A career in disease dynamics: a marriage of biology and math

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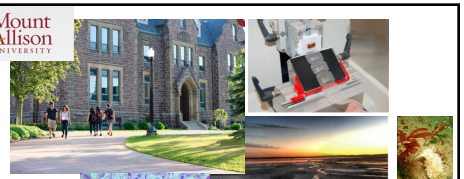

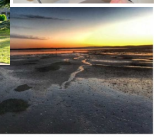

The Bay of Fundy in New Brunswick, Canada can have tides up to 16 feet high. Photo by Carl Wilborne.

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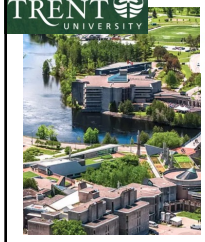
TRENT UNIVERSITY



Comparative Study > Dis Aquat Organ. 2005 Nov 9;67(1-2):9-14. doi: 10.3354/dao067009.

Five amphibian mortality events associated with ranavirus infection in south central Ontario, Canada

Amy L Greer [1], Michael Berrill, Paul J Wilson

Affiliations + expand

PMID: 16385802 DOI: 10.3354/dao067009

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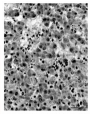

Fig. 1. Rana sylvatica. Example of a common hemorrhage

Table 1. Diagnostic criteria for amphibian mortality events in south central Ontario, Canada. +: positive result, –: negative result, ND: no data available

Location	Year	No. ind. meeting case definition	Abnormal liver pathology	Inclusion bodies	% samples positive by PCR
Oliver Pond (field)	2001	>100	ND	ND	77
Kortright Pond (field)	2001	>10	ND	ND	93
Oliver Pond (lab-raised)	2002	0	+	–	66
Oliver Pond (field)	2002	9	+	–	70
Cannon's Narrows (field)	2002	>100	+	+	82
Archeology Pond (field)	2002	0	–	–	0

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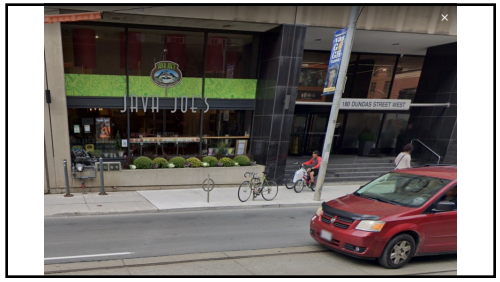
JAVA JOE'S
180 DUNDAS STREET WEST

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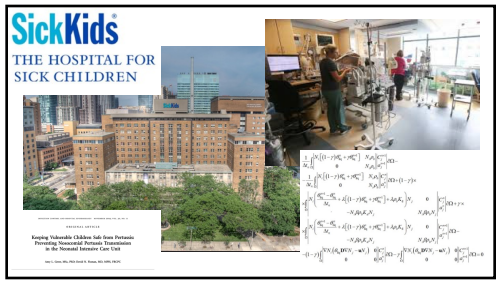
SickKids
THE HOSPITAL FOR SICK CHILDREN

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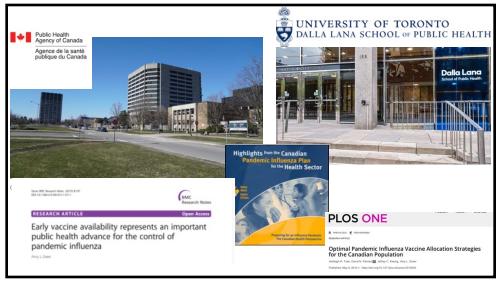
Public Health Agency of Canada
Agence de la santé publique du Canada
UNIVERSITY OF TORONTO
DALLA LANA SCHOOL OF PUBLIC HEALTH
Dalla Lana
Highlights from the Canadian Pandemic Influenza Plan for the Health Sector
RESEARCH ARTICLE
Open Access
Early vaccine availability represents an important public health advance for the control of pandemic influenza
PLOS ONE
Optimal Pandemic Influenza Vaccine Allocation Strategies for the Canadian Population

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We study the introduction, spread, prevention, and control of infectious diseases in populations.
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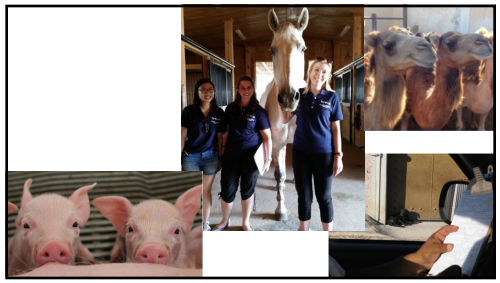

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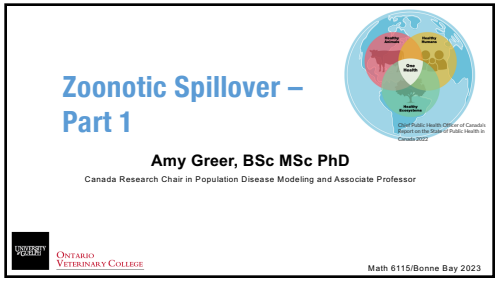

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What are you going to hear about today?

1. The ecology of zoonoses and spillover
2. What is disease spillover?
3. What factors are associated with disease spillover events?
4. Considerations for modelling spillover

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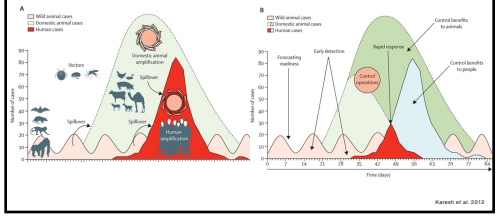
The ecology of zoonoses



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How much do you think you know about spillover?

A spillover pop quiz

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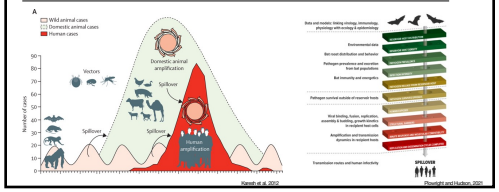
What factors are associated with disease spillover events?



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Police in Wuhan, China, shut down the Huanan Seafood Wholesale Market on 1 January, 2020. Credit: Noel Celis/AFP via Getty

Khan et al. 2012

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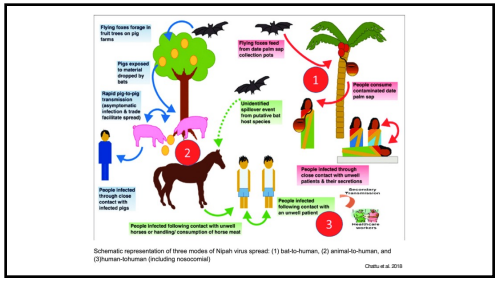

Schematic representation of three modes of Nipah virus spread: (1) bat-to-human, (2) animal-to-human, and (3)human-tohuman (including nosocomial)

Chattu et al. 2018

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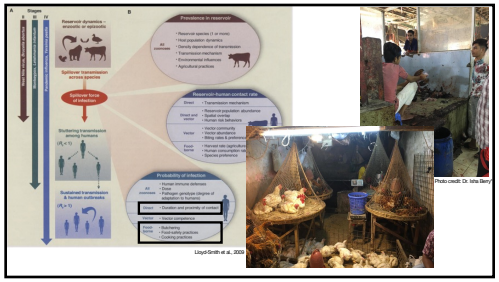

Photo credit: Dr. Isha Berry

Lloyd-Smith et al., 2009

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Aim & Objectives

- To develop a model that tracks influenza dynamics at the human-poultry interface to better understand risk of influenza reassortment and pandemic emergence in DCC, Bangladesh.
- To evaluate the potential effectiveness of intervention strategies on reducing avian influenza spillover and co-infections with seasonal influenza in humans in DCC, Bangladesh

Berry et al. unpublished

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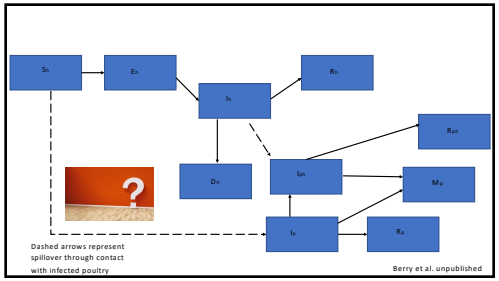

Berry et al. unpublished

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Spillover rate (Iacono 2016)

- Probability that K spillover events occur during time τ is described by a stochastic Poisson process
  - $P(k) = \frac{exp^{-\lambda\tau}(\lambda\tau)^k}{k!}$
  - Where λ is the expected number of zoonotic spillovers per unit time, which is specified as
    - $\lambda = N_h(t) Pr_R(N_R)\, \chi_R \eta_R(N_R)$
      - $N_h(t)$ = *Number of susceptible humans at time t, initial population size*
      - $Pr_R(N_R)$ = *Prevalence of infected poultry , calibrated using average prevalence of AIV in poultry from Sink Surveillance data in DCC = 52% in 2018*
      - χ_R = *infection response efficiency , estimated as 0.0001 (high uncertainty)*
      - $\eta_R(N_R)$ = **Average human exposure to poultry in LBM, calibrated using DCC mobile phone survey =30.2/365= 0.082**

Berry et al. unpublished

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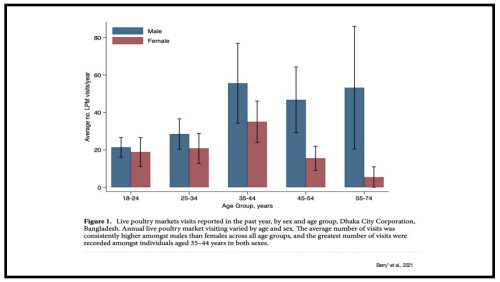

Figure 1. Live poultry markets visits reported in the past year, by sex and age group, Dhaka City Corporation, Bangladesh. Annual live-poultry market visiting varied by age and sex. The average number of visits was consistently higher amongst males than females across all age groups, and the greatest number of visits were recorded amongst individuals aged 35–44 years in both sexes.

Barry[1] et al., 2021

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	Male	Female	All	
	% (95% CI)	% (95% CI)	% (95% CI)	p-value[a]
Weighted sample[b]	n = 406	n = 359	n = 765	–
Washed hands with soap				<0.001
Always			1.6–79.2)	
Not always			1.5–23.7)	
Never			–6.7)	
Wore gloves[c]				0.220
Always			–3.9)	
Not always			–3.1)	
Never			6.1–97.4)	
Wore facemask				0.002
Always			–4.1)	
Not always			–9.8)	
Never			7.6–92.2)	
Wore aprons[c]				0.182
Always			–1.2)	
Not always	0.0	1.2 (0.3–2.8)	0.7 (0.3–1.7)	
Never	99.6 (96.9–99.9)	98.5 (96.8–99.3)	98.9 (97.8–99.4)	

Table 3. Uptake of protective practices among those with poultry exposure in the past year, by sex, Dhaka City Corporation, Bangladesh. *CI* confidence interval. [a]P-value obtained from chi-square test comparing males and females. [b]Sample weighted by age, sex and education to the Dhaka City Corporation demographic profile of the 2011 Bangladesh census. Weighted denominator is those who report any exposure to live poultry in the past year. [c]Question was only asked to those who report slaughtering, defeathering, eviscerating and/or cutting poultry; weighted denominator includes only those who report these exposures, n = 566.

Barry[1] et al., 2021

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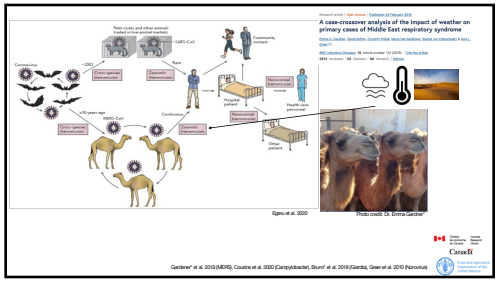

Gardner[2] et al. 2019 (MERS), Cousins et al. 2020 (Campylobacter), Blum[3] et al. 2018 (Giardia), Greer et al. 2016 (Norovirus)

CanoeIR

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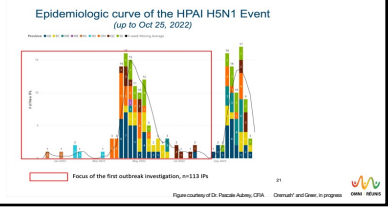
Are environmental conditions associated with spillover of HPAI (H5N1) in Canada?



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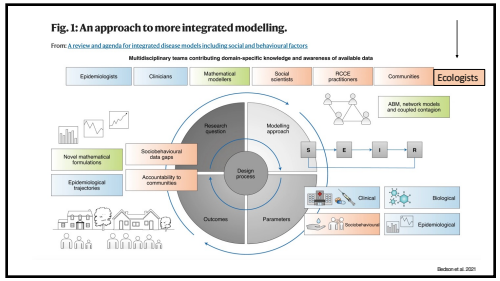

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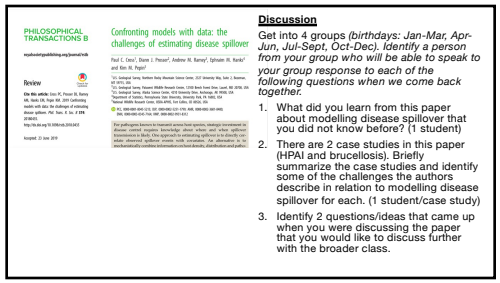

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Problem set 1.7

1. Think of a simple example of a zoonotic pathogen where the transmission of the pathogen requires both a human and animal host. Describe the natural history of the host-pathogen system in a short paragraph with a link to a reference.
2. Translate the biology from part 1 into a compartment diagram and write the basic corresponding equations to describe the dynamics of the disease in the populations of interest.
3. If you were going to move forward with modelling this zoonotic host-pathogen system, what components of the system would be the most difficult aspects to parameterize? Why?

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