Understanding the Ecology of Emerging Zoonoses
Clinician Outreach and Communication Activity (COCA)
Webinar
Thursday, November 2, 2017
At the end of this COCA Call, the participants will be able to:

• Describe how human activities drive zoonotic disease emergence including examples of human behaviors that promote increased contact with wildlife

• Describe key elements of an ecological study of zoonotic viruses

• List effective interventions that reduce the risk of spillover of pathogens to humans from wildlife

• Discuss how One Health is used in research and response to zoonotic diseases
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Today’s Presenter

Jon Epstein, DVM, MPH, PhD
Vice President, Science & Outreach
EcoHealth Alliance
Understanding the Ecology of Emerging Zoonoses

Jon Epstein  DVM, MPH, PhD
@epsteinjon

Vice President for Science and Outreach

Local conservation. Global health.
Opportunities for spillover and adaptation

Emergence

Pandemic

Morse et al. 2013, *Lancet*
Urbanization

Open landfills provided alternate food resource

ibis ecology was altered

Overpopulation
Risk of Zoonotic Disease Transmission

What is the risk of disease transmission from ibis to people?

*Increased contact rates between ibis and people in parks*
Risk of Disease Transmission to/from Livestock

Avian Influenza

Newcastle Disease

Salmonella
Ebola Virus
Invasive Species, Travel and Climate

Zika Virus
Illegal Wildlife Trade

> 13 million live confiscated animals

>1.5 billion live animals imported into US (2000-2006)$^1$

20%-32% ($1.3–2.1 billion) of wild-caught seafood US imports are illegal$^2$

2. Pramod et al., Marine Policy 2014
Global Legal Trade: Exotic Pets

Bush et al, 2014
Monkeypox: In the U.S.
EIDs in Wildlife: Extinction by Infection

**Amphibians**
- chytrid fungus

**Bats**
- White Nose Syndrome (N. America)
- Fungal disease
- >90% mortality
- Endangered and common species affected
Global Challenges to Surveillance and Response to Emerging Zoonoses

- No single agency responsible for global wildlife disease surveillance
- Veterinary & wildlife departments often lack expertise in wildlife health/disease
- Many laboratories unable to detect/diagnose known or novel pathogens
- Inter-ministerial cooperation/communication often lacking
- Global Health Security Agenda (GHSA) & USAID’s Emerging Pandemic Threats: PREDICT program address these challenges
Economic Impact of Emerging Diseases

Economic Impact of Selected Infectious Disease Outbreaks

- SARS: China, Hong Kong, Singapore, Canada, $30-50bn
- H1N1: Worldwide, $45-55bn
- HSN1 Avian Flu: Worldwide, $30bn
- Ebola: Africa, $31-33bn
- Foot & Mouth: Taiwan, $5-8bn; UK, $10-15bn
- BSE: UK, $3bn
- Nipah: SE Asia, $550-650m
- Lyme Disease: US, $200m
- BSE: US, $3.5bn; Canada, $3bn
- E. Coli 0157:H7: US, $1.8bn

Figures are estimates and are presented as relative size. Based upon bio-era and other data.
Severe Acute Respiratory Syndrome (SARS)
Severe Acute Respiratory Syndrome (SARS)

- SARS-CoV emerged Nov, 2002
- Spread rapidly
- 8110 cases; 775 deaths (~9% cfr)
- First global pandemic of 21st (26 countries including U.S.)
Early clues that SARS was zoonotic

<table>
<thead>
<tr>
<th>Occupation</th>
<th>Jan 2003 and earlier (%)</th>
<th>Feb 2003 (%)</th>
<th>Mar 2003 (%)</th>
<th>Apr 2003 (%)</th>
<th>Total (%)</th>
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<tbody>
<tr>
<td>Retired</td>
<td>2 (9)</td>
<td>44 (10)</td>
<td>46 (23)</td>
<td>32 (16)</td>
<td>124 (15)</td>
</tr>
<tr>
<td>Worker</td>
<td>2 (9)</td>
<td>40 (9)</td>
<td>28 (14)</td>
<td>22 (11)</td>
<td>92 (11)</td>
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<tr>
<td>Student</td>
<td>0 (0)</td>
<td>29 (7)</td>
<td>28 (14)</td>
<td>34 (18)</td>
<td>91 (11)</td>
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<tr>
<td>Civil servant</td>
<td>3 (13)</td>
<td>43 (10)</td>
<td>26 (13)</td>
<td>19 (10)</td>
<td>91 (11)</td>
</tr>
<tr>
<td>Housewife</td>
<td>0 (0)</td>
<td>20 (5)</td>
<td>28 (14)</td>
<td>30 (15)</td>
<td>78 (9)</td>
</tr>
<tr>
<td>Food Industry</td>
<td><strong>9 (39)</strong></td>
<td><strong>20 (5)</strong></td>
<td><strong>4 (2)</strong></td>
<td><strong>19 (10)</strong></td>
<td><strong>52 (6)</strong></td>
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<tr>
<td>Farmer</td>
<td>1 (4)</td>
<td>10 (2)</td>
<td>4 (2)</td>
<td>4 (2)</td>
<td>19 (2)</td>
</tr>
<tr>
<td>Teacher</td>
<td>1 (4)</td>
<td>7 (2)</td>
<td>6 (3)</td>
<td>4 (2)</td>
<td>18 (2)</td>
</tr>
<tr>
<td>Child</td>
<td>0 (0)</td>
<td>9 (2)</td>
<td>4 (2)</td>
<td>4 (2)</td>
<td>17 (2)</td>
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<tr>
<td>Other</td>
<td>2 (9)</td>
<td>49 (11)</td>
<td>14 (7)</td>
<td>18 (9)</td>
<td>83 (10)</td>
</tr>
<tr>
<td>Unknown</td>
<td>3 (13)</td>
<td>157 (37)</td>
<td>14 (7)</td>
<td>8 (4)</td>
<td>182 (21)</td>
</tr>
<tr>
<td>Total</td>
<td><strong>23 (100)</strong></td>
<td><strong>428 (100)</strong></td>
<td><strong>202 (100)</strong></td>
<td><strong>194 (100)</strong></td>
<td><strong>847 (100)</strong></td>
</tr>
</tbody>
</table>

SARS: Are civets the source?

• SARS CoV isolated from civets
• China culls 10,000 civets
• Marketplace civets had high seroprevalence
• Farmed civets seronegative
• How do civets get infected?

The Search for SARS in Bats

Collaboration between zoologists, virologists, veterinary epidemiologists (USA, China, Australia)
Investigated market and wild-caught bats (2003-2004)
SARS-like CoV
LETTER

Isolation and characterization of a bat SARS-like coronavirus that uses the ACE2 receptor

Xing-Yi Ge1*, Jia-Lu Li1*, Xing-Lou Yang1*, Aleksei A. Chmura2, Guangjian Zhu2, Jonathan H. Epstein2, Jonna K. Mazer3, Ben Hu1, Wei Zhang1, Cheng Peng1, Yu-Ji Zhang1, Chu-Ming Luo1, Bing Tan1, Ning Wang1, Yan Zhu1, Gary Crameri4, Shu-Yi Zhang5, Lin-Fa Wang5,6, Peter Daszak1, & Zheng-Li Shi1

Ge et al. 2013, Nature
Could SARS emerge again?

Bat SARS CoVs in Yunnan
People hunt bats and live/work around these caves
What types of exposure to CoVs do they have?
Anthropology team working to identify “high risk” behaviors and exposure to CoVs
Nipah Virus
Bats were the presumptive reservoir

Hendra in Australia

Found seropositives during outbreak\(^1\)

NiV isolated from *P. hypomelanus* on Tioman Island\(^2\)

\(^1\)Johara *et al.*, *EID* vol 7 (3), 2001

Distribution of NiV in Malaysian *Pteropus* spp.

- **Widespread circulation of virus**
  - Pulau Tioman: 7% (29)
  - Tanjung Agas: 47% (34)
  - Lenggong: 52% (27)
  - K. Berang: 38% (13)
  - Pulau Kapas: 38% (26)
  - Tk. Memali: 17% (12)
  - Muar: 38% (26)
  - Kg. Nipah: 58% (24)

- **Low incidence, short viremic period**
  - (Sumatra): 6% (1164)

- **Temporal variation**
Agricultural intensification, priming for persistence and the emergence of Nipah virus: a lethal bat-borne zoonosis

Juliet R. C. Pulliam¹,²,Jonathan H. Epstein³, Jonathan Dushoff¹,², Sohayati A. Rahman⁴,⁵,⁸, Michel Bunning⁶, Aziz A. Jamaluddin⁷, Alex D. Hyatt⁸, Hume E. Field⁹, Andrew P. Dobson¹, Peter Daszak³,* and the Henipavirus Ecology Research Group (HERG)³,⁴
Nipah virus in Bangladesh and India

- 20+ outbreaks reported since 2001
- >300 cases (~75% cfr; up to 100%)
- Spatial and seasonal patterns
- Bat-to-human transmission\(^1,2\)
- Human-to-human transmission

Are NiV outbreaks driven by both host viral dynamics and human behavior?
Bats, Date Palm Sap, and Nipah Cases

Gurley et al., EID 2017
Henipaviruses in domestic animals

- Non-neutralizing antibodies found in cattle (6.5%), goats (4.3%) and pigs (44.2%)\(^1\)
- Clinically “normal” animals
- Diversity of henipaviruses circulating in bats\(^2\)
- Farmers feed bat-bitten fruit\(^3\)

2. Anthony, Epstein et al., (2013) *mbio*
3. Openshaw et al., (2016). *EcoHealth*
One Health approach to NiV surveillance, control, & research

- Integrated human, livestock, wildlife surveillance & outbreak response
- Anthropological study of risk factors and interventions
- Bangladesh One Health Secretariat coordinates communication and response
Emerging Zoonoses Hotspots

Allen et al., *Nature Comm.*, 2017

EcoHealth Alliance
Conclusions

• Human activities drive zoonotic disease emergence

• An multidisciplinary approach, including ecology, is effective for understanding zoonotic disease emergence

• Simple, practical solutions are required.
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