Wildlife, the Environment, and Biodiversity: The Wild Cards in the One Health Game

Christine Ellis DVM MPH
Colorado State University, Animal Population Health Institute,
College of Veterinary Medicine
National Wildlife Research Center
Fort Collins, CO

Kurt VerCauteren PhD
National Wildlife Research Center
Fort Collins, CO

Mo Salman BVMS, PhD, FACE
Colorado State University
Animal Population Health Institute
Fort Collins, CO

Statistics

- 57 million global deaths globally annually
  - 25% caused by microbes

- 1415 human pathogens
  - 217 viruses & prions
  - 538 bacteria & rickettsia
  - 307 fungi
  - 287 helminths
  - 66 protozoa

- 868 (62%) are zoonoses
Statistics

- 868 zoonoses
  - 3% human origin
  - 71.8% wildlife origin

- Ungulates
  > 250 human pathogens
  > 50 emerging and re-emerging pathogens

- Human EIDs over the last 30 years
  ~ 75.0% are zoonotic
  ~ 22.8% are vector-borne

Economic Impacts of Zoonotic EIDs

- SARS
  - $40 billion worldwide
  - Thousands of people quarantined
  - 50-70% drop in international travel
  - 60% drop in hotel occupancy
  - Businesses failed
  - Some large production facilities suspended operations

* - Lee & McKibbin. Estimating the Global Cost of SARS. In: Learning from SARS: Preparing for the Next Disease Outbreak
* - WHO. The World Health Report
“One Medicine”

- The study of health and disease regardless of species differences between human and animals, focusing on the commonality of human and veterinary medicine.

- A clinical definition
  - Insufficiently reflects *interactions* between human and animal health
  - Does not fully consider *external factors*
    - societal dimensions
    - public health
    - environment
    - ecology

“One Health”

“The health of animals, people and the environment are inextricably linked”

A worldwide strategy to expand interdisciplinary collaborations and communications in all aspects of health care for humans, animals and the environment.
“One Health/ One World/ One Environment”

“Ecosystem Health”

The “World” and “Environment” are “Ecosystems”

Humans & Animal Wellness

Ecosystem Wellness

“Ecosystem Health”

Requires integrated approaches to human and animal health and their respective social and environmental contexts
What Makes a Disease Emerge?

Wildlife

Humans
Domestic animals

Infectious organisms

Environment

Potential Disease Occurrence

Potential Disease Occurrence

Disease Occurrence
Causes of Disease Emergence

What Makes a Disease Emerge?

Human Population Density

Environment

Wildlife

Humans

Domestic animals

Infectious organisms

Disease Occurrence
What Makes a Disease Emerge?

1: Changes in land use or agricultural practices
2: Changes in human demographics and society
3: Poor population health
4: Hospitals / Medical procedures
5: Pathogen evolution
6: Contamination of food sources or water supplies
7: International travel
8: Failure of public health programs
9: International trade
10: Climate changes

Causes of Emergence

- Zoonoses 18%
- 13%
- 26%
Causes of Emergence: Agriculture & Land Use

- Occupies ~ 38% of Earth’s surface
- Crop production increased 47% between 1985-2006

- Worldwide agriculture has cleared or converted
  - 70% of grasslands
  - 50% of savannas
  - 45% of temperate deciduous forests
  - 37% of tropical forest biomes

- Irrigated cropland doubled in the past 50 years
  ~ 70% of global freshwater devoted to irrigation

- Global fertilizer use increased by 500% (>800% for nitrogen)

Nipah Virus

- October 1998 – May 1999
  > 265 cases human encephalitis
    - 105 deaths
    - Disproportionate number of farmers
What Makes a Disease Emerge?

Zoonotic Pathogen “Weediness”
– Makes certain pathogens adept at taking advantage of new epidemiologic opportunities

Pathogens are “smart”
Exploit any change in ecology that provides new opportunities
Causes of Emergence: Climate

Highest concentration of EID events per 1 million km² land

Hotspots:
- NE US
- western Europe
- Japan, SE Australia
**An Integrated Systems Approach to Pathogens**

- **Aedes Albopictus** ("Asian Tiger Mosquito")
  - Invader
    - fastest spreading mosquito in the world
  - Aggressive daytime biter
  - Transmits
    - Dengue, WNV, Encephalitis viruses
    - Ross River fever
    - Rift Valley fever

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**Aedes albopictus**

You have requested the following:

Spread of The Tiger: Global Risk of Invasion by The Mosquito Aedes albopictus

Hank B. Benedict, Rebecca S. Levine, William A. Hawley, and L. Philip Lounibos

Vector-Borne and Zoonotic Diseases, March 2007, Vol. 7, No. 1: 76-85

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**NOT SUBSCRIBED?**

See pricing options.

**INSTANT ACCESS OPTIONS**

- **PAY PER VIEW** Vector-Borne and Zoonotic Diseases - 7(1):76-85; Spread of The Tiger: Global Risk of Invasion by The Mosquito Aedes albopictus (access for 24 hours for US $1.00)
- **PAY PER VIEW** Vector-Borne and Zoonotic Diseases - 7(1) (access for 48 hours for US $2.00)
- **PAY PER VIEW** Vector-Borne & Zoonotic Diseases 2012 (unlimited access for US $9.99)

Add to Cart
Aedes albopictus

Present predicted distribution, native range in Asia

Aedes albopictus: Invasion risk map

Invasion Risk Map

– Used ecological data from the Asian niche
**Aedes albopictus: USA invasion**

**Causes of Emergence: Biodiversity Loss**

- “The variety of species, the diversity of their genetic make-up, and the natural communities in which they occur”
Biodiversity and Pathogen Emergence

- What role does biodiversity have in the processes by which pathogens emerge?
  - Biodiversity may act as a source pool
    - A large number of potential pathogens
  - Biodiversity may PREVENT exposure
    - Pathogen transmission is reduced

Schistosoma mansoni

[Diagram showing the life cycle of Schistosoma mansoni]

[Map showing the geographical distribution of Schistosoma mansoni]
West Nile Virus in the US

- Low bird diversity = increased human risk or incidence
- Communities with low avian diversity
  - dominated by species that amplify the virus
- Communities with high avian diversity
  - contain many species that are less competent hosts
Hantavirus

- West & Central
  - Sin Nombre

- Northeast
  - New York hantavirus

- Texas
  - Muleshoe virus

- Southeast
  - Bayou Virus

- Florida
  - Black Creek Canal virus

Lyme Disease

Lyme Disease Human Risk Map

- Northeastern U.S. states
  - Risk areas indicated on map.
How many of you learned this stuff in school, or in your professional training?

This is why including wildlife biologists, ecologists, environmental scientists in discussions of One Health is important.
One Health Approach to Rabies

- Ancient Greeks called it “Lyssa” or “Lytta”
- Present on all continents except Antarctica
  - 100 countries
  - 3 billion people at risk
  - 55,000 human deaths annually *
    - 50% children < 15 years

Rabies in the United States

- Prior to 1947:
  - Canine rabies was predominant variant
  - Incidence in domestic canines > wildlife
  - ~ 100 human deaths / year

- 1947:
  - Efficacious canine rabies vaccines developed
  - National Rabies Control effort
    - Local & National Education campaigns
    - Urban field operations (domestic pets)
    - Rural field operations (livestock, wildlife)

- 1957:
  - Domestic dog cases > wildlife for the first time
Rabies in the US – 2009

- Enzootic Rabies is present in the continental US & Puerto Rico

<table>
<thead>
<tr>
<th>Animal</th>
<th>Total Cases</th>
<th>Wildlife Cases</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bat</td>
<td>24%</td>
<td>26%</td>
</tr>
<tr>
<td>Skunk</td>
<td>24%</td>
<td>26%</td>
</tr>
<tr>
<td>Fox</td>
<td>7%</td>
<td>8%</td>
</tr>
<tr>
<td>Raccoon</td>
<td>35%</td>
<td>38%</td>
</tr>
<tr>
<td>Puerto Rico</td>
<td>43 cases</td>
<td>79% Mongoose</td>
</tr>
</tbody>
</table>

Rabies and One Health

- Factors affecting occurrence:

  **Wildlife**
  - population biology
  - species interaction
  - movement
  - health
  - susceptibility

  **Environment**
  - climate change
  - encroachment
  - degradation
  - pollution
  - fragmentation

  **Humans & Domestic Animals**
  - population dynamics
  - health
  - agricultural practices
  - animal translocation

  **Rabies Virus**
  - variant proclivities
  - species specificity
  - mutation
Rabies in Puerto Rico

- Introduced in 1800’s
- High reproductive index
- Bad attitude
- Eats everything
- Negative environmental impact
- ~ 70% may be infected with rabies?

Human Population: 3,706,690
Mongoose Population: ~ 2,000,000
Mongoose Density: 2-9 / ha (1-4 / acre)
~ 25 people/day exposed
Rabies in Puerto Rico

A One Health Experience Waiting to Happen!
- Human Health
  - Education
  - PEP
- Veterinary Medicine
  - Large feral dog & cat populations
  - Livestock
- Wildlife Sciences
- Ecology
- Vaccine Research
- Economists

Wildlife Emerging Infectious Diseases

- Historically, wildlife diseases have been considered important only when human health or agriculture have been threatened
- Parallels between human and wildlife EIDS
  - Domestic animals introduce their own suites of pathogens
Bovine Tuberculosis in Michigan

- 1979: Michigan declared free of bovine TB
- 1994: A hunter-killed deer discovered with bTB
- 1995-2011: 1-4% deer (+)

- Other animals reported
  - Elk
  - Captive cervid facility
  - Domestic cattle
    - (9 beef, 2 dairy)
  - Carnivores

Bovine Tuberculosis

1917

- The most prevalent infectious disease in livestock
  - Cattle: ~5% prevalence
  - Swine: ~15% prevalence
  - Carcasses inspected: < 10 million
  - Carcasses retained: ~ 200,000

- Humans: 20% of cases caused by *M. bovis*

Last 10 years

- Cattle: <0.001% prevalence
- Swine – eradicated
- Carcasses inspected: 36 billion
- Carcasses retained: ~ 1300
- Human cases: 1-6 / year
  (11,182 TB cases in 2010)
Bovine Tuberculosis

- Spill over infection from cattle

- Human Intervention:
  - Hunt Clubs
  - increase in prevalence appears to be associated with escalation of feeding and baiting in the 1980-90s

- Data from the 1950s
  - deer were exceeding the natural carrying capacity of the habitat
**Bovine Tuberculosis in Michigan**

**Bovine Tuberculosis and One Health**
Bovine Tuberculosis and One Health

Volatile biomarkers of pulmonary tuberculosis in the breath

One Health & Bovine Tuberculosis
Summary

- “One Health/ One World/ One Environment”
  
  - Improved communication, cooperation and collaboration across disciplines and institutions is essential to safeguard the health of humans, animals and the environment

But . . .

- Most infectious disease research still emphasizes an etiologically based, disciplinary approach
Walking the Talk

- A gap exists between knowledge and its applications
  - Rabies
    - cases increase despite well-established knowledge of effective control
  - TB:
    - we still don’t have better vaccines

Walking the Talk

- A complex-system view of health
  - integrated surveillance and research
  - use of project management models

- The next research paradigm… must be collaborative
  - Biological Sciences
  - Ecology
  - Climatology
  - Sociology
  - Political Science
  - Medicine
  - Wildlife Sciences
  - Environmental Toxicology
Recognize Our Strengths and Weaknesses

<table>
<thead>
<tr>
<th>Veterinary Medicine</th>
<th>Human Medicine</th>
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<tr>
<td>Population health</td>
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<td>Food safety</td>
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<td></td>
<td>Infectious Disease</td>
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<td>Environmental Studies</td>
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<td>Ecology</td>
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<tr>
<td>Individual animal health</td>
<td>Evolutionary impact</td>
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<td></td>
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- Adopt an integrated, **“holistic”** approach that reflects both our interdependence and the realization that we are part of a larger ecological system.
Acknowledgements

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- Michigan Department of Natural Resources-Wildlife Health Section (2012) Summary of Michigan wildlife bovine tuberculosis surveillance
- Zinsstag J et al (2011) From a “one medicine” to “one health” and systemic approaches to health and well-being. Preventive Veterinary Medicine 101: 148-156
- www.onehealthcommission.org
- www.millenniumassessment.org
Zoonotic pathogens

~ 25% have limited person-to-person transmission
  – Do not persist without repeated reintroductions from a non-human reservoir

  ▪ Do not cause major epidemics

  ▪ A small minority spread almost exclusively from person to person

An Integrated Systems Approach to Pathogens

▪ For pathogens that emerge by switching host species
  – Land use change
  – Underlying biodiversity patterns
  – Surveillance of endemic wildlife and wildlife pathogens
  – Preserve / Protecting intact habitats in these hotspots

Managing potential emergence hotspots by attempting to eliminate them is not likely to work.

The species most resilient to habitat destruction and degradation may be those that amplify the pathogen transmission

▪ Husbandry management of high-density monocultures of domestic animals
  • surveillance for disease presence
  • employ measures to decrease contact with wildlife
Zoonotic Pathogens

- Monkey escapes
- Monkey infects a kid
- Kid infects family
- Family infects town
- Humanity in peril !!!
- Intrepid epidemiologist catches monkey
- Antibody harvested from monkey
- All of humanity saved !!!

Walking the Talk -- Literature Search (Anholt et al 2012)

Strategies for Collaboration in the Interdisciplinary Field of Emerging Zoonotic Diseases
Anholt R. M., Stephen C., Copes R.
Zoonosis and Public Health 2012, 59: 229-240

- Conducted a literature search looking at results of collaborations built in health partnerships, health research knowledge transfer and exchange, business knowledge management and system design engineering to identify key attributes of successful interdisciplinary collaboration.
Walking the Talk -- Literature Search (Anholt et al 2012)

- Opportunities exist, but are not without challenges
- Characteristics of the people
- Degree to which the task is a shared goal
- Policy, practices, and resources of the workplace(s)
- Personal relationships built on trust and respect are needed.
- Financial

- “It is necessary to move beyond the belief that collaborations are simply a “good thing” to demonstrate ID collaboration results in improved outcomes.”

- “There was a dearth of publications providing evidence of improved outcomes arising from such collaborations.”

But . . .

- Our ability to protect, improve, and advance health cannot be based on strategies and mindsets in the past

- Isolated silo thinking and actions persist
Integrated Systems Approach

- A complex-system view of health
  - integrated surveillance and research
  - use of project management models