Environment and Public Health: Climate, climate change and zoonoses

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Environment and zoonoses

- **Environmental SOURCES:**
  - Agroenvironment
  - Natural environment

- **Transmission ROUTES:**
  - Direct contact
  - Water
  - Food
  - Vectors
Zoonoses and the agroenvironment
Zoonoses in the agroenvironment: a long history of public health intervention

- **Legislated:**
  - Control of zoonoses on-farm (culling)
  - Meat inspection (and condemnation)
  - Food packaging/handling and processing
  - Water treatment
Taux par 100 000 pop.
Campylobactériose
Giardiase
Salmonellose
Shigellose
E.coli vérotoxigènes

Campylobactériose
Cryptosporidiose
Giardia
Salmonelle
Shigellose
E.coli vérotoxigènes
But despite all that.....

Endemic disease

Outbreaks
Spatial variation in risk associated with landscape/watershed geography and intensity of agricultural systems

Ravel et al. Int J Hygiene Env Health 2004
Origins and linkages of food and water-borne zoonoses

- Farmed animals
- Wildlife
- Water (surface, underground)
- Susceptibility
- Risk behaviour

Climate/weather

Disease case

Foodchain
Seasonal climate driven incidence of endemic disease

Salmonella Case Count and Mean Temperature per Week from 1992 to 2000

Week

Count

Temperature

Week
Accounting for seasonality, incidence of endemic disease increases with ambient temperature.

*Salmonella* incidence increases 1.2 % per degree above -10°C

*Campylobacter* incidence increases 2.2 % per degree above -10°C

*E. coli* incidence increases 6.0 % per degree above -10°C

Fleury et al. Int J Biometeorol. 2006
Incidence of waterborne disease outbreaks increase with frequency of heavy rainfall events.
Heavy rainfall > 93 percentile associated with 2 x risk of a waterborne disease outbreak: Thomas et al., Int J Environ Health Res. 2006
Change in annual degree-days > 0°C from 1961-1990 to 2070-2099 [CGCM2 A2]

(Remerciment - A. Maarouf, EC)
Crude incidence of salmonellosis with climate change
Crude incidence of campylobacter infections with climate change (Fleury et al)
Zoonoses and the natural environment
Emerging/re-emerging infectious diseases

1. Human awareness (Lyme, SARS)
2. Introduction of exotic parasites into existing suitable host/vector/human-contact ecosystem (West Nile, Rabies)
3. Geographic spread from neighbouring endemic areas (Lyme, Rabies)
4. Ecological change causing endemic disease of wildlife to ‘spill-over’ into humans/domesticated animals (Lyme, Hantavirus, Nipah)
5. True ‘emergence’: evolution and fixation of new, pathogenic genetic variants of previously benign parasites/pathogens (HPAI)
Lyme disease: Emergence by range expansion
Lyme disease distribution in the USA

ca 20,000 cases/year in USA = ca 8,000 cases/year in Canada
Reproducing (and self-sustaining) populations of *I. scapularis* in Canada

Climate change or inevitable range expansion?

Distribution of *I. scapularis* submitted to PHAC by the public: carried by migratory birds

• *I. scapularis* are being seeded into a wide geographic region of Canada

• Host densities are high

• Habitat is suitable (Ogden et al., 2006b. *J. Med. Entomol.*)

• Why haven’t populations set up more widely?

• Could climate be a limiting factor?

• If so will climate change affect this limitation?
How can climate affect vector-borne disease ecology?

Affecting geographic distribution of vectors
- Vector survival $T_{,RHP}$ (mossies)
- Vector activity (biting rate) $T_{,RHP}$
- Host species range and density $T_{,RHP}$ (ticks)
- Habitat distribution $T_{,RHP}$

Affecting existence of, and force of infection in, endemic transmission cycles
- Vector abundance $T_{,RHP}$
- Vector seasonality $T_{,RHP}$
- Extrinsic incubation period (latent period in mossie, duration of dvlpt in tick) $T$
- Host species abundance & demography $T_{,RHP}$

General VBD

$$R_0 = \frac{Na^2 \beta_{V-1} \beta_{I-V} p^n}{H (r + h)(-\ln p)}$$

TBD (Randolph Parasitol Today 1998)

$$R_0 = \frac{Nf \beta_{V-T} \beta_{T-T} \beta_{T-V} p^n F}{H (r + h)}$$
Dynamic simulation model of *I. scapularis* populations
Simulation model output suggests temperature conditions constrain *I. scapularis* distribution, but if so, that will change with climate change.
Emergence by spillover: West Nile virus
West Nile Virus Cases in Canada 2003 to 2007
One World, One Health
Emergence of zoonoses at the wildlife-livestock-human interface

- Most emerging infectious diseases are zoonoses
- Most are generalist pathogens with a wide range of host species
- Most remain zoonoses
  - Nipah
  - Hendra
  - WNV
  - Zoonotic Avian Influenza
  - Lyme
- A few become human-to-human transmitted
  - Pandemic Avian Influenza (Spanish flu)
  - HIV-AIDS
  - SARS
  - Haemorrhagic fevers
- Environmental change is a major driver of emergence!
Conclusions

• Zoonoses are a significant endemic cause of disease in Canada
• Important foodborne and waterborne zoonoses arise from the agroenvironment despite controls
• Climate is an important driver of the incidence of both cases and outbreaks
• Climate is an important determinant of the geographic occurrence of vector-borne zoonoses, and a driver of outbreaks via effects on vector abundance
• Climate change is likely to increase the incidence of foodborne, waterborne and vector-borne zoonoses in Canada
• Climate change may drive the emergence of zoonoses at the wildlife-livestock-human interface
• Global emerging infectious diseases can rapidly become local diseases