Drinking Water "Safety" in Smaller Communities

Steve E. Hrudey, FRSC, FSRA, PhD, DSc(Eng), PEng
Professor of Environmental Health Sciences
Associate Dean (Academic)

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UNIVERSITY OF ALBERTA

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"Safe" Drinking Water is the Goal

- What does "safe" drinking water mean?
- There is no definition of "safe drinking water" in the Guidelines for Canadian Drinking Water Quality, nor in any federal or provincial legislation (including the Ontario **Safe** Drinking Water Act or U.S. **Safe** Drinking Water Act)
- We should know that safe is not risk-free (i.e. safety ≠ zero risk)

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Safe Drinking Water

- The Walkerton Inquiry led to the Ontario **Safe** Drinking Water Act
- The Part 2 Inquiry report: "*A Strategy for **Safe** Drinking Water*" sought:

  "*to ensure that Ontario's drinking water systems deliver water with a level of **risk so negligible** that a reasonable and informed person would **feel safe** drinking the water*"
- ***Safe*** means ***risk so negligible*** that it is not worth worrying about

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What are the Major Water-Related Risks to Public Health?

1. Insufficient “clean” water for sanitation
2. Pervasive ingestion risks from pathogens
3. Selected chemicals only (via drinking water)
   - Arsenic
   - Fluoride
   - Selenium
   - Nitrates and nitrites
   - Lead
   - Cyanobacterial toxins (by dialysis exposure)

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What are the Major Water-Related Risks to Public Health?

4. Other contaminants (e.g. pesticides, solvents, etc.) only by extraordinary contamination
5. Disinfection By-Products - a classic risk tradeoff
6. Aesthetics

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Some brief thoughts about RISK

Risk is multidimensional

- Hazard
- Probability
- Consequences
- Time frame
- **What matters to those affected**

The magnitude of risk depends on contributions from each

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Some brief thoughts about RISK

- Consider 2 skydivers, one with a parachute, one without

- Who is the greater risk?

  Answer depends on whether uncertainty or consequences is the greater concern

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Risk Magnitude & Risk Tradeoffs

- Risk trade-offs: disinfection by-products (DBPs)
- **Certain** danger from pathogens vs. **Uncertain** danger from DBPs
- Potential but uncertain consequences for DBPs may be more severe than consequences from pathogens
- Depending on which is weighted more heavily, probability or consequences, you get a different rating of risk
- Need to accept validity of using a strictly **precautionary** rating for many risks

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Challenges for Small Systems

- Limited financial base – capital and operating
- Recruiting and retaining well-trained operators
- Isolation makes supplies, contractors, etc. costly and difficult.
- Lack of support network / backup for operators for advice and relief

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Challenges for Small Systems

- Package plants often fail to meet small system needs
- Poor construction and inadequate commissioning
- Lack of standard operating procedures
- Some source waters require more than conventional treatment

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Challenges for First Nations

- First Nation systems are usually small but also face additional challenges
- There is no consistent regulatory framework for safe drinking in First Nations communities in Canada
- Multiple jurisdictions and limited definition of roles and responsibilities

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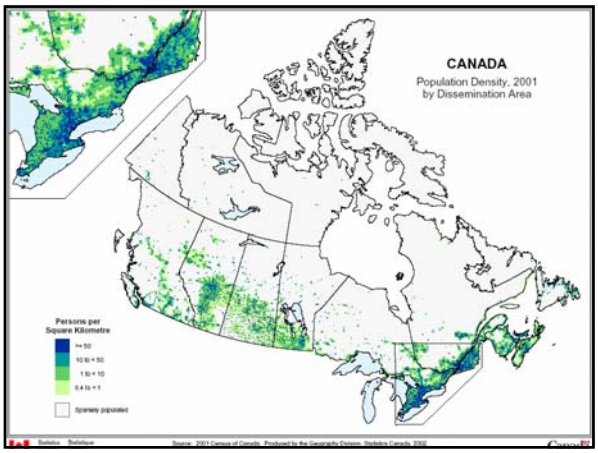
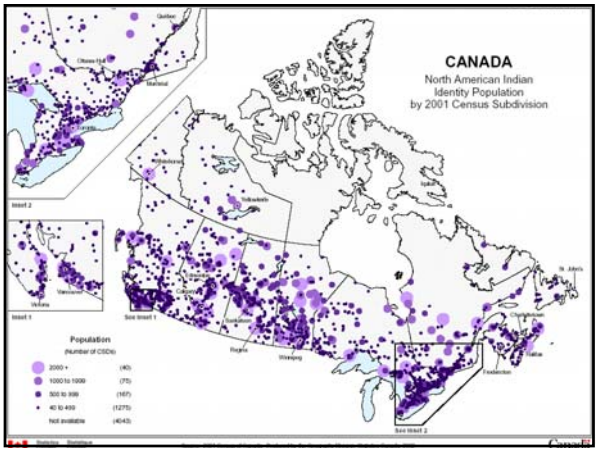
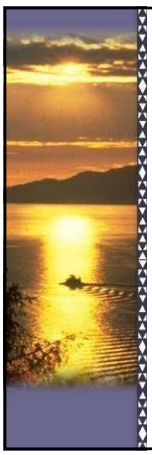
Challenges for First Nations

- Need greater capacity of human resources –operators & managers
- Lack of an economic base in many First Nations
- Housing and social factors demand attention in many First Nations







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Drinking Water to First Nations Communities

90 %	**First Nations communities with 1000 inhabitants or less**
92	**Average number of connections per community with at least one piped system**

Provision of drinking water to residents of First Nations Communities:

63%	via pipes
16%	via trucks to cisterns
15%	via private water supplies
4%	via community wells
2%	without water service

Slide courtesy FNIHB, Health Canada

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Demographics of First Nations in Canada

4½ X	Rate of population growth compared to rest of Canada
> 40 %	Population under 20 years of age
Live in metropolitan areas	24%
Live in rural areas off -reserve	29%
Live in First Nations communities	47%

Slide courtesy FNIHB, Health Canada

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Reliance on Finished Water Monitoring for Assuring Safety is Problematic

Three main types of evidence that may signal water contamination and risk of waterborne illness:

1. Apparent incidence of illness possibly attributable to water exposure
2. Adverse water quality monitoring
3. Anecdotal / circumstantial / inferential evidence of likely contamination

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Apparent Illness

Reliance on apparent illness is limited by:

- Detectability of candidate diseases against background fluctuations in disease prevalence
- Ability to discriminate detectable disease incidence among other plausible routes of transmission (i.e. foodborne, person-to-person)

Such evidence can be compelling but is inherently reactive

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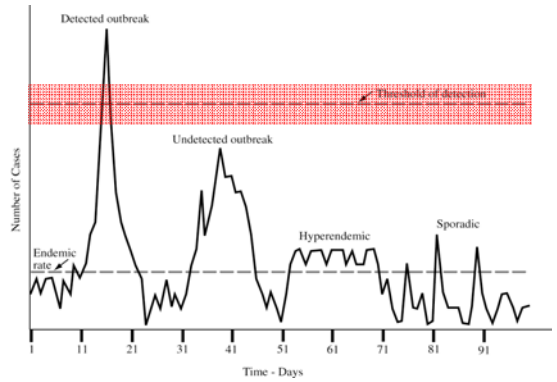

After Frost et al. 1996. *J. Am. Water Works Assoc.* 88(9): 66-75.

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Adverse Finished Water Quality Data

WQ evidence may be preventive, but there are a number of limitations:

- Inadequate coverage (comprehensiveness)
  - Agent of interest is not monitored directly or by relevant indicator
  - Inadequate frequency of monitoring to catch intermittent contamination
- Inadequate timeliness
  - Delays in reporting impair ability to prevent

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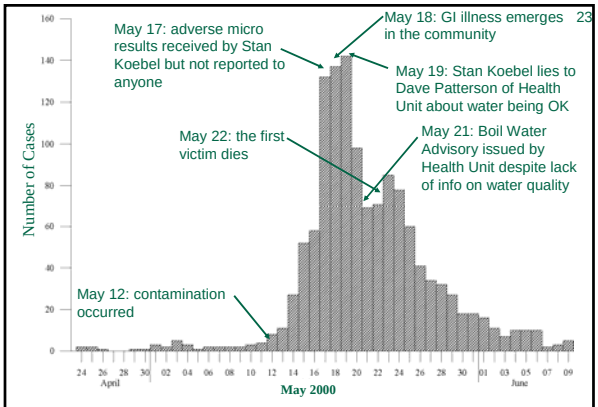
Inadequate Comprehensiveness

Washington County Fair, New York, September 1999

- **2800 – 5000 ill, 127 cases of *E. coli* O157:H7, 45 *Campylobacter*, 14 HUS, 71 hospitalized, 2 died (3-year old, 79-year old)**
- **7 m shallow well responsible was located ~11m from septic tank seepage field**
- **Dye testing showed toilet flush appearing in well in less than 10h**
- **Quarterly microbiological monitoring at this site since 1995 had only ever shown *E. coli* for one other well, but there was no monitoring evidence of contamination reported for the well which caused the outbreak**
- **Inadequate frequency of monitoring to catch an intermittent contamination event**
- **Practical frequency of monitoring will never be enough to compensate for an inherently flawed system**

Inadequate Timeliness
Walkerton, Ontario 2000

- The only "real time" monitoring that was required at Walkerton was *chlorine residual* and *turbidity* once a day
- The inadequately trained operators who failed to understand the meaning of these measures failed to do even these
- An intermittent distribution system microbiological sample was done and it revealed contamination, but the result was late and it was ignored by the GM



Walkerton Epidemic Curve

Adverse Finished Water Quality Data

Water Quality evidence may be preventive, but suffers from:

- Inadequate relevance
  - Indicator is ambiguous
  - Direct measure of agent cannot be interpreted for health risk
- Inadequate predictive value or accuracy
  - Monitoring treated water, where contamination should be rare, presents an inherent challenge

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Inadequate Relevance
Edmonton, Alberta 1997

- Edmonton has two “run-of-river” water treatment plants
- In 1997 Edmonton experienced intermittent high, to extremely high raw water levels of *Giardia* and *Cryptosporidium*
- On a few occasions, these pathogens “*broke through*” to treated water, leading to targeted boil water advisories
- Value and meaning of pathogen monitoring in treated water was a problem

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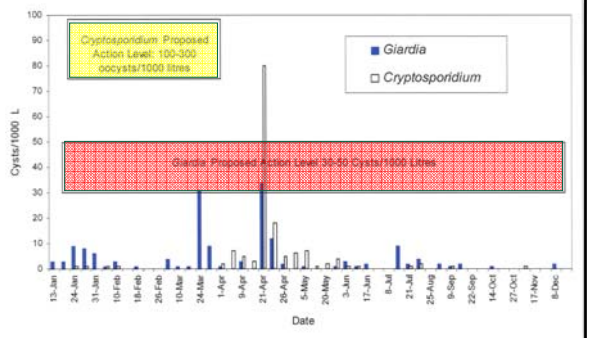
Treated water levels of pathogens – Edmonton 1997



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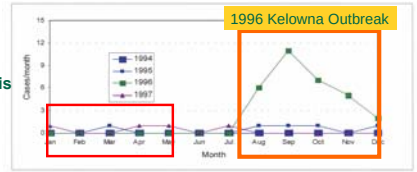
Monthly Disease Levels: Edmonton 1994 – 1997

Giardiasis

Cryptosporiosis



Inadequate Relevance
Belfast, N. Ireland 2001

- 3 communities in the Belfast region experienced small outbreaks of cryptosporidiosis in 2000 and 2001
- The last of these involved about 240 laboratory confirmed cases
- Throughout the duration of the outbreak, continuous sampling for Cryptosporidium oocysts was performed
- Oocyst number never exceeded 25 per 1000L compared with the DWI standard of 100 per 1000L

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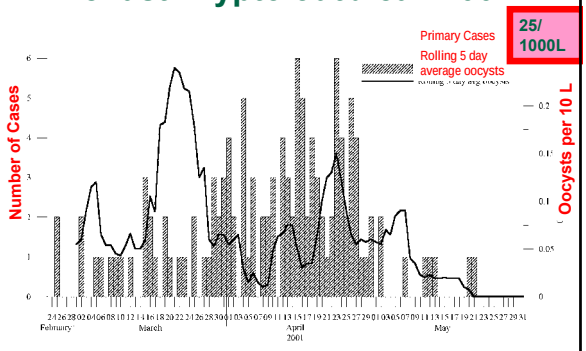
Belfast Crypto outbreak 2001



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Inadequate Relevance

- 1997 Edmonton experienced high levels of *Giardia* cysts and *Cryptosporidium* oocysts with no illness in the community
- 2001 Belfast experienced low levels of *Cryptosporidium* with detectable levels of cryptosporidiosis in the community
- Evidently, our monitoring tools need to improve substantially for these and other pathogens if we are to expect them to guide decision-making

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Interpretation of Monitoring Data

(Rizak & Hrudey 2006 *Env.Sci.Technol.* 40:5244-5250)

- Objective: To explore degree of understanding of the quantitative interpretation of monitoring evidence and appreciation of the effect of hazard frequency interpreting monitoring results
- Australian Water Association (2004 membership) - Operators, Public health, Water supply, Water management, law and policy
  - 352 respondents
  - 63% > 10 years experience (38.1% >20 years)
  - 42% directly involved with interpreting/decision-making

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Interpretation of Monitoring Data

Hypothetical Monitoring Scenario to Evaluate Use of Evidence

Monitoring evidence for a city has indicated that in treated drinking water, a pesticide, say atrazine, is truly present above the recognised standard methods detection limit once in a 1000 water samples from consumers' taps. The analytical test for the pesticide has the following characteristics:

•95% of tests will be positive for detection when the contaminant is truly present,

•98% of tests will be negative for detection when the contaminant is truly not present above the detection limit.

With these characteristics, given a positive result (detection) on the analytical test for the pesticide in the drinking water system, how likely do you think this positive result is true? Provide your scale of agreement below:

☐ almost certain (95 to 100%)
☐ highly likely (80 to 95%)
☐ more likely than not (50 to 80 %)
☐ less likely than not (20 to 50%)
☐ highly unlikely (5 to 20%)
☐ extremely unlikely (0 to 5%)
☐ Don't know

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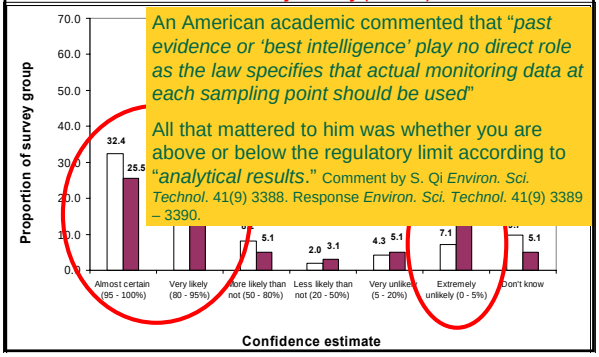
Results

CORRECT ANSWER FOR THE INFORMATION SUPPLIED IS 4.54% or Extremely unlikely (0 to 5%)



An American academic commented that "*past evidence or 'best intelligence' play no direct role as the law specifies that actual monitoring data at each sampling point should be used*"

All that mattered to him was whether you are above or below the regulatory limit according to "*analytical results*." Comment by S. Qi *Environ. Sci. Technol*. 41(9) 3388. Response *Environ. Sci. Technol*. 41(9) 3389 – 3390.

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Anecdotal, circumstantial & inferential evidence

Many factors in incidents and outbreaks

- Unusual conditions are almost always a factor
  - Severe weather
  - Unusual raw water conditions
  - Fluctuations in treatment performance
  - Signs of plausible contamination
- Such evidence is usually insufficient alone, but in combination with other evidence it can be very influential

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Anecdotal, circumstantial & inferential evidence

- Milwaukee is famous as largest known cryptosporidiosis outbreak in the developed world, infecting hundreds of thousands and causing 50 deaths over the following 2 years
- Most of what has been written focuses on the failure to recognize the meaning of a turbidity spike in treated water (still meeting regs)
- Less well known were the opportunities to recognize and act on circumstantial and inferential evidence

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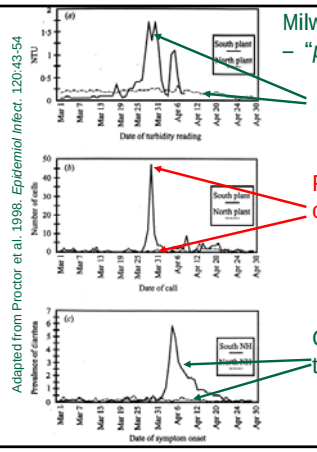
Milwaukee Outbreak 1993

– *"process monitoring"*



Adapted from Proctor et al. 1998. *Epidemiol Infect.* 120:43-54

Finished water turbidity

Phone complaints

GI Cases - the outbreak

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Risk-Based Multi-Barrier Approach for Public Health Protection

- Cannot rely strictly on finished water monitoring to assure safety
- Need a multiple barrier approach suited to the risks facing the system
- Must use multiple barriers effectively

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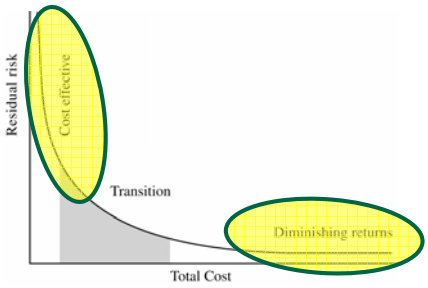
Multiple Barrier Approach



Generic risk reduction – cost curve for a **single** barrier

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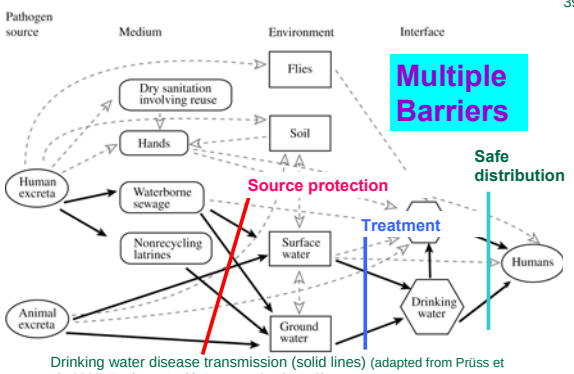

Drinking water disease transmission (solid lines) (adapted from Prüss et al., 2002. *Environ. Health Persp.* 110: 537-542)

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International Progress on Safe Drinking Water

- Australian Drinking Water Guidelines 2004 – Framework for the Management of Drinking Water Quality www.nhmrc.gov.au/publications/synopses/eh19syn.htm
- WHO Drinking Water Guidelines 3rd Edition – Water Safety Plans www.who.int/water_sanitation_health/dwq/guidelines2/en/
- New Zealand Ministry of Health – Public Health Risk Management Plans www.moh.govt.nz/moh.nsf/by+unid/5AF58E090CF4098BCC25699600754798?Open
- The Bonn Charter www.who.int/wsportal/bonn/en/

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Conclusions

- Small systems face specific challenges
- Capacity and competence at the core of assuring safe drinking water
- Public health & water professionals need to understand the inherent limitations of treated water monitoring for guiding public health response
- Compliance monitoring ALONE, limits responses to reactive ones
- Invest in a practical preventive approach!

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Conclusions

- Risk assessment should be focused first and foremost on what in drinking water we know **WILL make people sick unless fixed**.
- This does not require rocket science, only a good understanding of the risks
- Being **precautionary** is a valid public health approach for other realistic possibilities, but you must **KNOW AND UNDERSTAND THAT YOU ARE BEING PRECAUTIONARY!!!**
- Institutionalize learning from past mistakes

Those who cannot remember the past are condemned to repeat it.

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— George Santayana

Walkerton Memorial Park