Health risks associated with faecally-contaminated freshwater: Background, History, Issues

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NIWA
Taihoro Nukurangi

Background

Pathogens and disease

Animal & human faecal wastes contain pathogens that can cause disease.

Pathogens in water may be:

- *Ingested* while swimming
- *Inhaled* while skiing
- *Ingested* when drinking water that is not well treated
- *Ingested* whilst eating food that has been in contact with contaminated water

Disease transmission

Human illnesses from pathogens may be:

- Zoonoses: vertebrate animals → humans
  - campylobacteriosis (bacterium),
  - cryptosporidiosis (protozoan),…
- Anthroponoses: human → human
  - particularly from viruses

Zoonoses are nearly all from bacteria and protozoa

  - Rare that animal viruses infect humans
  - Hepatitis E and Rotaviruses may be exceptions

Reported NZ rates of notifiable diseases

Dominated by zoonoses:

- Particularly campylobacteriosis
- Reported rates under-estimate actual rates (e.g., by a factor of 10)
  - VTEC excepted; it is a serious disease (and is increasing)
- Few substantial outbreaks, mostly an endemic pattern

Top 10 reported rates of notifiable diseases

*Disease**	*Annual rate per 100,000 (2013)*	
	Nationwide	*Waikato DHB*
Campylobacteriosis	152.9	207.6
Pertussis	79.2	80.2
Giardiasis	38.7	48.0
Cryptosporidiosis	30.2	57.7
Salmonellosis	25.6	25.3
Gastroenteritis	12.5	8.9
Yersiniosis	10.8	7.0
Invasive pneumococcal disease	10.7	NA
Tuberculosis disease	6.2	6.4
VTEC/STEC infection	4.6	11.8

*Red = zoonotic and potentially waterborne

Source: http://www.nzpho.org.nz/NotifiableDisease.aspx

History

Developing the MfE/MoH 2003 Guidelines

Used Quantitative Microbial Risk Assessment (QMRA). Four steps:

1. Identify pathogen(s)
2. Establish exposures (e.g., while swimming)
3. Identify dose-response
4. Characterise health risk

Uses iterative Monte Carlo statistical sampling

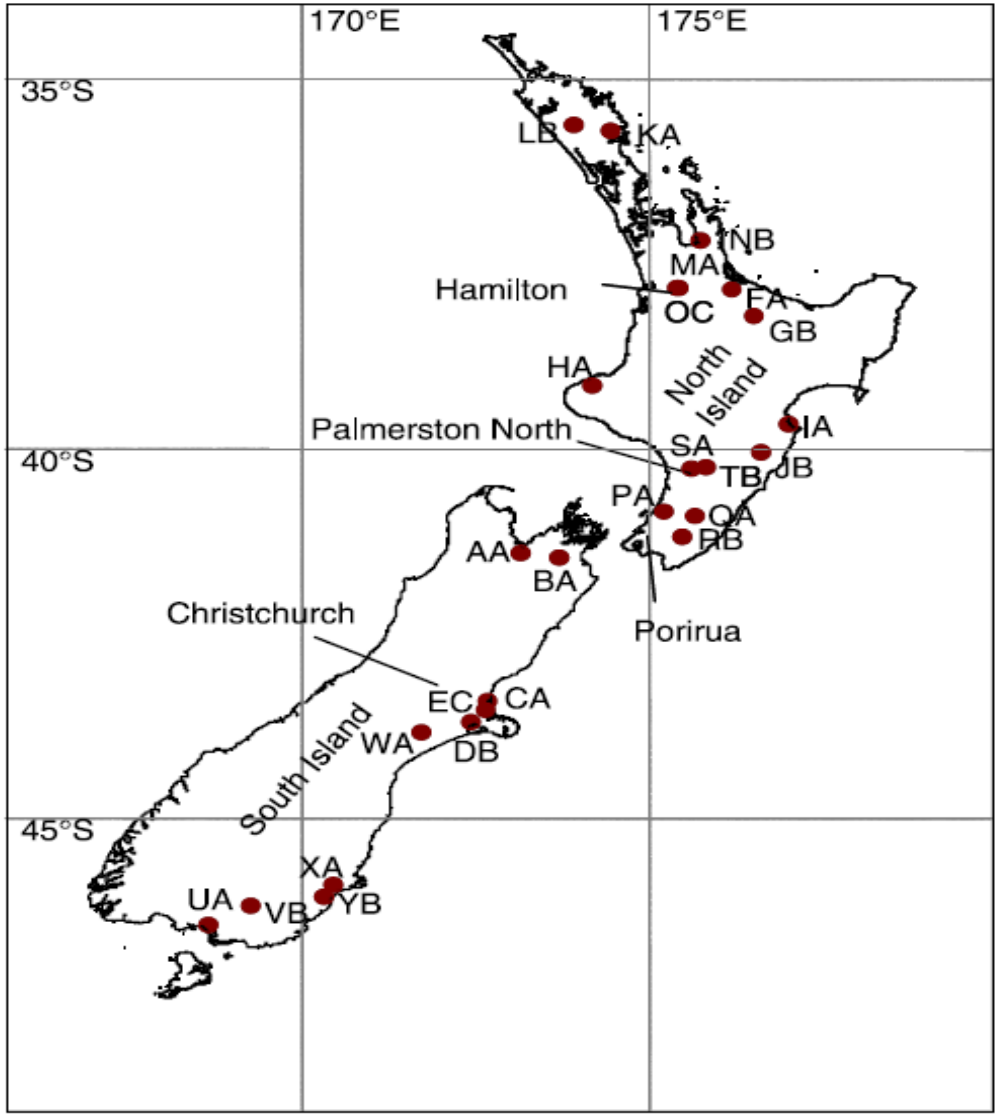
- Captures extremes otherwise smoothed out by averaging

Developing the MfE/MoH 2003 Guidelines (1): Select pathogen(s)

Undertook Freshwater Microbiological Research Programme (1998-2000)

- Sampled 25 freshwater recreational sites fortnightly for 15 months for six pathogens (and six potential indicators such as *E. coli*); cost ~$1m
- Six of these sites were also drinking-water abstraction sites

Developing the MfE/MoH 2003 Guidelines (1): Select pathogen(s)



Developing the MfE/MoH 2003 Guidelines (1): Select pathogen(s)

Results

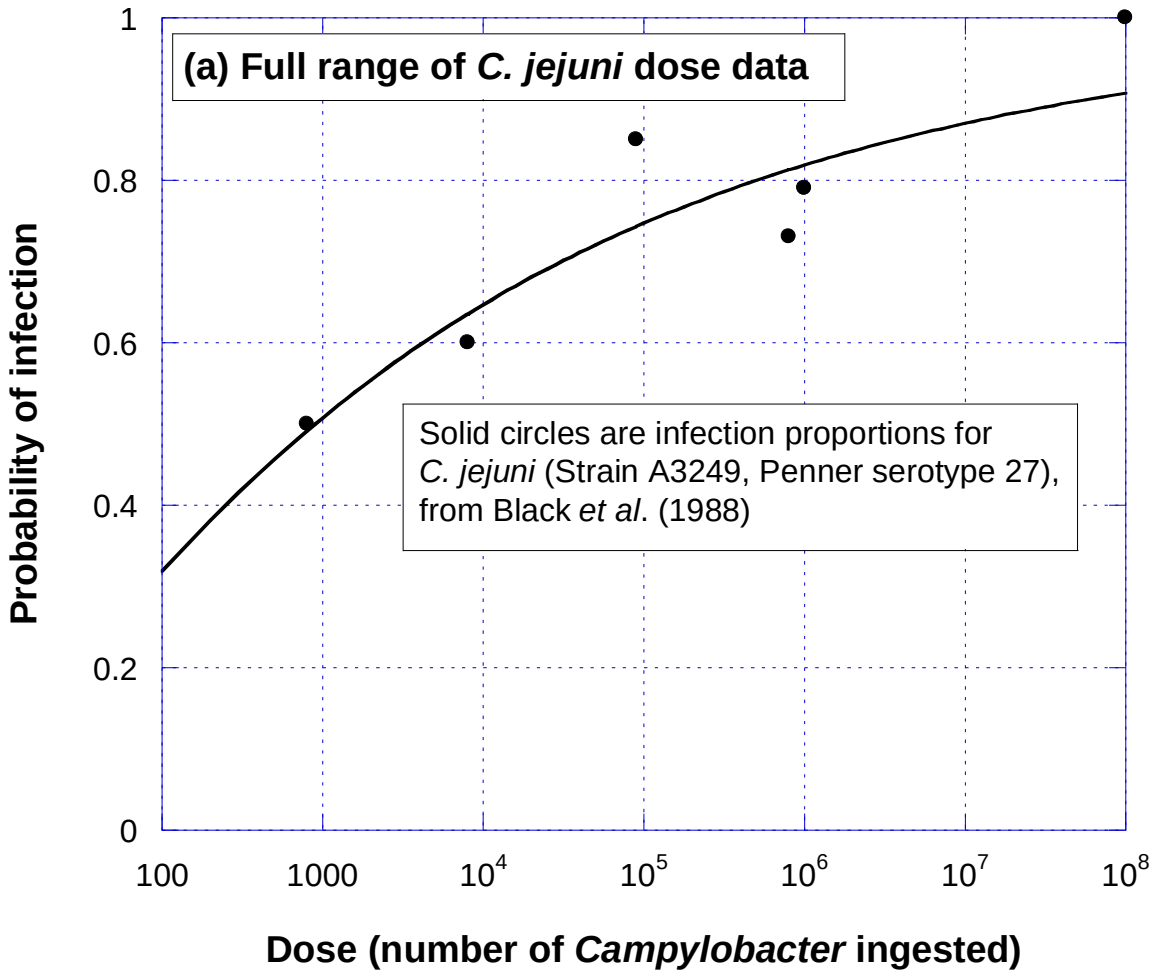
- *Campylobacter* present 2/3 of samples
- Viruses surprisingly common
- Moderate correlation between *Campylobacter* and *E. coli*; negligible correlation between presence of viruses and any indicator
- Therefore chose *Campylobacter* infection for QMRA
  - Not *Campylobacter* illness (a lower value)

Developing the MfE/MoH 2003 Guidelines (2): Establish exposures

- Swimmers spend 1/4 hour to 2 hours in water
- Infection rates 10-100 mL per hour

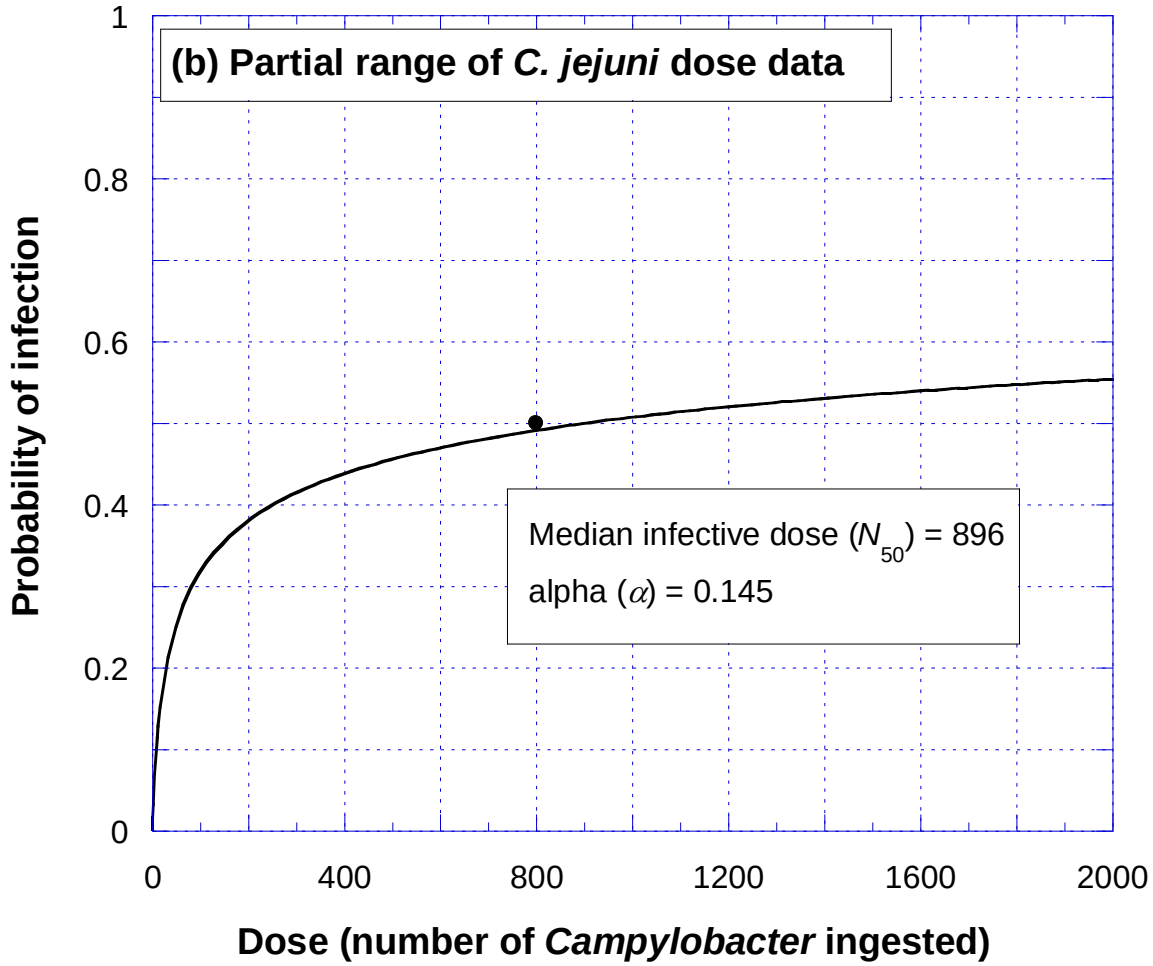
Developing the MfE/MoH 2003 Guidelines (3): Identify dose-response

From a USA clinical trial

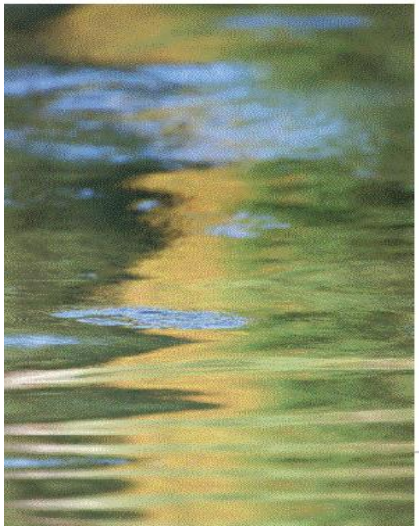


Developing the MfE/MoH 2003 Guidelines (3): Identify dose-response

From same USA clinical trial (NOTE: Initial steepness, some very susceptible



Developing the MfE/MoH 2003 Guidelines (4): Calculating risk



Large-scale freshwater microbiological study: rationale, results and risks

Desmond Till, Graham McBride, Andrew Ball, Ken Taylor and Eric Pyle

ABSTRACT

A fifteen-month fortnightly survey of microbial health risk indicators and pathogens has been carried out at 25 freshwater recreational and water supply sites distributed throughout New Zealand, for: *E. coli*, *Clostridium perfringens* spores, F-RNA bacteriophage, somatic coliphage, human enteroviruses, human adenoviruses, *Cryptosporidium* oocysts, *Giardia* cysts, *Salmonella* and *Campylobacter*. Sites were selected to represent five geographical areas covering New Zealand and five categories of predominant environmental impact: birds, dairy farming, forestry/undeveloped, municipal, and sheep/pastoral farming. Six of the sites were also source waters for treated drinking-water supplies. Of the indicators, *E. coli* was detected in 99% of all samples, with somatic coliphage being detected most of the time (89%). Of the pathogens tested, *Campylobacter* and human adenoviruses were inferred to be the most likely to cause human waterborne illness to recreational freshwater users. Using data from all sites, an estimated 5% of notified campylobacteriosis cases in New Zealand could be attributable to water contact recreation. The critical value for *E. coli* as an indicator of increased *Campylobacter* infection is in the range of 200–500 *E. coli* per 100 ml. This result has been used to derive new national water quality guidelines for recreational fresh water in New Zealand.

Key words | *Campylobacter*, catchment type, faecal indicators, microbiological seasonality, survey, risks, waterborne pathogens

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INTRODUCTION

Management of health risks for recreational users of fresh waters has focused on faecal health indicators (*E. coli*, faecal coliforms and enterococci), using relationships derived from a small number of epidemiological studies (Prüss 1998; WHO 2003). These serve to index both health risks and the possible presence of pathogenic material. There are three strong practical reasons for indexing health risk to bacterial indicators: (i) particular pathogens may only occasionally be present whereas, in many fresh waters, the indicator tends to be present most of the time suggesting that faecal material is also often present; (ii) pathogen enumeration is generally expensive and time-consuming, whereas indicator enumeration is relatively cheap; and (iii) a relationship between health risk and indicator concentration is available. However, focusing *exclusively* on indicators in this manner may not take adequate cognizance of the pathogen profile for local conditions, especially when one notes that the epidemiological studies and monitoring programmes seldom include direct pathogen assessments, and that the freshwater epidemiological studies were mostly performed in one country (the USA). For example, pathogen contamination in the rural New Zealand landscape can be expected to be dominated by zoonotic agents such as *Campylobacter* or *Cryptosporidium*. In contrast, the waters for which epidemiological studies were conducted were mainly impacted by human sewage.

doi: 10.2166/wh.2008.071

Developing the MfE/MoH 2003 Guidelines (4): Calculating risk

Used percentile matching to obtain equivalent *E. coli*

- From QMRA, 70% of the time infection risk is below 1%.
- The *E. coli* 70%ile = 260 per 100 mL.
- So "best guess" is health risk < 1% when *E. coli* < 260 per 100 mL.
- Similarly for other infection risk percentages.

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- Even though this is a "best guess" compliance with 95%ile is required (not median) → precautionary

National Objectives Framework

New national microbiological water quality standards for secondary (and primary) contact recreation:

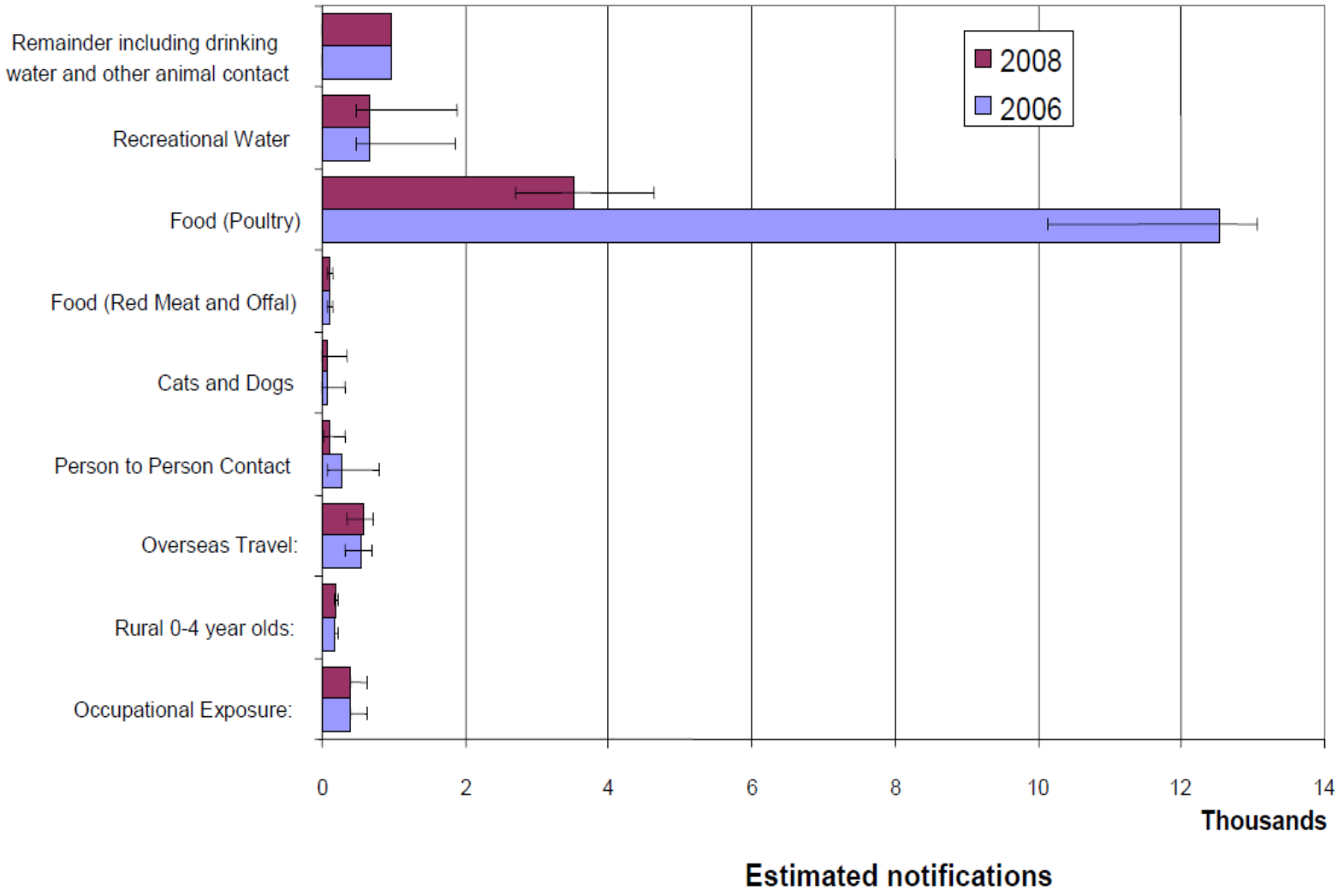
- Based on same QMRA model, with reduced exposures for secondary contact
- Extremely tough for primary contact recreation in agricultural areas
  - Especially because it is based on 95%iles
- Less onerous for secondary contact
  - Because it is based on medians

National Objectives Framework

Value	Human health for recreation		
Freshwater Body Type	Lakes and rivers		
Attribute Unit	*E. coli*/100 mL		
Attribute State	**Numeric Attribute State**	**Sampling Statistic**	**Narrative Attribute State**
A	≤260	Annual median	2º: Health risk < 0.1%
		95%ile	1º: Health risk < 1%
B	>260 and ≤540	Annual median	2º: Health risk <1%
		95%ile	1º: Health risk <5%
C	>540 and ≤1000	Annual median	2º: Health risk <5%
National Bottom Line	1000	Annual median	2º: Health risk 5%
D	>1000	Annual median	All Health risk >5%

Issues

Relative importance of waterborne disease



http://www.foodsafety.govt.nz/elibrary/industry/examining-link-with-public-health/campylobacter-in-food-and-the-environment-pathway-attribution.pdf

Relative importance of waterborne disease

- Substantial reduction in poultry-associated campylobacteriosis between 2006 & 2008
- As a result the *proportion* of water-related cases has *increased*
- Currently, water-related campylobacteriosis illness >10% of the total burden, maybe as much as 20%

Revise basis of QMRA?

Changes since 2000:

1. Less direct deposition from cattle (Clean Streams Accord)
   - Pathogen-to-indicator ratio for cattle will have *reduced*
2. Dominance of wild bird *Campylobacter* in flowing water → *less infective* than ovine/bovine/poultry strains

3. More within-between cycling of pathogens in herds?

4. More *Giardia* and *Cryptosporidium* now?
5. New (2005) *Campylobacter* dose-response relationship
   - Outbreak study for children visiting farms drinking raw milk
   - More infectious

Mahinga kai?

Work to be done on this. Should be able to marry wild foods surveys with studies of microbial concentration on surfaces of aquatic plants (leaves etc.) and perform more QMRA.

Important question: "If a water body is suitable for swimming (95%ile *E. coli* < 540 per 100 mL), is Mahinga kai 'safe' for consumption?"

- My hunch is "yes", because the swimmable standard is precautionary (based on 95%iles not medians)
- But maybe "not necessarily" for consumption of raw freshwater shellfish
- Topic needs to be addressed (with ESR—have data on wild foods)