroinvasive *Escherichia coli*	*Cryptosporidium*
Other bacteria carrying 140-MD plasmid (?)	*Isospora belli*
Shigella	*Plasmodium falciparum*
Salmonella	*Trichuris trichiura*
Vibrio cholerae	*Strongyloides stercoralis, S. fulleborni*
Vibrio parahaemolyticus	*Trichinella spiralis*
Campylobacter fetus jejuni	*Necator americanus, Ancylostoma duodenale*
Aeromonas hydrophila	*Capillaria phillippinensis*
Edwardsiella tarda	*Schistosoma mansoni, S. japonicum, S. intercalatum*
Yersinia enterocolitica	

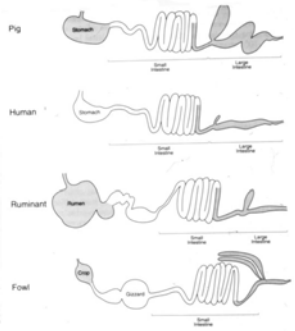


Figure 2.1 The distribution of the microflora in the gastrointestinal tract of pigs, humans, ruminants and fowl. Areas harbouring the normal microflora are indicated by shading.

Microbial Pathogenicity

- Entry into host
- Find a unique niche
- Evasion, subversion or circumvention of initial host defense mechanisms
- Multiplication or persistence
- Cause overt disease (**optional**)
- Exit the host - transmissibility

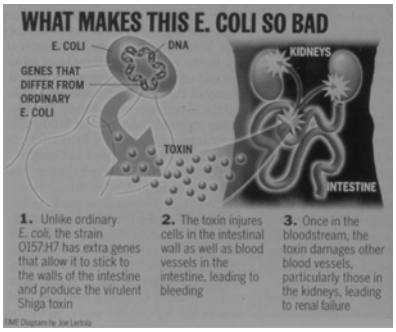
"A key distinction is that a pathogen has an inherent capacity to breach host cell barriers, whereas a commensal species and opportunistic pathogens do not."

Stanley Falkow's lecture at Columbia University 4/17/97; Falkow, S. American Society of Microbiology News, 63: 539-365.

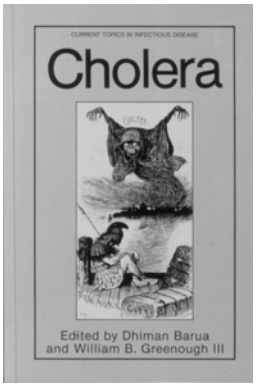
"Not all *E.coli* are created equally"

Escherichia coli
- *commensal*
- *part of normal gut microflora*

Enterohemorrhagic *E. coli*	pathogen, causes GI disease
Enterotoxigenic *E. coli*	"
Enteropathogenic *E. coli*	"
Enteroaggregative *E. coli*	"
Enteroinvasive *E. coli*	"



Healthy diet? Feeding cows hay may help prevent the spread of *E. coli* in beef.

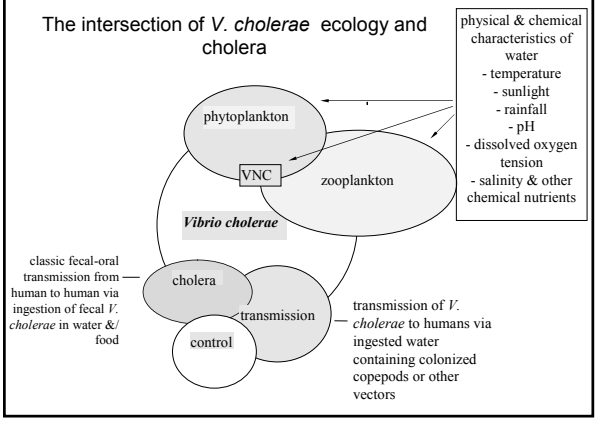


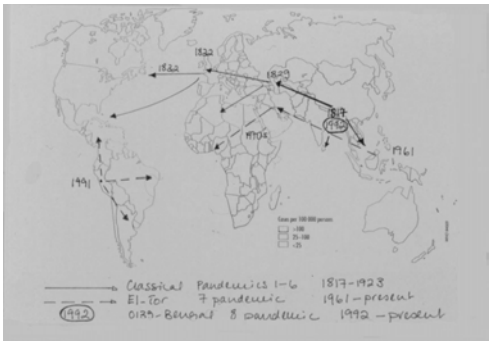
Virulence of *Vibrio cholerae*

[Classical Inaba strain]

Inoculum	10^4	10^6	10^8
Subjects	13	52	2
Symptoms			
None	4 (30%)	10 (19%)	0
Mild diarrhea	9 (70%)	28 (54%)	1
Severe diarrhea	0	14 (27%)	1

The intersection of *V. cholerae* ecology and cholera





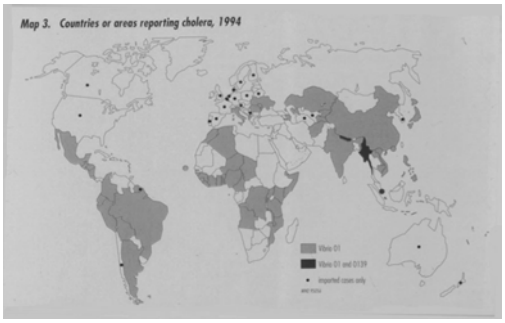
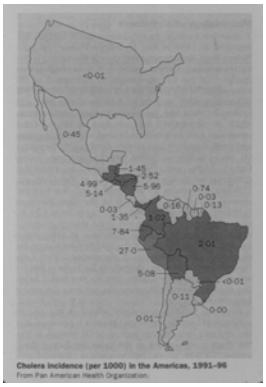


Figure 1. Geographic extent of the Latin American cholera epidemic over time. Lines represent the advancing front of the epidemic at different dates. As of mid-1995, all Latin American countries except Uruguay have reported cases; no cases have been reported from the Caribbean.



Cholera incidence (per 1000) in the Americas, 1991–96
From Pan American Health Organization.

Table 2. Mechanisms of transmission of epidemic cholera in Latin America, as determined in eight epidemiologic investigations, 1991-1993[a]

	Peru			Ecuador	El Salvador	Bolivia	Brazil	Guatemala
Transmission mechanism	Trujillo Urban 3/91 (15)	Piura Urban 3/91 (16)	Iquitos Urban 7/91 (17)	Guayaquil Urban 7/91 (18)	Rural 3/91 (19)	Saipina Rural 2/92 (20)	Fortaleza Rural 6/93 -[b]	Guatemala City Urban 7/93 (21)
Waterborne								
Municipal water	+	+		+				
Surface water			+		+	+	+	
Putting hands in water vessel	+	+						
Foodborne								
Street vendors' foods		+						+
Street vendors' beverages		+		+				+
Street vendors' ice/ices		+						+
Leftover rice		+	+					+
Fruits/vegetables			+					
Seafood								
Uncooked seafood				+				
Cooked seafood				+	+			

[a] Reference numbers are in parentheses.
[b] CDC Unpublished data.

Table 2.—Location of Exposure to Toxigenic *Vibrio cholerae* O1 or O139 for Cholera Cases Diagnosed in the United States, 1992-1994 (n=160)

Country	No. of Cases
United States and territories	
United States	6
Guam	1
Latin America	
Ecuador	6
El Salvador	18
Guatemala	2
Mexico	13
Nicaragua	1
Peru	83*
Venezuela	2
Asia	
Cambodia	2
China	1
India	2
Indonesia	1
Pakistan	2
Philippines	8
Thailand	9†
Turkey	1
Unknown	2

*Includes 75 airplane passengers in 1992 outbreak.
†Includes 5 cruise ship passengers in 1994 outbreak.

Domestically acquired cholera cases in the United States 1992–1994

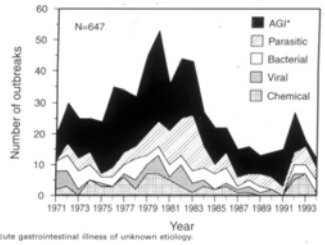
2 exposure: eating shellfish harvested off Gulf Coast caused by endemic Gulf Coast *Vibrio cholerae* 01

4 exposure: unusual foods of non-US origin

No evidence of secondary transmission in the US

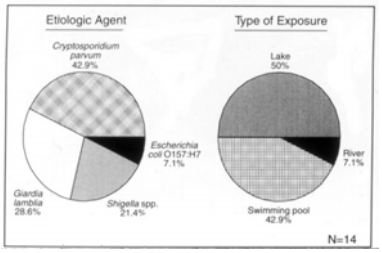
From: Mahon *et al*. 1996, JAMA, 276: 307-312

FIGURE 4. Number of waterborne-disease outbreaks associated with drinking water, by year and etiologic agent — United States, 1971–1994



*Acute gastrointestinal illness of unknown etiology.

FIGURE 3. Waterborne-disease outbreaks of gastroenteritis associated with recreational water, by etiologic agent and type of exposure — United States, 1993–1994



Features favoring transmissibility of *Cryptosporidium parvum*

- Broad host ranges
- Life cycle in single host / autoinfective
- Highly infectious
- Oocysts fully infective upon excretion
- Large numbers of oocysts may be shed
- Ubiquitous distribution in environment
- Highly resistant to disinfection and environmental pressures
- No effective therapy

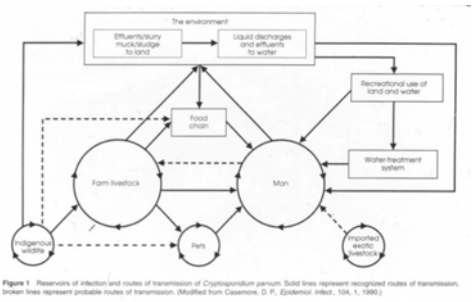


Figure 1 Reservoirs of infection and routes of transmission of *Cryptosporidium parvum*. Solid lines represent recognized routes of transmission; broken lines represent probable routes of transmission. (Modified from Casemore, D. P., *Epidemiol. Infect.*, 104, 1, 1990.)

Casemore, D.P. *et al.* 1997. Cryptosporidiosis - human and animal epidemiology. In: *Cryptosporidium* and Cryptosporidiosis. Ed. R. Fayer.

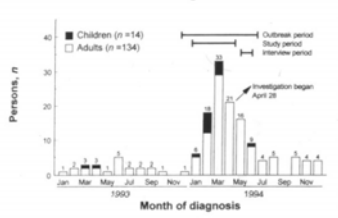
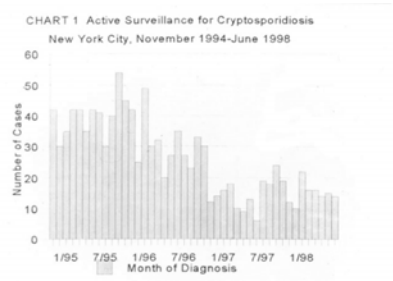
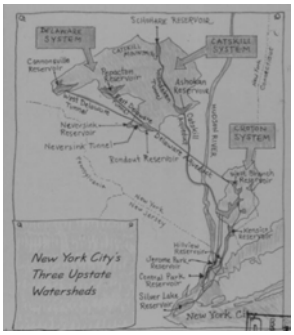
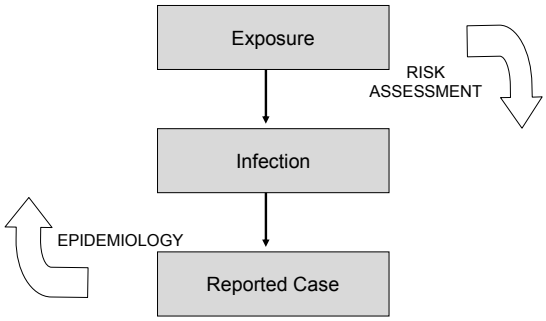


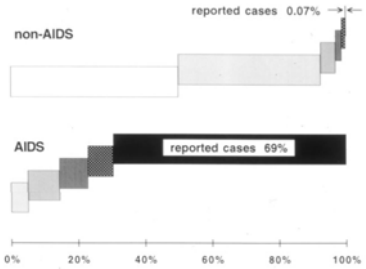
Figure 1. Number of cases of *Cryptosporidium* infection reported to the Clark County Health Department by month of diagnosis, January 1993 to December 1994 (n = 148)

Source: S.T. Goldstein *et al.* Ann Intern Med. 1996;124:459-468



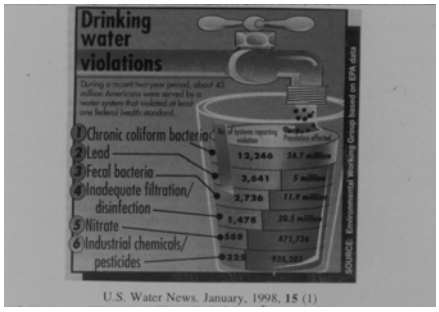






Conclusions

- the distribution of cases is consistent with common source exposure
- tapwater may contribute to endemic cryptosporidiosis



H_2O HYPOCRISY

Eighty-eight percent of the members of Congress who tried to weaken water standards in 1994 had bottled water delivered to their Capitol Hill offices.