Microbiological Safety of Drinking Water: To Your Health

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Introduction

- What are the pathogens?

- Why should we be concerned?

- How do they enter treated water?

- How do we measure microbiological safety?

- How do we reduce the risks?

What are the pathogens?

- human viruses
  - enteric - Norwalk, Hepatitis A
- bacteria
  - enteric - Campylobacter, Shigella, Salmonella, E. coli O157
  - respiratory - Legionella
- protozoa
  - enteric - Giardia, Cryptosporidium
  - systemic - Toxoplasma

How do they differ?

- Size/Filterability
  - protozoa > bacteria > viruses
- Chlorine resistance
  - protozoa > viruses > bacteria
- Obligate parasites
  - viruses and protozoa +, bacteria -
- Survivability outside host
  - viruses and protozoa > bacteria
- Ease of detection
  - bacteria > protozoa > viruses

What are the acute health effects?

- DIARRHEA! DIARRHEA! DIARRHEA!
  - Norwalk - mild
  - Campylobacter - acute (profuse, watery or bloody)
  - Shigella - acute (mucous or bloody)
  - E. coli O157 - acute (bloody)
  - Salmonella - sudden (watery)
  - Giardia - acute (explosive, pale)
  - Cryptosporidium - acute (profuse and watery)

More acute health effects

Organism	Inf. Dose	Symptoms	Duration
Norwalk	Low	V, C, F, H, N	12-48 h
Campy.	Med	C, F, N, V	2-3 d
Shig./O157	Low - Med	F, N, V, C	4-7 d
Salmonella	High	F, C	2-5 d
Giardia	Low	C, G, V	2 -12 w
Crypto.	Low	C, N, F	10-15 d

Acute effects other than the "d" word

- Toxoplasma gondi
  - fever, pharyngitis (infectious mononucleosis)
  - persists days to weeks
- Hepatitis A
  - nausea, vomiting, jaundice
  - persists 1-2 weeks
- Legionella
  - Legionnaires' disease (pneumonia, often fatal)
  - Pontiac fever (non-infectious flu-like illness, self-limiting)

Chronic Health Effects

Organism	Disease
Helicobacter pylori	ulcers, gastric cancer
Campylobacter	Guillain-Barré syndrome
Toxoplasma	blindness, mental illness
Shigella/E.coli O157	kidney damage
Salmonella	reactive arthritis

I Outbreaks 1974-1996

Agent	Outbreaks	Known Cases
Viruses	23	1506
Bacteria	78	3149
Protozoa	59	1320
Unknown	43	2678
All	203	8653

II Outbreaks 1974-1996

Agent	% Outbreaks	% Cases
Viruses	11.3	17.4
Bacteria	38.4	36.4
Protozoa	29.1	15.2
Unknown	21.2	31.0

Sources of outbreaks

Supply	% Outbreaks	% Cases
Public	35	65
Semi-public	45	32
Private	20	3

Outbreaks are easily missed!

- Pop'n   1,000,000
- MDs   1,000
- Hospitals   25
- 50% attacked   500,000 ill (2 weeks)
- Each week:
- 1% to MDs   2500   2.5 per MD
- 0.01% to Hosp   25   1 per Hosp

Endemic diarrhea

- How often do you have diarrhea?
    - once per year?
    - twice per year?
    - five times per year?
    - ten times per year?
- 0.5 times per year

Sources of endemic diarrhea

Sources	%
Water	30
Food	30
Person to person	30
Other (animal, stress, etc.)	10

Annual costs of endemic diarrhea

Population	30M people	Cost per case	Total cost
0.5 cases/y	15M		
0.30 water	5M	$300	$1,500M
0.1 md	0.5M	$400	$200M
0.01 Hos	5,000	$4,000	$20M
0.002 RIPs	10	$0.5M	$5M

How do pathogens enter treated water?

- Insufficient treatment
  - disinfection
    - E. coli O157, Walkerton
    - Crypto, Kelowna
    - Giardia, Botwood
  - filtration
    - Crypto, Milwaukee,

How do pathogens enter treated water?

- Inadequate integrity during storage and distribution
  - infiltration
    - E. coli O157, Cabool MO
  - faulty storage
    - Salmonella, Gideon MO
  - back siphonage
  - faulty construction and repairs

How do we monitor microbiological safety?

- Microbiological quality

- Physical - chemical quality

- Sanitary surveys

- Disease surveillance

Microbiological quality

- Samples must represent true water quality
  - sufficient sampling points
  - adequate sampling frequency
  - proper sample collection and transport
- Optimise recovery in lab.
  - Proper storage
  - Standard media
  - No short cuts

Non-random distribution

10	10	0	5	0
10	0	5	10	5

55 bacteria in 10 x 100mL of water, av. 0.5/100mL, range 0-10/100mL

Indicators - the best vs. the rest

- E. coli
  - best indicator of recent or substantial contamination
  - simple detection methods available
- Total & thermotolerant coliforms (in absence of E.coli)
  - indicates regrowth
  - no health significance
- HPC
  - measure of water quality deterioration
  - monitoring changes and trends in system condition

E. coli testing - Making decisions with old data

- Water was unsafe yesterday and maybe even before then so a boil water advisory is being issued today.

- Hope you are feeling well!

- The water may or may not be safe today but we won't know for sure until tomorrow.

- Stay tuned!

Monitoring Crypto.

- Legal requirement in UK
- Cost - £ 8M per year
- Cases prevented - 1500 per year
- Cost per case prevented - £ 5.3K per year!
- Skewed cost/benefit relationship?

Physical-chemical quality

- Free chlorine residuals
  - 0.2-0.5 mg/L
- Turbidity
  - sudden increases above background
- Total dissolved solids
  - conductivity

Sanitary surveys

- Simple to conduct

- Cost effective

- Should be carried out periodically

- Identify acute and potential problems

- Especially relevant to small systems

Disease surveillance

- Passive
  - MDs and labs. report cases to MOHs
- Enhanced
  - MOHs seek cases from MDs and labs.
    - sentinel physicians and pharmacies
    - clinical lab reports
    - health hot-lines
  - improves detection of outbreaks
  - controls spread of outbreaks
    - timely boil water advisories

How can we reduce the risks?

- Guidelines

- Multi-barrier approach

- Adequate monitoring

- Public education

Guidelines

- F/P/T Drinking Water Subcommittee develops guidelines

- Reduce risk of illness to tolerable levels at reasonable costs

- Reviewed on a continuous basis and revised when necessary

- Provinces and municipalities apply them judiciously

Multi-barrier approach

- Select the best source and protect it

- Proper system design and evaluation

- Effective treatment (in WTP or home)

- Intact storage & distribution system

- based upon Hazard Analysis Critical Control Point framework

HACCP - new approach for safe water

- HACCP developed as a means to ensure food safety for US space programme

- Systematic approach to identify, evaluate and control safety hazards

- Emphasis placed upon failure prevention rather than end-product testing

- Will form basis of new WHO drinking water quality guidelines

HACCP Principles

- Perform hazard analysis
- Identify critical control points (CCPs)
- Establish critical limits for CCPs
- Establish system to monitor CCPs
- Establish corrective actions as needed
- Establish verification procedures
- Establish documentation procedures

In-home disinfection devices

- Effective devices are available and include:
  - 1 micron filter + UV light or Ozone or Chlorine
    - viruses, bacteria and protozoa
    - EPA Guide Standard or NSF Int'l Standard 55
  - 0.1 micron filter (ceramic)
    - bacteria and protozoa
    - EPA Guide Standard
  - 1 micron filter (carbon block or RO)
    - protozoa
    - NSF Int'l Standards 53 or 58

Public education

- Regular monitoring of private supplies and proper waste management practices

- Domestic hygiene

- Compliance with boil water advisories

- Selection and operation of home water treatment devices

Conclusions I

- Waterborne pathogens can cause serious acute and chronic diseases
- Most waterborne outbreaks are never detected
- Waterborne diseases (epidemic and endemic) present significant costs to society
- Caused by faulty treatment, storage and distribution

Conclusions II

- E. coli is the faecal indicator of choice

- But monitoring safety involves more than just testing for E. coli

- Reduce risks through a multi-barrier approach (HACCP)

- Educated public can make informed decisions

To Your Health...