Waterborne Disease Risk

http://extension.usu.edu/agwastemanagement/Permits/cafo-permit

Outline

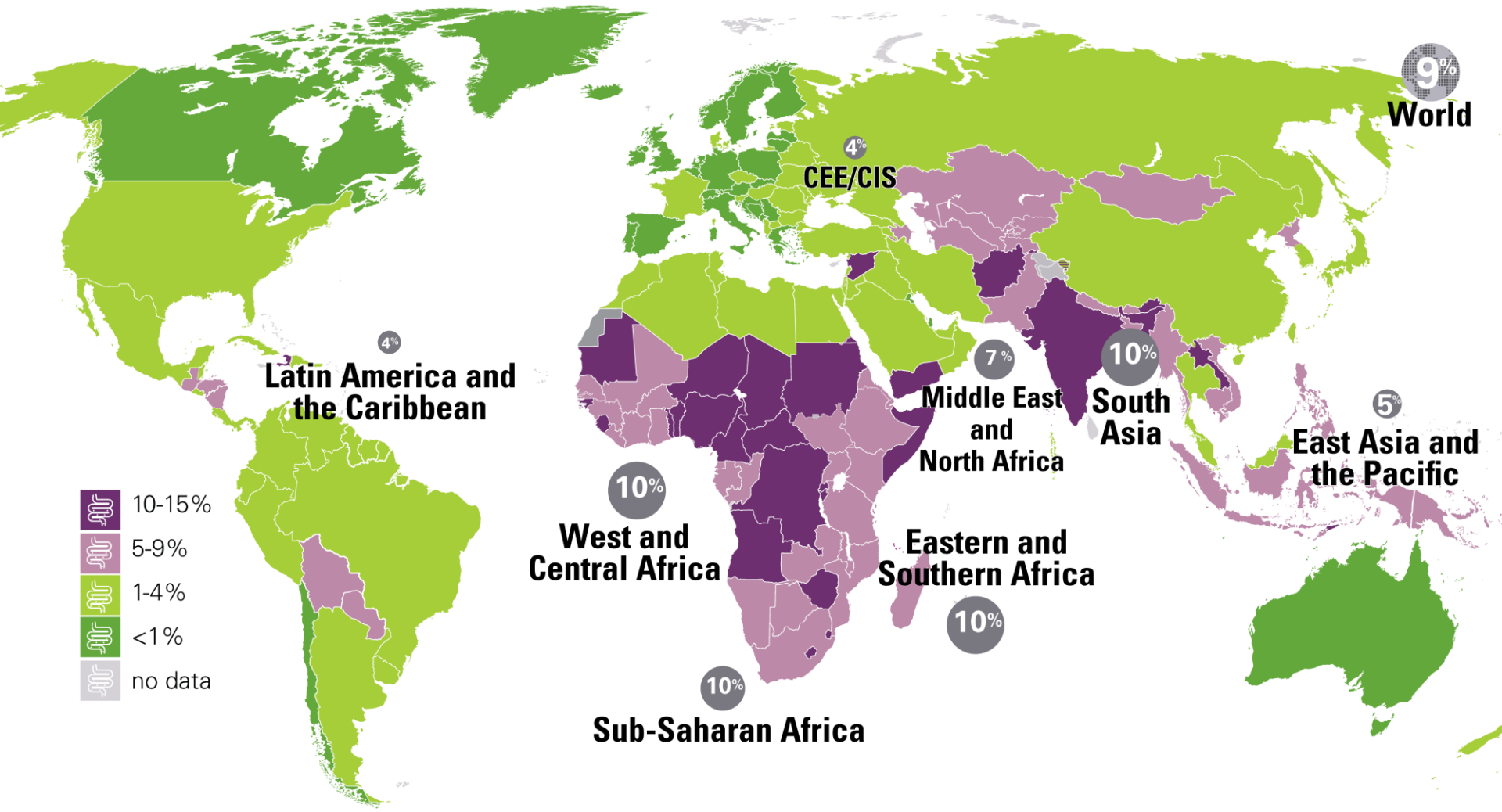
1. The Global Problem
2. The epidemiological link
3. The US
4. Assessing risk
5. Small water systems – the Walkerton experience

Water-Related Diseases
(~80% infectious diseases)

- Waterborne:
  - Cholera, typhoid, bacillary dysentery, infectious hepatitis
- Water-washed:
  - Trachoma, scabia, dysentery, louse-borne fever
- Water-based:
  - Schistosomiasis, Guinea worm
- Water-related (insect vector):
  - Malaria, sleeping sickness, onchocerciasis

Leading causes of mortality from infectious diseases (WHO 2015 and 2016 estimates)

Disease	Mortality
LRI	3.2 million
Diarrheal Diseases	1.4 million
Tuberculosis	1.4 million
HIV/AIDS	1.1 million
Malaria	0.4 million



Percentage of deaths among children under age 5 attributable to diarrhoea, 2015.
https://data.unicef.org/topic/child-health/diarrhoeal-disease/

The Size of the Problem in 2012

- 842,000 people die every year from diarrhoeal diseases linked to inadequate water, sanitation and hygiene
- 748 million people lacked access to improved water sources (11% of the global population)
- 2.5 billion people lacked access to improved sanitation (36% of the world's population)
- 1 billion practice open defecation

(Prüss-Üstün et al. 2014. Trop. Med. Int. Health 19:894-905)

The good news in 2012:

- Mortality estimates related to WASH much lower than a decade ago
- Since 1990,
  - >2 billion gained access to improved water sources (now 89% global population with 116 countries meeting MDG)
  - Almost 2 billion gained access to improved sanitation (now 64%, with 77 countries meeting MDG)

The focus today is on the extreme disparities, with poor, marginalized (and often rural) peoples bearing the burden of disease

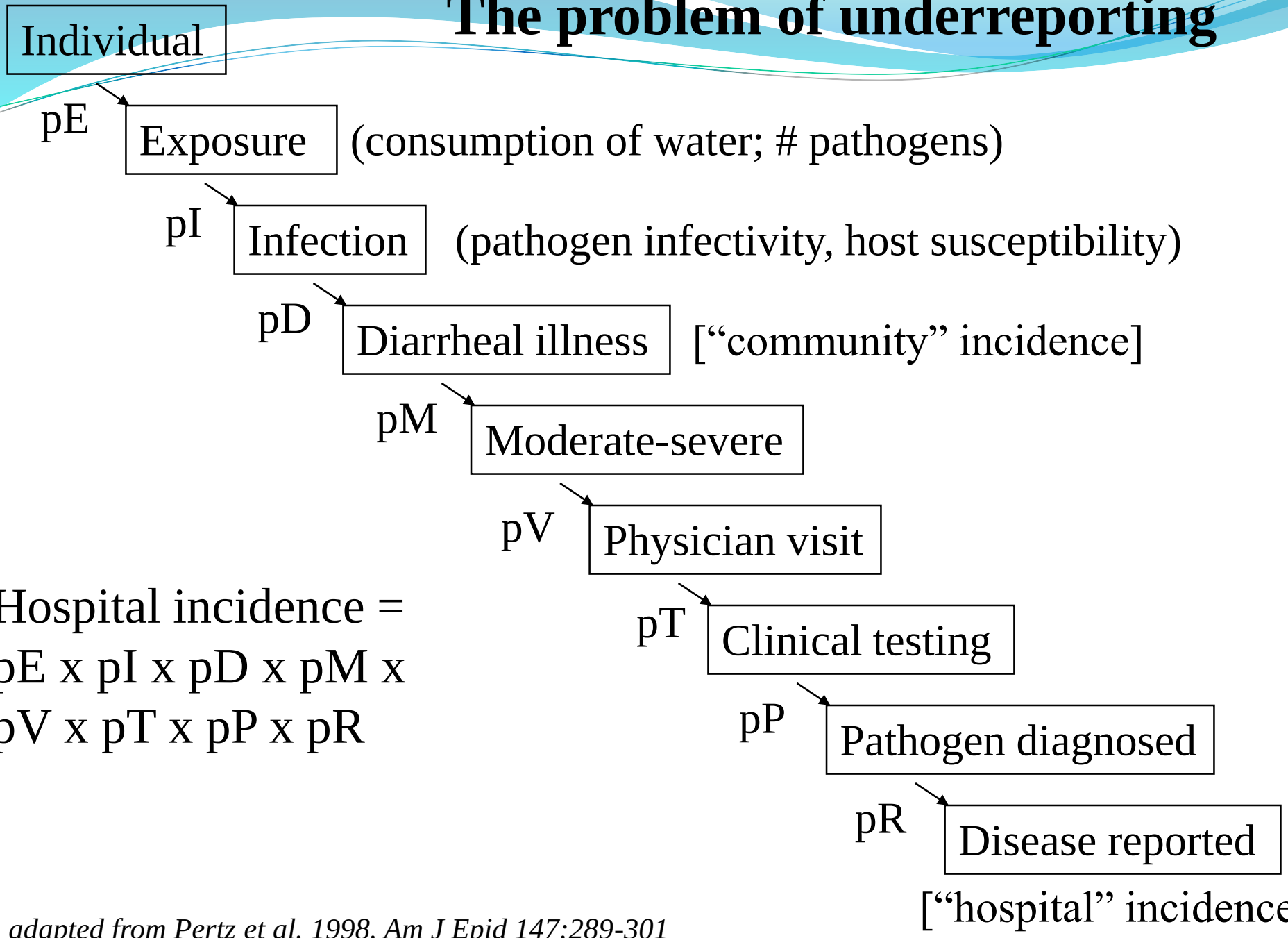
(Progress on Drinking Water and Sanitation 2014 update, UNICEF & WHO)

- How do you make the epidemiological link between human disease and water, in order to inform policy decisions?

  - officially reported data vs. self reported data

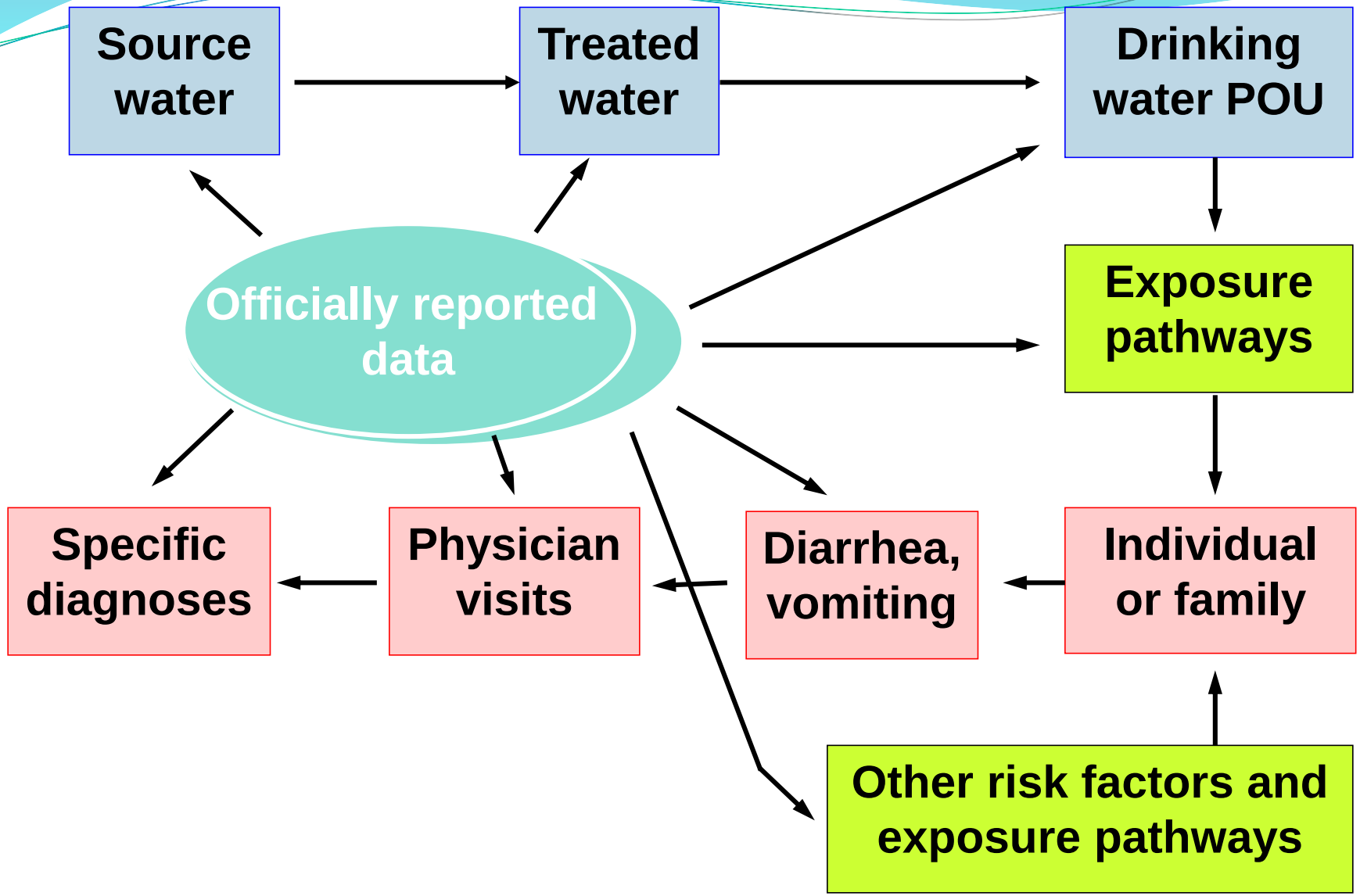
    (questionnaire-based studies)

The problem of underreporting



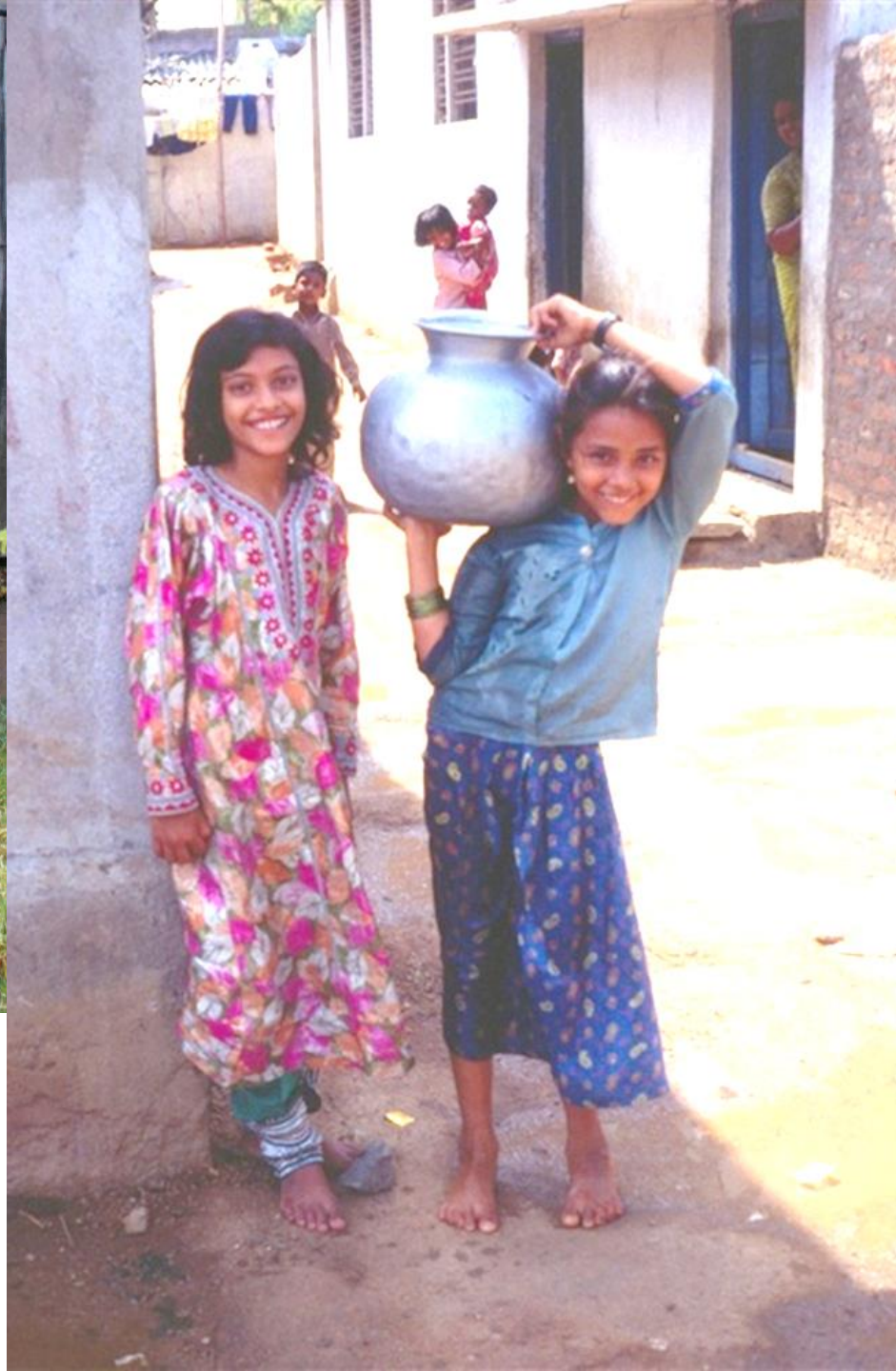
Hospital incidence =
pE x pI x pD x pM x
pV x pT x pP x pR

adapted from Pertz et al. 1998. Am J Epid 147:289-301



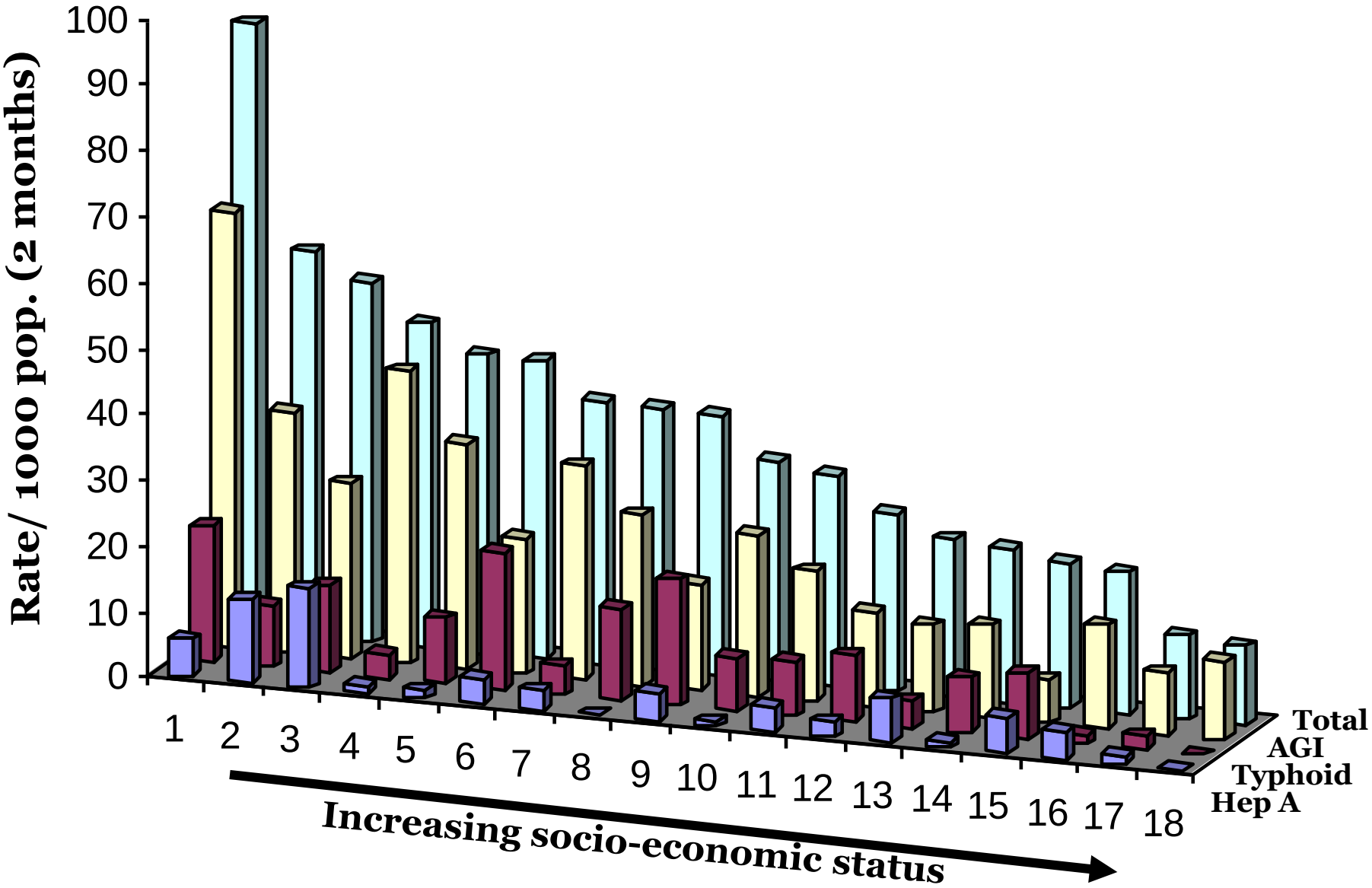
Adapted from R. Morris, 2000

Water Quality and Health Studies in Hyderabad, India



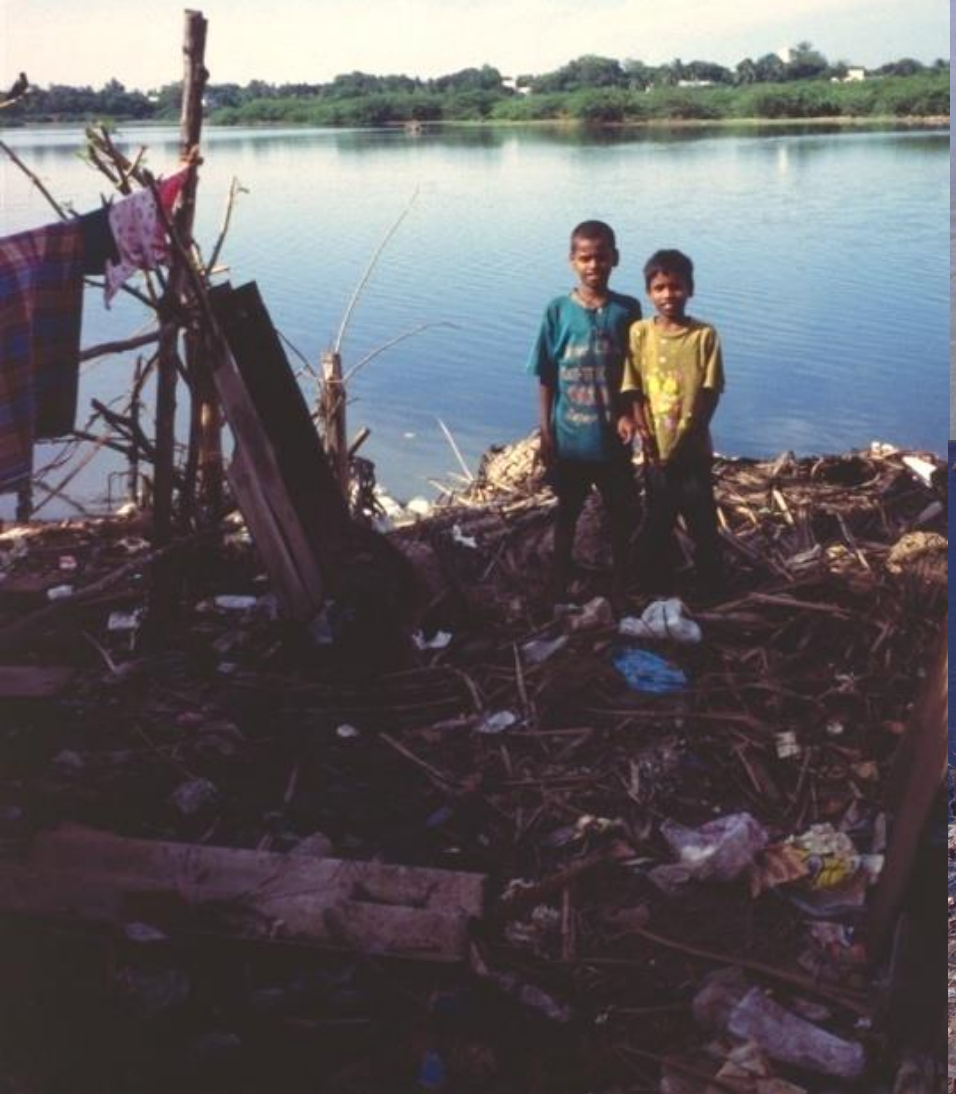
Waterborne diseases in Hyderabad by Zone

(Jatish Mohanty, HSPH doctoral thesis, 1996)



Risk Factors for Disease

- Sewage around home
- Lack of education
- Deteriorating infrastructure



Cleaning utensils on the road
Use of damaged food
Drinking water w/o residual chlorine
Using mud as a cleaning agent


OPEN

How about the US?

- Relatively protected sources are susceptible to contamination from wildlife, accidents or contaminated groundwater flows

Surface Waters? e.g., the Ohio River

- "out of 58 water supply intakes along ~980 miles of river, 48 are within 5 miles downstream of effluent discharge from a wastewater treatment plant

- a study of 20 cities serving 7 million people estimated minimum wastewater component ranged from 2.3-18% and increased to predominantly wastewater for several municipalities during low flow periods"

McFeters

Cryptosporidium parvum

http://www.biosci.ohio-state.edu/~parasite/protozoans.html

Change in complacency with Milwaukee Cryptosporidiosis outbreak

- estimates of >400,000 sick
- >100 related deaths
- probably related to poor filter backflushing practices at one of Milwaukee's treatment plants

Microbiological Risk Assessment (MRA)

(1). Hazard identification

- can we measure pathogens? are they viable? are they infectious?
- what about pathogen/pathogen and pathogen/chemical mixtures?

(2). Exposure assessment

- for most infectious agents; waterborne (drinking? showering? toilet flushing, etc?), foodborne, fecal-oral?

(3). Dose-response analysis

- most susceptible individual? mixtures?

(4). Risk characterization

- numbers and severity

Pathogens in drinking water (infectious dose, incidence and survival)

	Infectious Dose	Estimated Incidence (US)	Survival DW (d)
Bacteria			
Vibrio cholerae	10^{8}	(v. few)	30
Salmonella spp.	10^{6-7}	59,000	60-90
Shigella spp.	10^{2}	35,000	30
toxigenic *E. coli*	10^{2-9}	150,000	90
Campylobacter spp.	10^{6}	320,000	7
Leptospira spp.	3	?	?
Francisella tularensis	10	?	?
Yersinia enterocolitica	10^{9}	?	90
Aeromonas spp.	10^{8}	?	90
Helicobacter pylori	?	high	?
Legionella pneumophila	>10	11,000	long
Mycobacterium avium	?	?	long

	Infectious Dose	Estimated Incidence (US)	Survival DW (d)
Protozoa			
Giardia lambia	1-10	260,000	25
Cryprosporidium parvum	1-30	420,000	?
Naegleria fowleri	?	?	?
Acanthamoeba spp.	?	?	?
Entamoeba histolica	10-100	?	25
Cyclospora cayetanensis	?	?	?
Isospora belli	?	?	?
The Microsporidia	?	?	?
Ballantidium coli	25-100	?	20
Toxoplasma gondii	?	?	?
Viruses*			
Total estimates:	1-10	6,500,000	5-27

*Includes Norwalk virus, Rotavirus, Coxsachievirus, Echovirus, Reovirus, Adenovirus, HAV, HEV, Poliovirus, SRSV, Astrovirus, Coronavirus, Calicivirus, and unkown viruses

EPA's Contaminant List

Regulated

Cryptosporidium

Giardia

Heterotrophic plate count

Legionella

Total coliforms, including fecal coliform and *E. coli*

Turbidity

Viruses (enteric)

(DBPs)

CCL-4

Adenovirus

Calicivirus

Enterovirus

Hepatitis A virus

Campylobacter jejuni

Escherichia coli (0157)

Helicobacter pylori

Legionella pneumophila

Mycobacterium avium

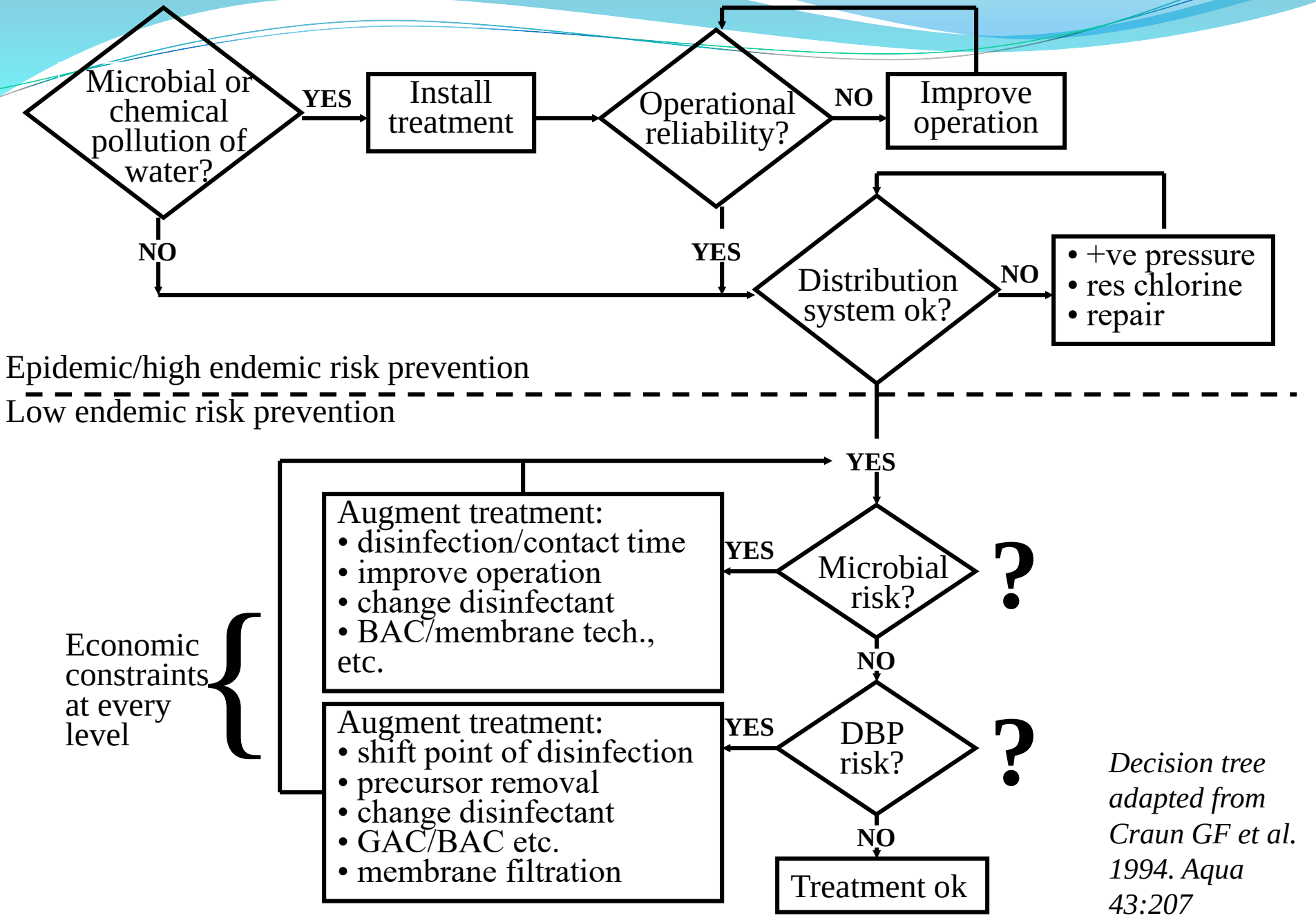
Naegleria fowleri

Salmonella enterica

Microbiological Risk Assessment

- “to predict how many people in the community are infected through drinking water consumption under non-outbreak conditions
- to determine pathogen densities which give an acceptable risk and hence to set microbiological standards for drinking water supplies
- to determine the effectiveness of drinking water treatment for different source waters and to estimate the increased risk if a drinking water treatment fails
- to balance microbial risks against the chemical risks from disinfection by-products and to assess the microbiological impact of eliminating disinfection on public health
- to identify the most cost effective option to reduce microbiological health risks to drinking water consumers”

(Gale P. 1996. Developments in microbiological risk assessment models for drinking water- a short review. J Appl Bacteriol 81:403-410)

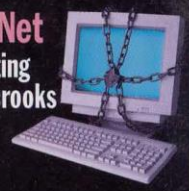


Decision tree adapted from Craun GF et al. 1994. Aqua 43:207

Canada's Weekly Newsmagazine
Maclean's
June 12, 2000 www.macleans.ca $4.50

The Rocket
Celebrating a Legend

The Net
Fighting Cyber-crooks



Beyond Walkerton

When Water Kills

Factory farms: Mountains of deadly waste

Who's testing your water: A province-by-province breakdown

$4.50
24
55113 70001 9

Walkerton, Ontario - 2000

May 12: Torrential downpour washes bacteria from CAFO into well

May 17: Complaints of bloody diarrhea, vomiting, cramps, fever

May 18: Tests of water sampled May 15 reveal *E. coli* contamination, but not notified

May 21: Independent testing, boil-water advisory.

May 22: First death directly linked to E. coli.

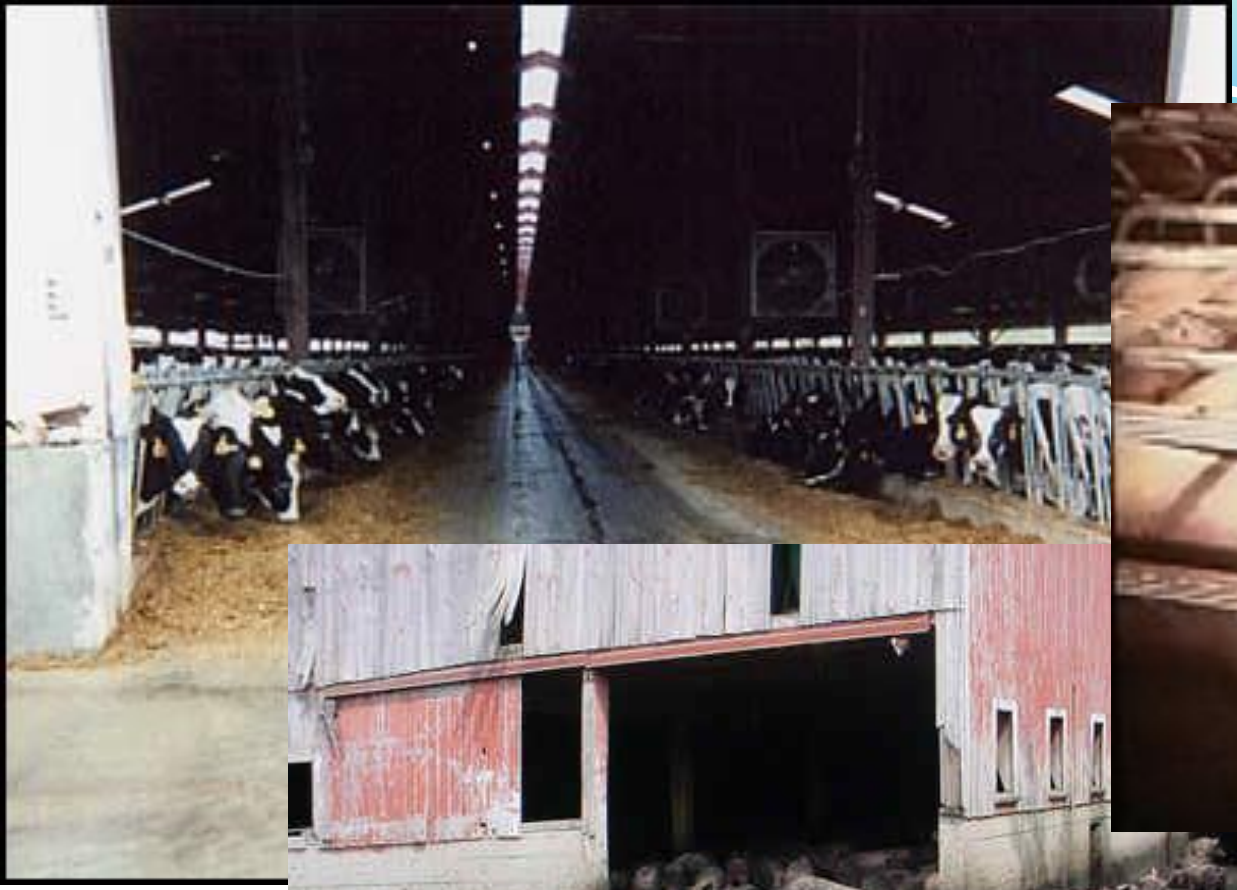
May 23: E. coli O157:H7 recognized. Two-year-old girl dies, > 150 people seek hospital treatment, another 500 have symptoms.

May 24: Two more die.

May 25: Fifth person dies. At least four children in critical condition.

May 29: Sixth death.

May 30: Seventh death.



Walkerton 5 years on

https://vimeo.com/18382889

Walkerton water treatment plant

https://www.youtube.com/watch?v=DtZ-2O6wyl8