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

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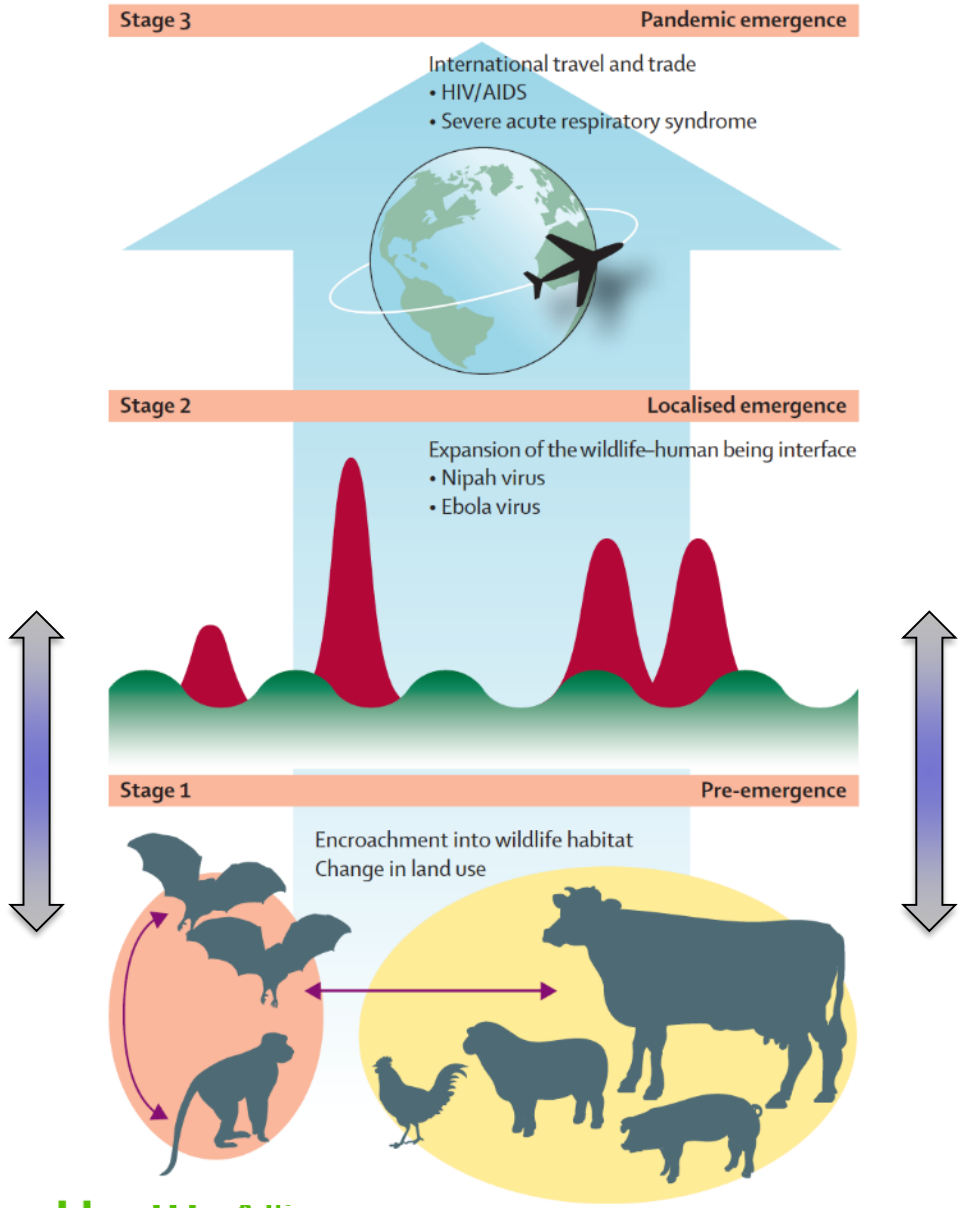
Understanding the Ecology of Emerging Zoonoses

Jon Epstein DVM, MPH, PhD
@epsteinjon

Vice President for
Science and Outreach

Local conservation.
Global health.



Pandemic

Emergence

Opportunities for spillover and adaptation

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Morse et al. 2013, *Lancet*


Urbanization
INDONESIA
INDONESIA
PAPUA NEW GUINEA
ARAFURA SEA
CAPE YORK
Darwin
GULF OF CARPENTARIA
INDIAN OCEAN
Wyndham
Derby
Cooktown
CORAL SEA
Cairns
NORTHERN TERRITORY
Townsville
Cloncurry
QUEENSLAND
Alice Springs
Ashburton
WESTERN AUSTRALIA
Rockhampton
Charleville
SOUTH AUSTRALIA
Brisbane
Bourke
Darling
NEW SOUTH WALES
Geraldton
Coolgardie
Perth
Port Augusta
Newcastle
Adelaide
Murray
Sydney
CANBERRA
Albany

Urbanization

Open landfills provided alternate food resource

ibis ecology was altered

Overpopulation

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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

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Risk of Disease Transmission to/from Livestock

Avian Influenza

Newcastle Disease

Salmonella

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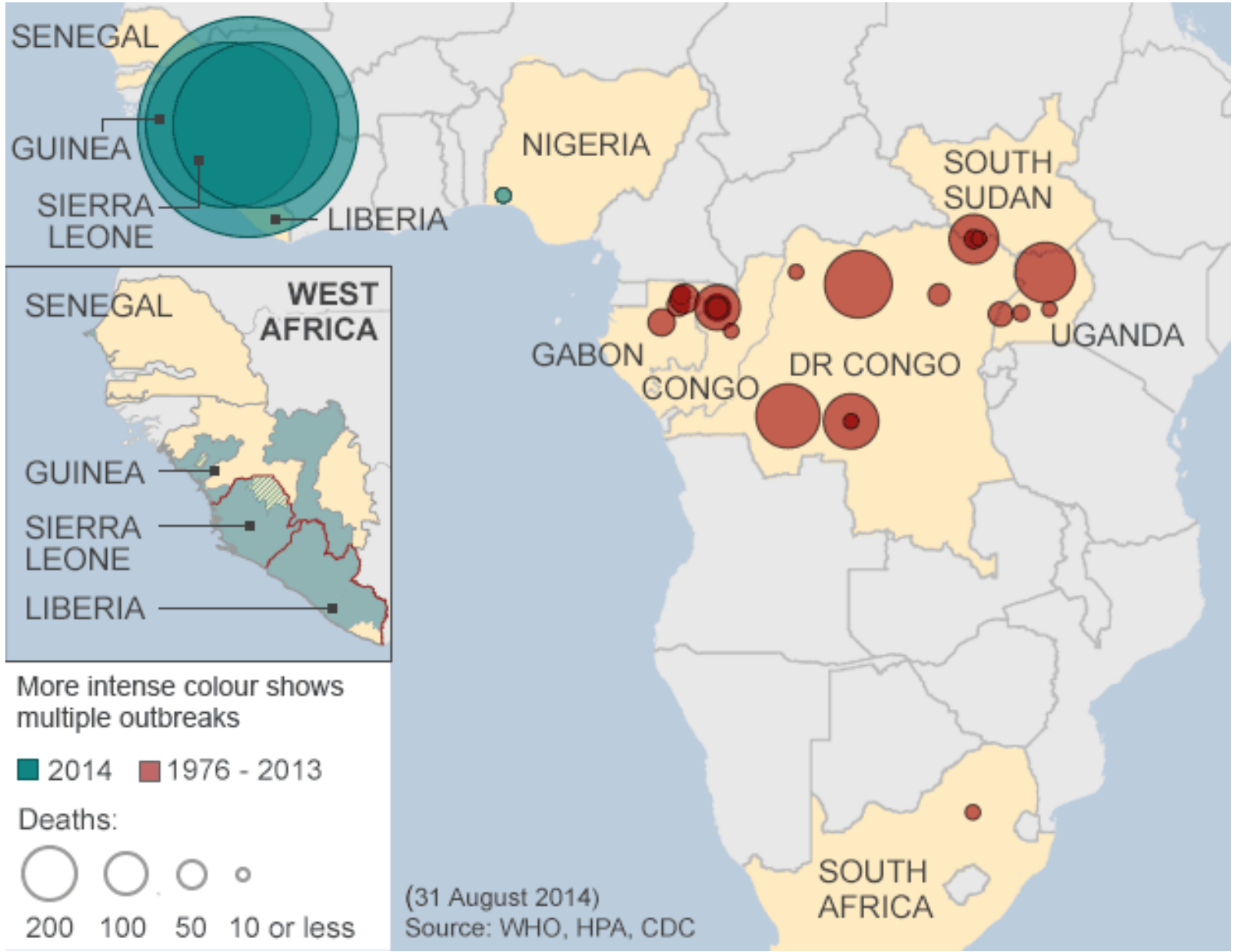
Ebola Virus



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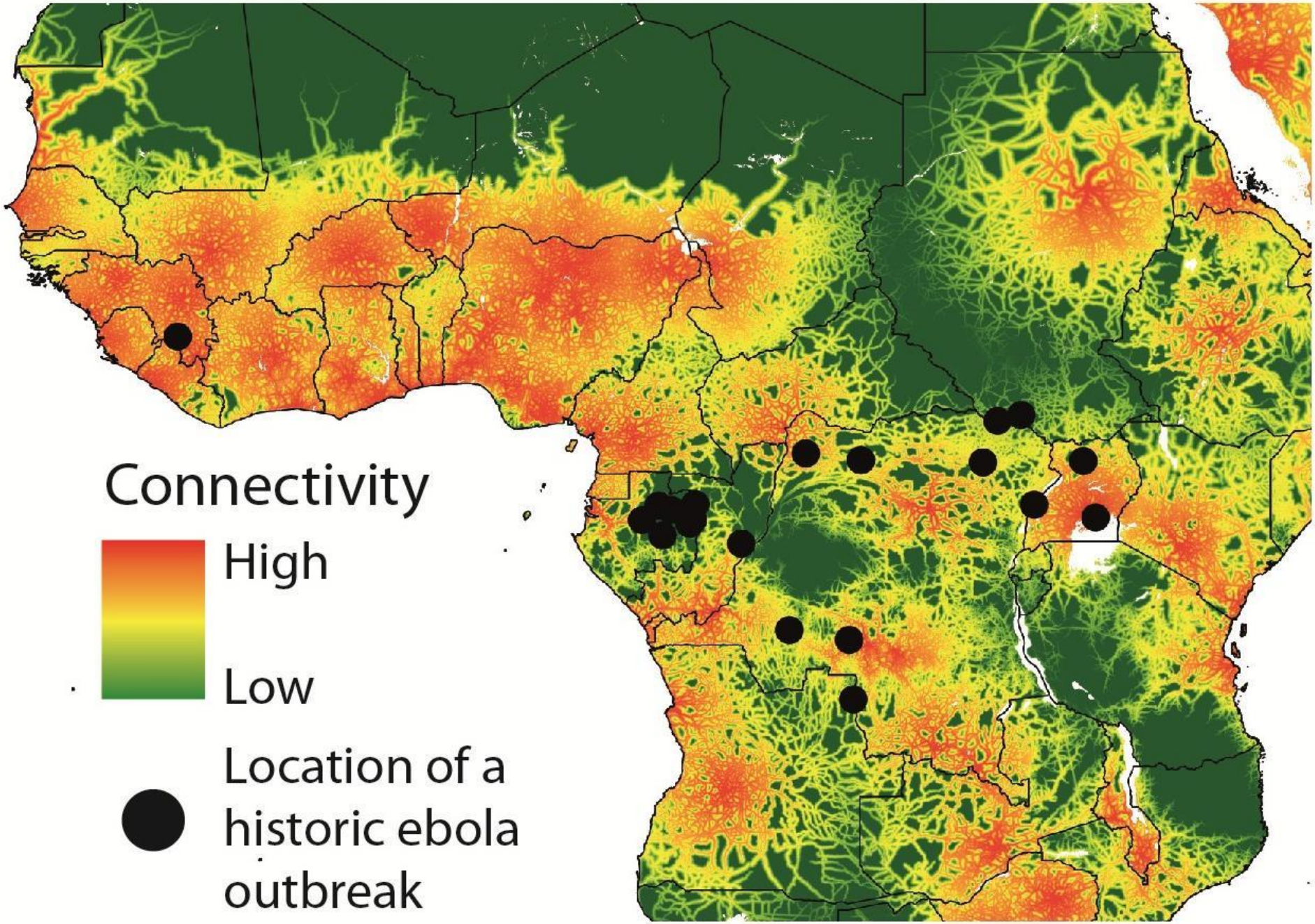
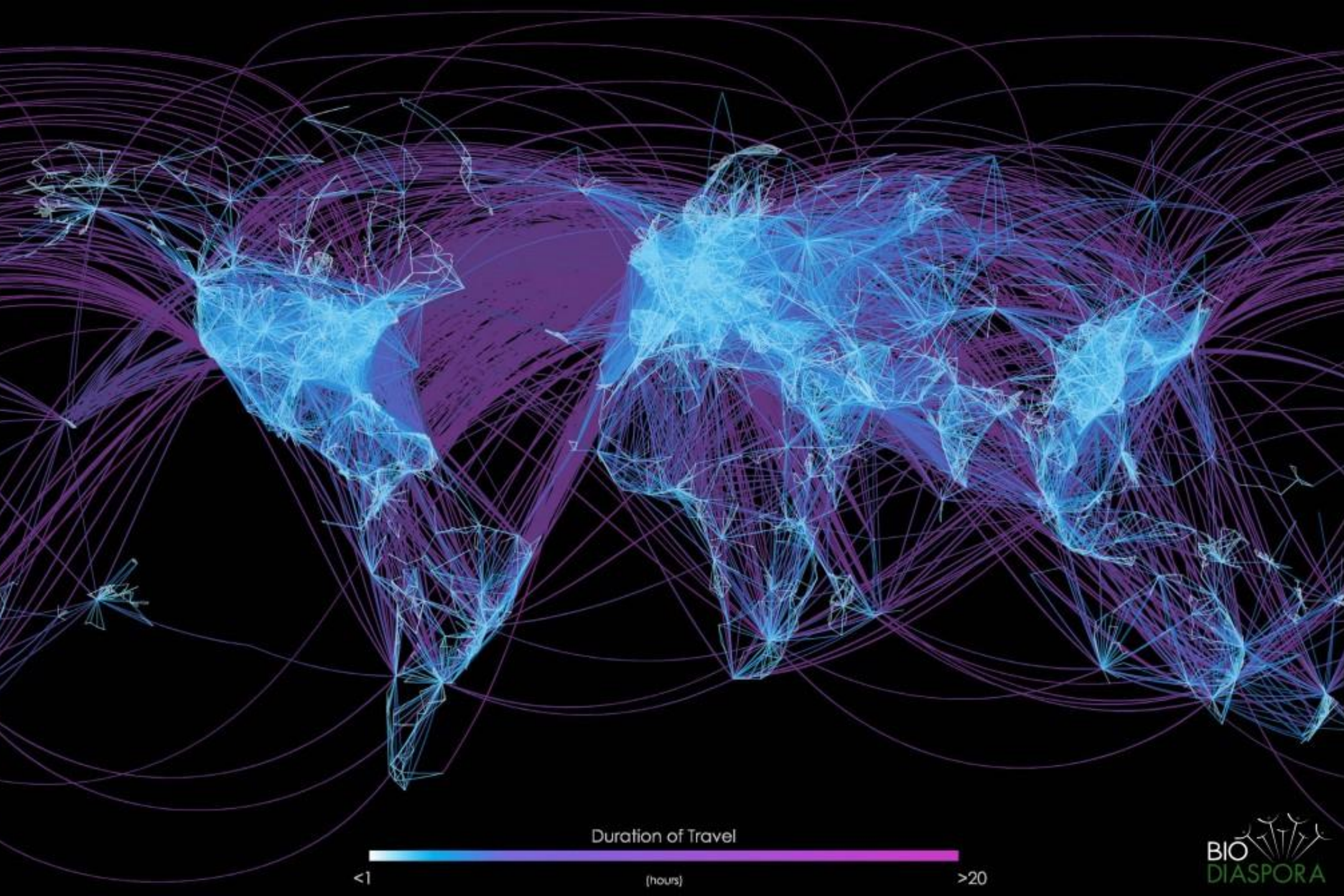
NYTimes.com



Wesolowski et. al. 2014


Duration of Travel
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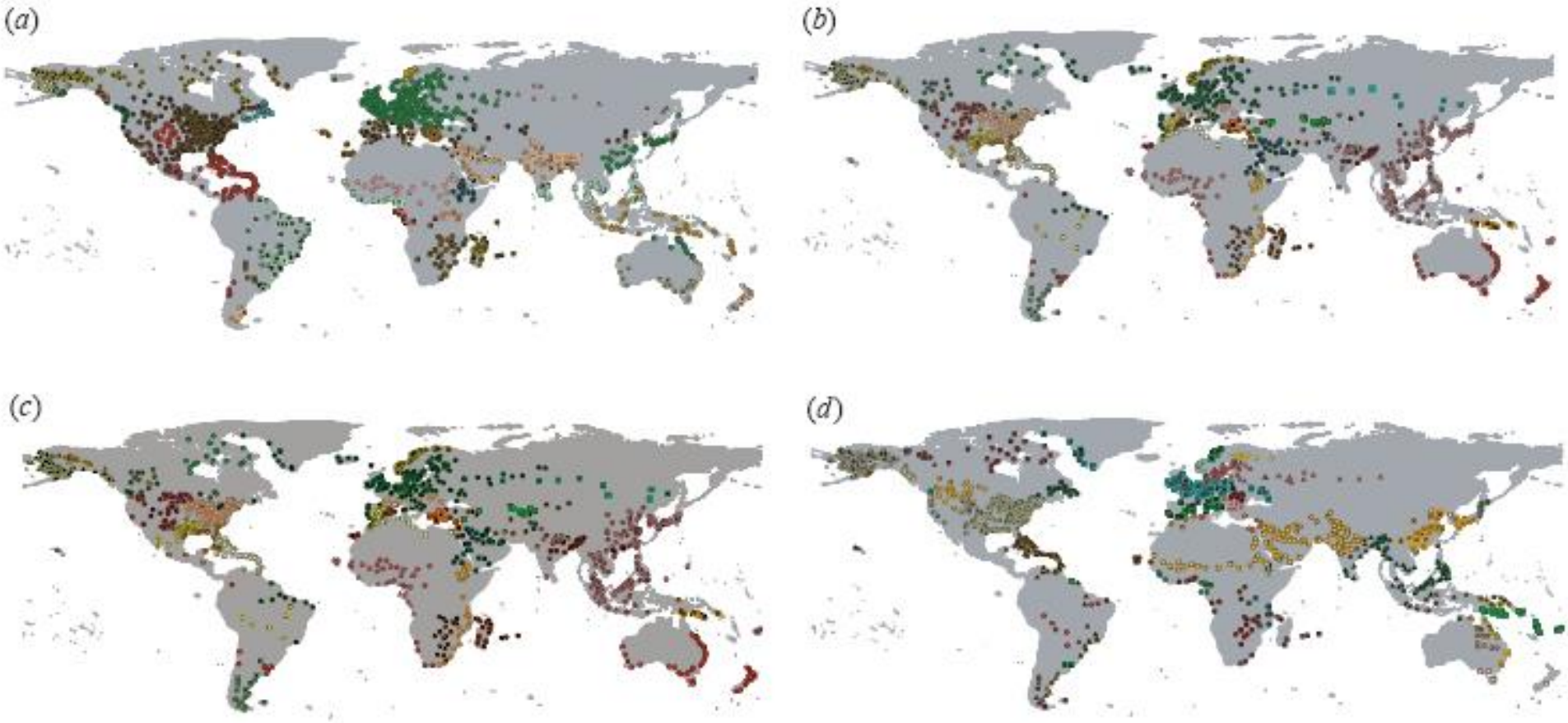
(hours)
>20
BIO
DIASPORA

Invasive Species, Travel and Climate



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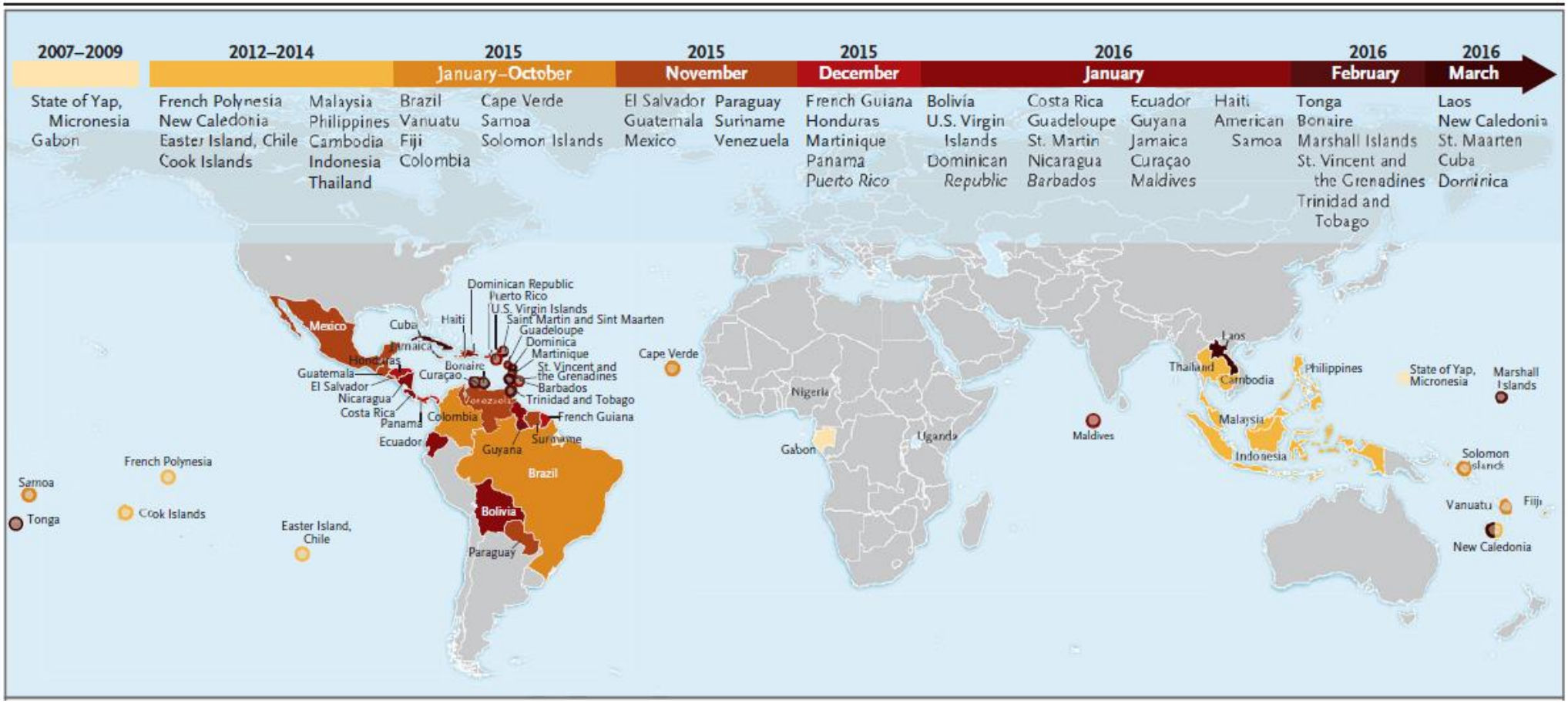
Tatem and Hay, Proc R Soc B 2007

Zika Virus



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Illegal Wildlife Trade

Photo: Emmanuel Dunand

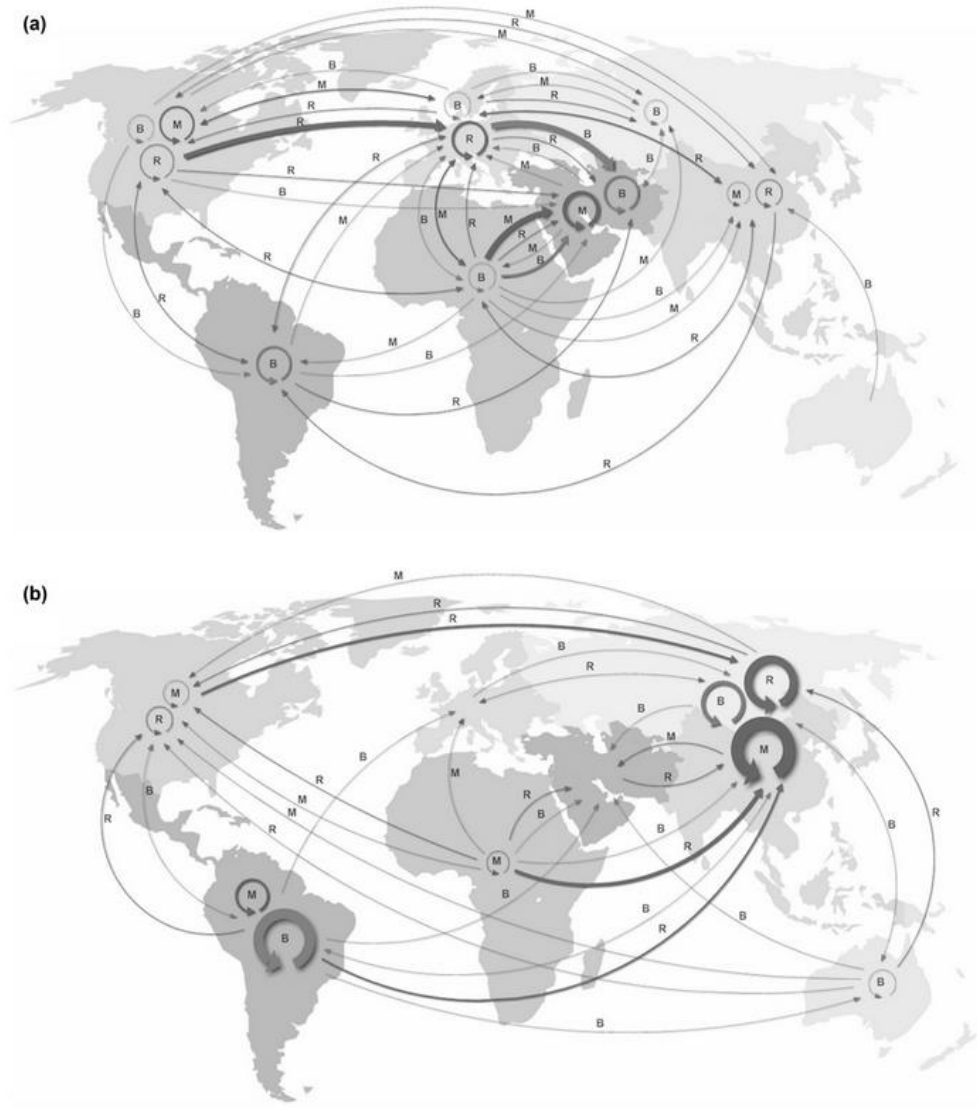
> 13 million live confiscated animals

>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]

1. Smith et al. *Science* 2009
2. Pramod et al., *Marine Policy* 2014

Global Legal Trade: Exotic Pets



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Bush et al, 2014

Monkeypox: In the U.S.

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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

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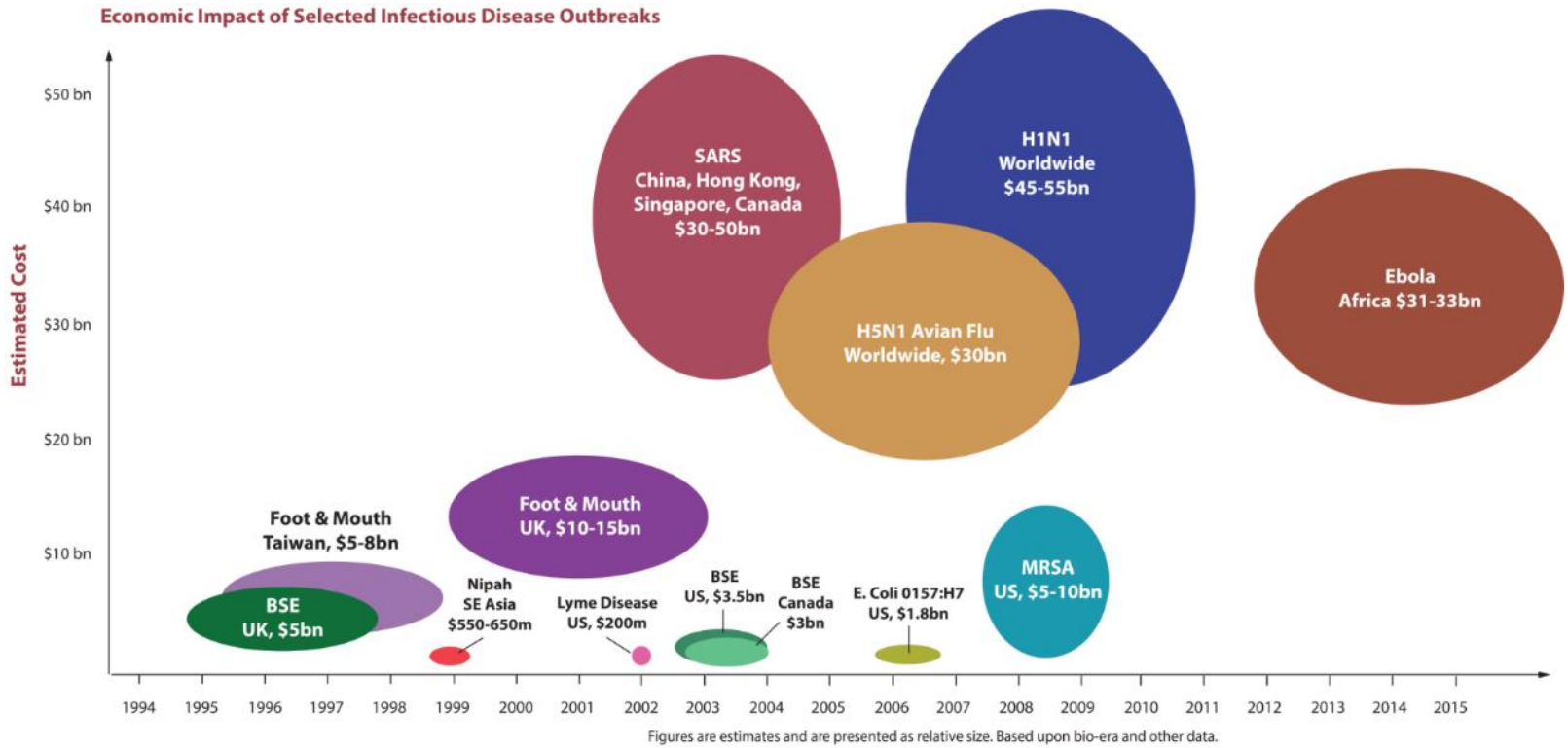
Economic Impact of Emerging Diseases



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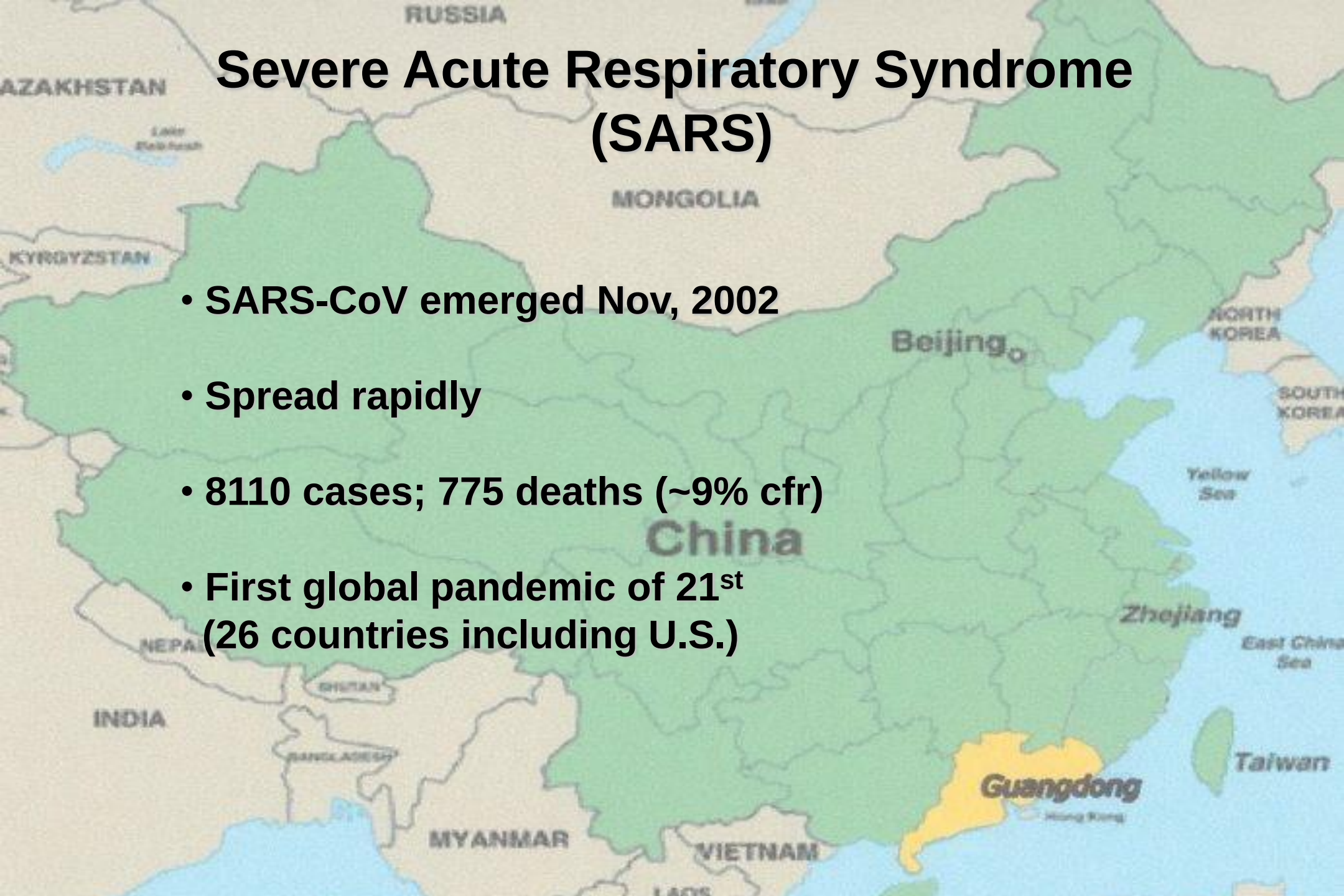
Severe Acute Respiratory Syndrome (SARS)

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.)


SPORT

Early clues that SARS was zoonotic

Table 1: Commuity cases with no contact history by month of onset and occupation

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

Source: Rui-Heng Xu, Jian-Feng He, Meirion R Evans, Guo-Wen Peng, Hume E Field *et al* 2003. Epidemiologic Clues to the Origin of Severe Acute Respiratory Syndrome in China. Submitted JAMA.

SARS: Are civets the source?

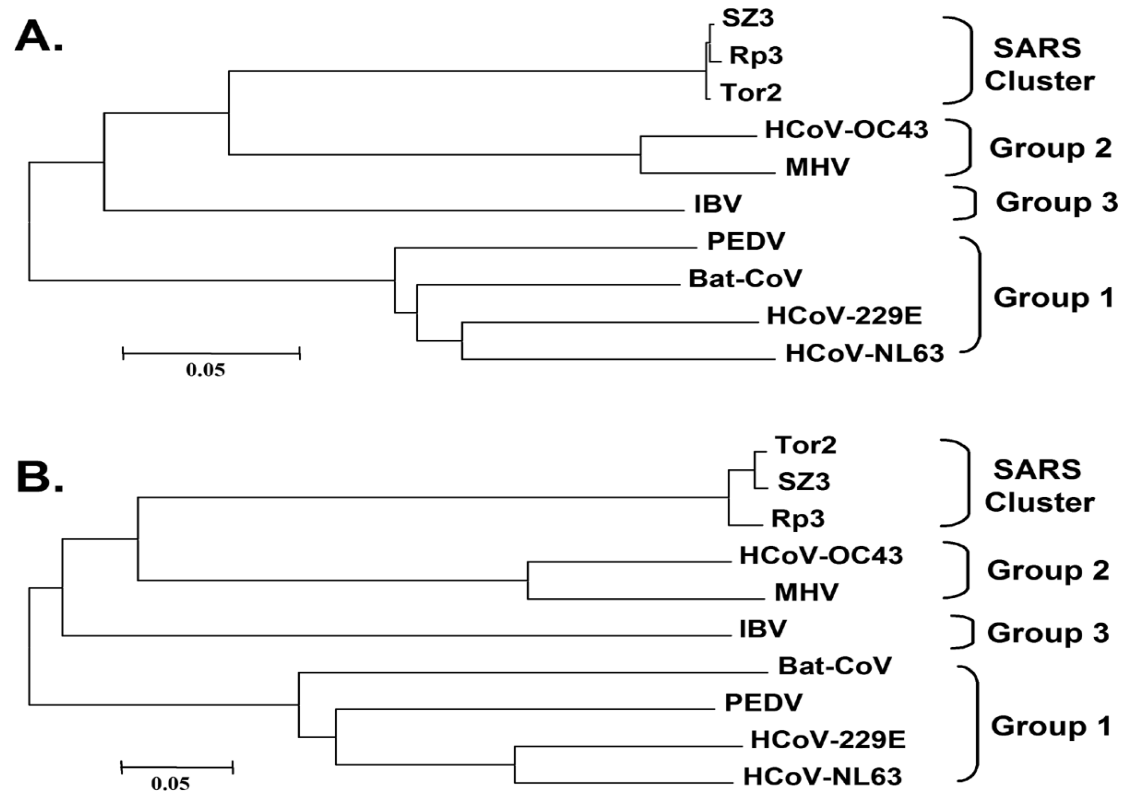
- SARS CoV isolated from civets
- China culls 10,000 civets
- Marketplace civets had high seroprevalence
- Farmed civets seronegative[1]
- How do civets get infected?

1. Tu et al, EID 12(10) 2004.

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



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LETTER

doi:10.1038/nature12711

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

Xing-Yi Ge[1]*, Jia-Lu Li[1]*, Xing-Lou Yang[1]*, Aleksei A. Chmura[2], Guangjian Zhu[2], Jonathan H. Epstein[2], Jonna K. Mazet[3], Ben Hu[1], Wei Zhang[1], Cheng Peng[1], Yu-Ji Zhang[1], Chu-Ming Luo[1], Bing Tan[1], Ning Wang[1], Yan Zhu[1], Gary Crameri[4], Shu-Yi Zhang[5], Lin-Fa Wang[4,6], Peter Daszak[2] & Zheng-Li Shi[1]

Ge et al. 2013, Nature

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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

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Nipah Virus

Bats were the presumptive reservoir

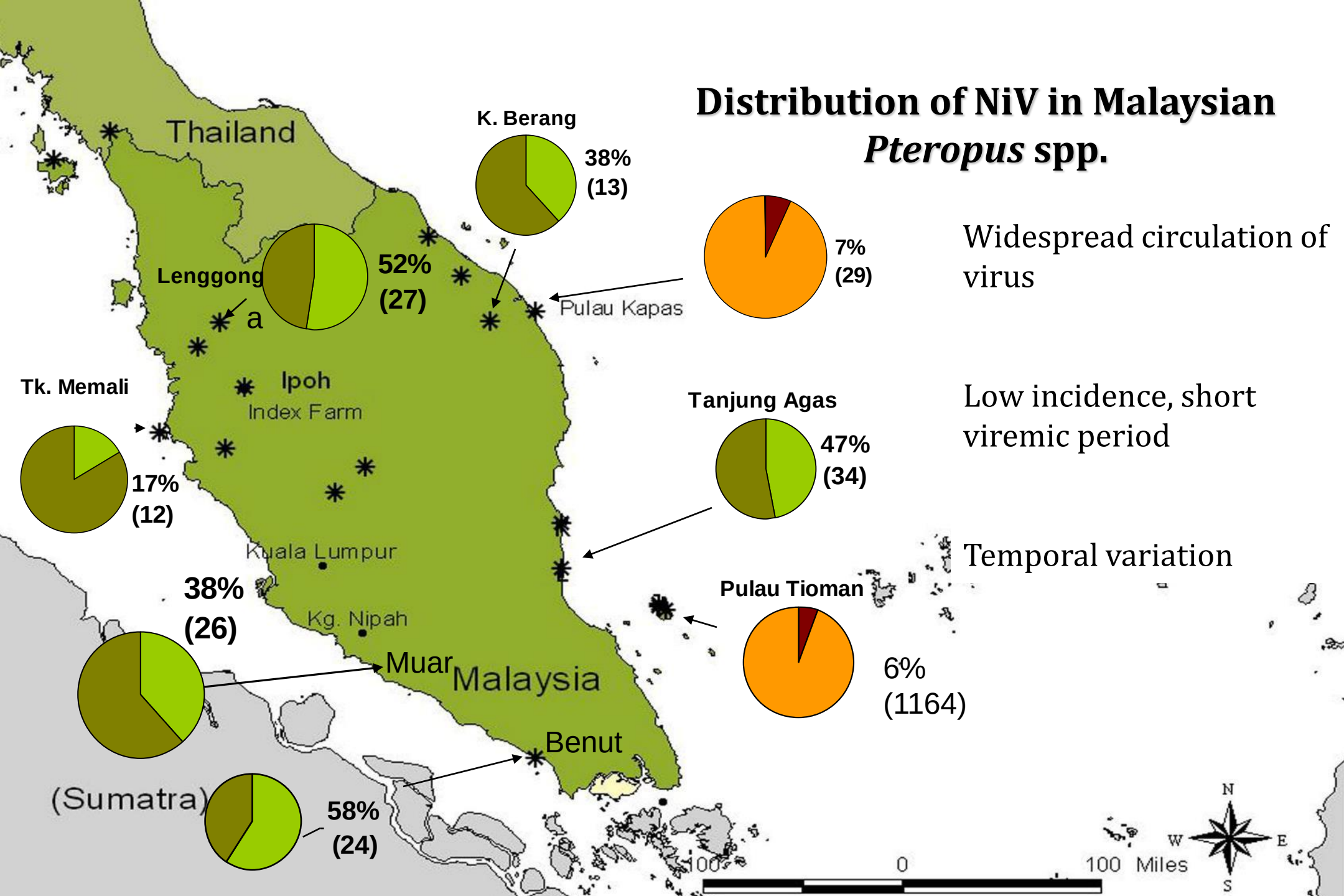
Hendra in Australia

Found seropositives during outbreak[1]

NiV isolated from *P. hypomelanus* on Tioman Island[2]

[1]Johara *et al.*, *EID* vol 7 (3), 2001

[2]Chua et al., *Microbes Infect,* 4, 145-151. 2002.

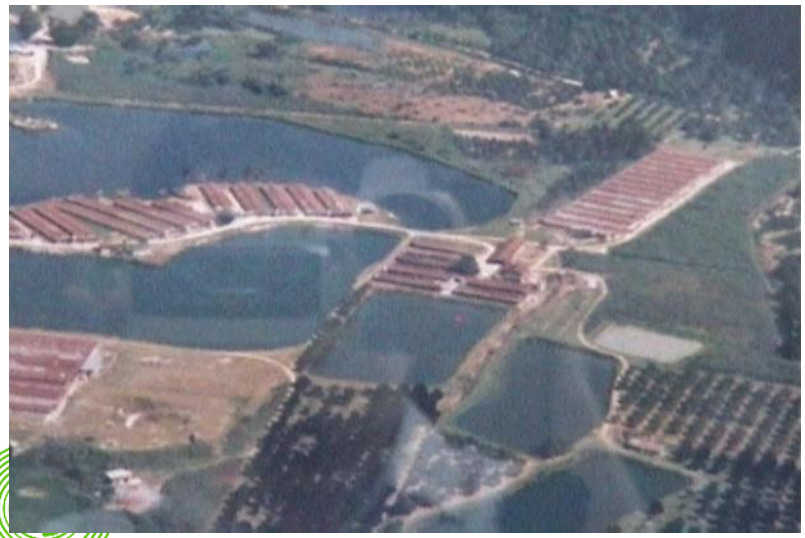

Distribution of NiV in Malaysian *Pteropus* spp.
Thailand
K. Berang
38%
(13)
7%
(29)
Pulau Kapas
Lenggong
a
52%
(27)
Tk. Memali
17%
(12)
Ipoh
Index Farm
Tanjung Agas
47%
(34)
Kuala Lumpur
38%
(26)
Kg. Nipah
Pulau Tioman
Muar
Malaysia
6%
(1164)
Benut
(Sumatra)
58%
(24)
100
0
100 Miles
N
W
E
S
Widespread circulation of virus
Low incidence, short viremic period
Temporal variation

JOURNAL OF THE ROYAL SOCIETY Interface

J. R. Soc. Interface (2012) **9**, 89–101
doi:10.1098/rsif.2011.0223
Published online 1 June 2011

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

Juliet R. C. Pulliam[1,2,†], Jonathan H. Epstein[3], Jonathan Dushoff[1,‡], Sohayati A. Rahman[4,5,§], Michel Bunning[6], Aziz A. Jamaluddin[7], Alex D. Hyatt[8], Hume E. Field[9], Andrew P. Dobson[1], Peter Daszak[3,*] and the Henipavirus Ecology Research Group (HERG)[3,¶]



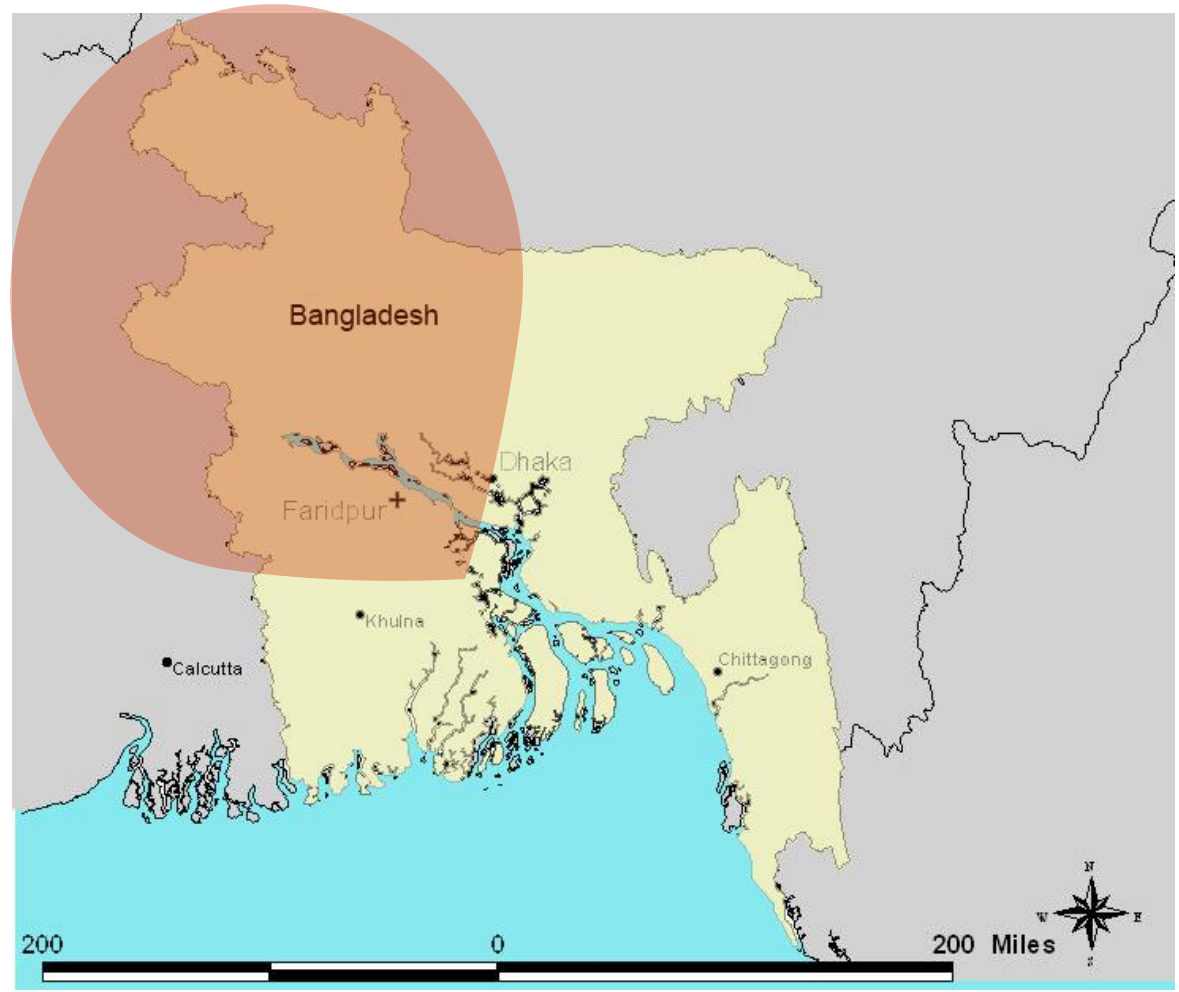

New Delhi
Mt. Everest
(8850 m)
Lhasa
HIMALAYAS
NEPAL
Jaipur
Lucknow
Kānpur
Kathmandu
BHUTAN
Thimphu
CHINA
ZHONG GUO
Changsha
Chongqing
Nanchang
China Sea
Tropic of Cancer
Guiyang
Taipei
TAIWAN
Ahmadābād
INDIA
BHARAT
Ganges
Brahmaputra
BANGLADESH
Dhaka
Irrawaddy
Kunming
Xi Jiang
Guangzhou
Philippine Sea
Hong Kong S.A.R.
Macau S.A.R.
Nanning
Surat
Kolkata
(Calcutta)
Chittagong
MYANMAR
(BURMA)
Nāgpur
Mandalay
Salween
Hanoi
Mumbai
(Bombay)
Pune
DECCAN
Haiphong
Hainan Dao
LAOS
Vientiane
Luzon
Hyderābād
WESTERN GHATS
EASTERN GHATS
Nay Pyi Taw
Yangon
Hue
Manila
Bay of
Bengal
THAILAND
PRATHET THAI
Bangkok
Mekong
South
China
Sea
PHILIPPINES
Bangalore
Chennai
(Madras)
VIET
NAM
CAMBODIA
SPRATLY
ISLANDS
Cebu
Andaman
Sea
ANDAMAN
ISLANDS
(INDIA)
Phnom
Penh
Sulu Sea
Mindanao
Davao
Cochin
Jaffna
Ho Chi Minh City
(Saigon)
Laccadive
Sea
SRI LANKA
Colombo
Gulf of
Thailand
Bandar Seri
Begawan
BRUNEI
Celebes Sea
NICOBAR
ISLANDS
(INDIA)
Male
MALAYSIA
Kuala Lumpur
MALAYSIA
MALDIVES
Medan
Singapore
SINGAPORE
Borneo
Equator
Pontianak
Celebes
Sumatra
INDONESIA
Palembang
Java Sea
Makassar
Jakarta
Surabaya
Dili
EAST TI
Timor
Bandung
Semarang
Java
Indian
Ocean
pital
s
ual-Area Projection
800 Kilometer
800 Miles

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]**
- **<u>Human-to-human transmission</u>**



1. Hsu et al. EID 2005; 2. Gurley et al, 2008

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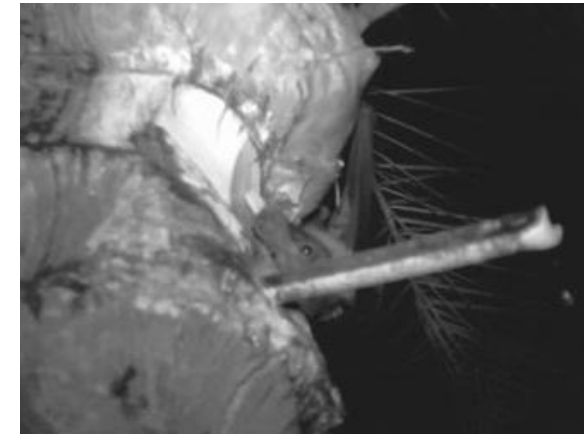
Are NiV outbreaks driven by both host viral dynamics and human behavior?



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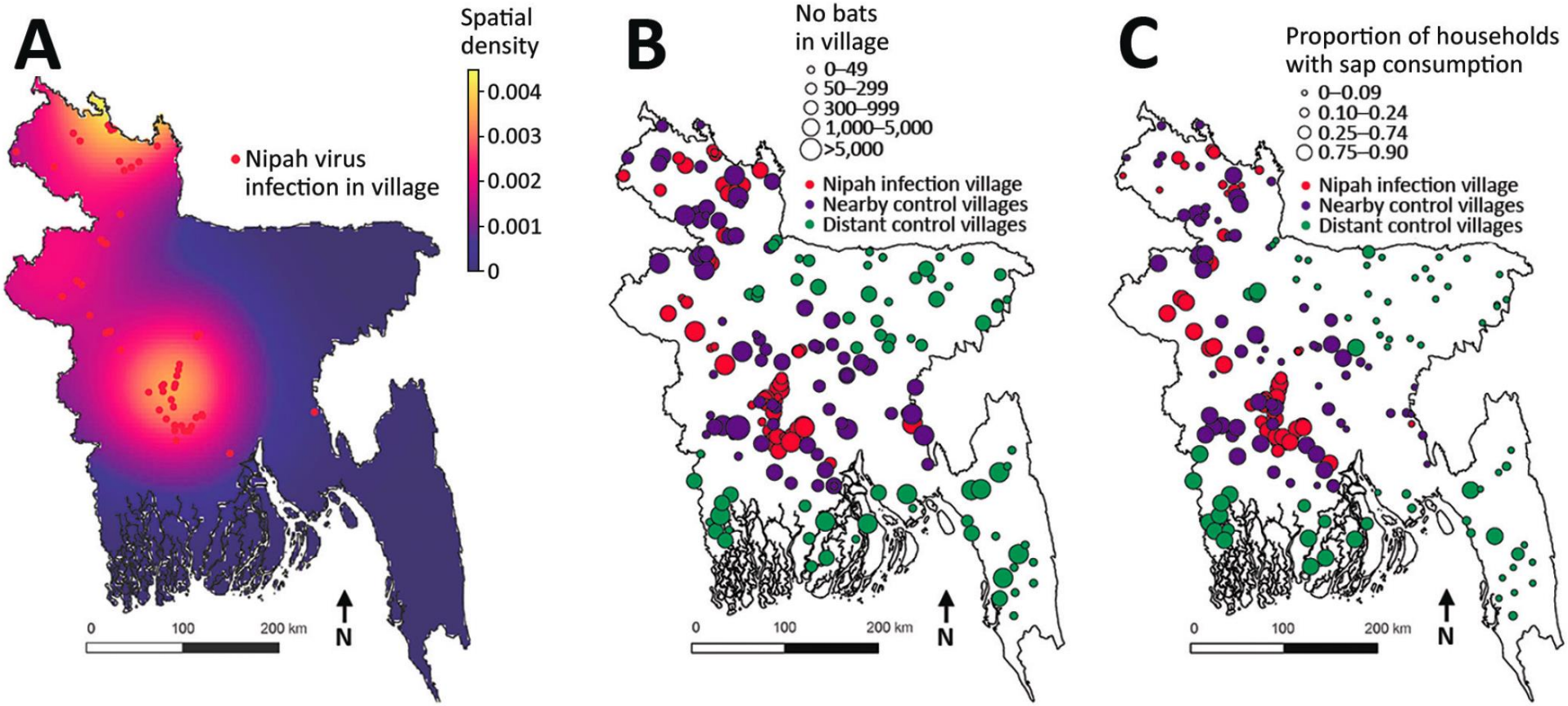
Bats, Date Palm Sap, and Nipah Cases



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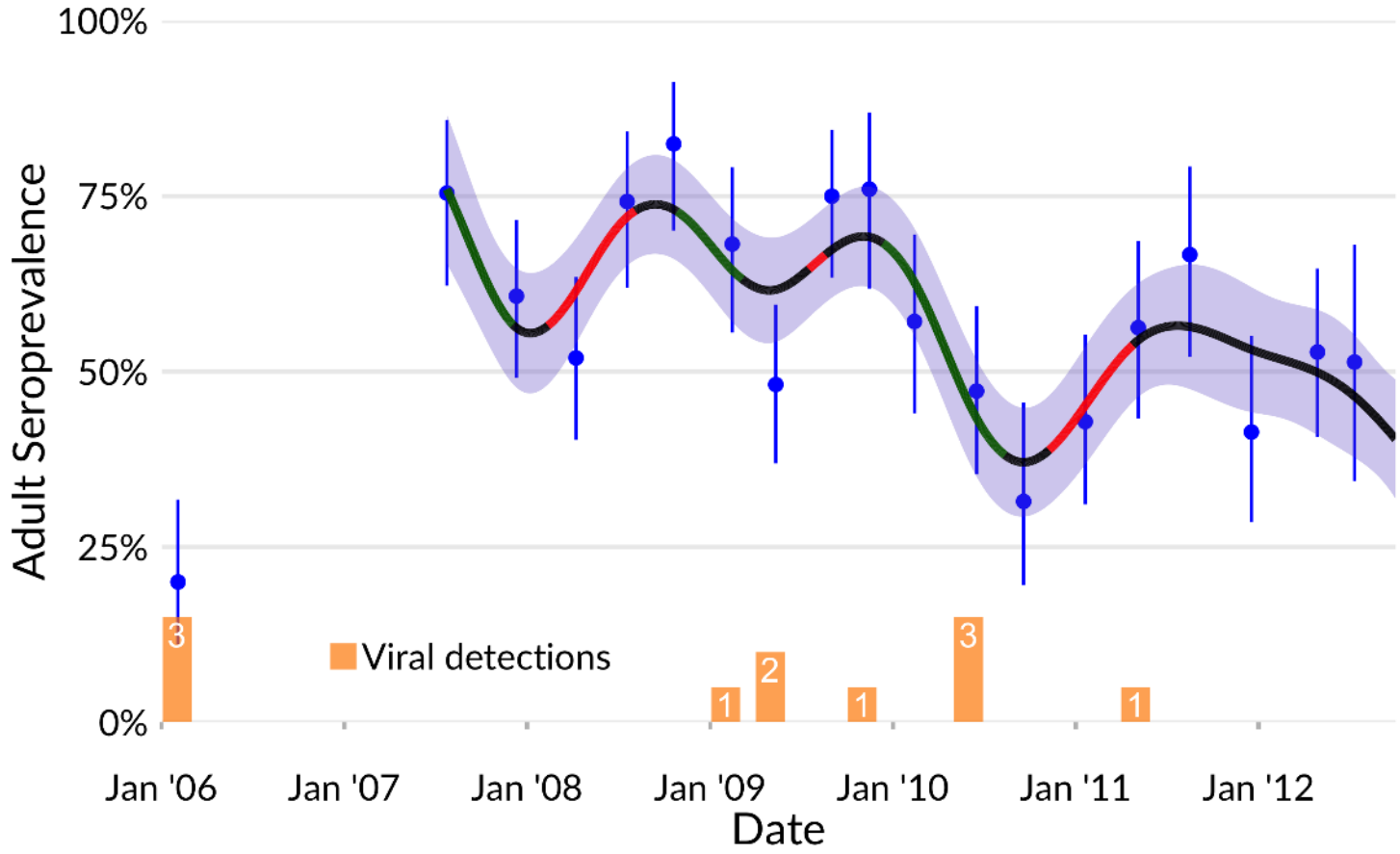
Gurley et al., EID 2017

Adult Bat NIV Serodynamics



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Epstein et al. *in review*

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]

1. S. Chowdhury et al., (2014) *PLoS Negl. Trop Dis.*
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

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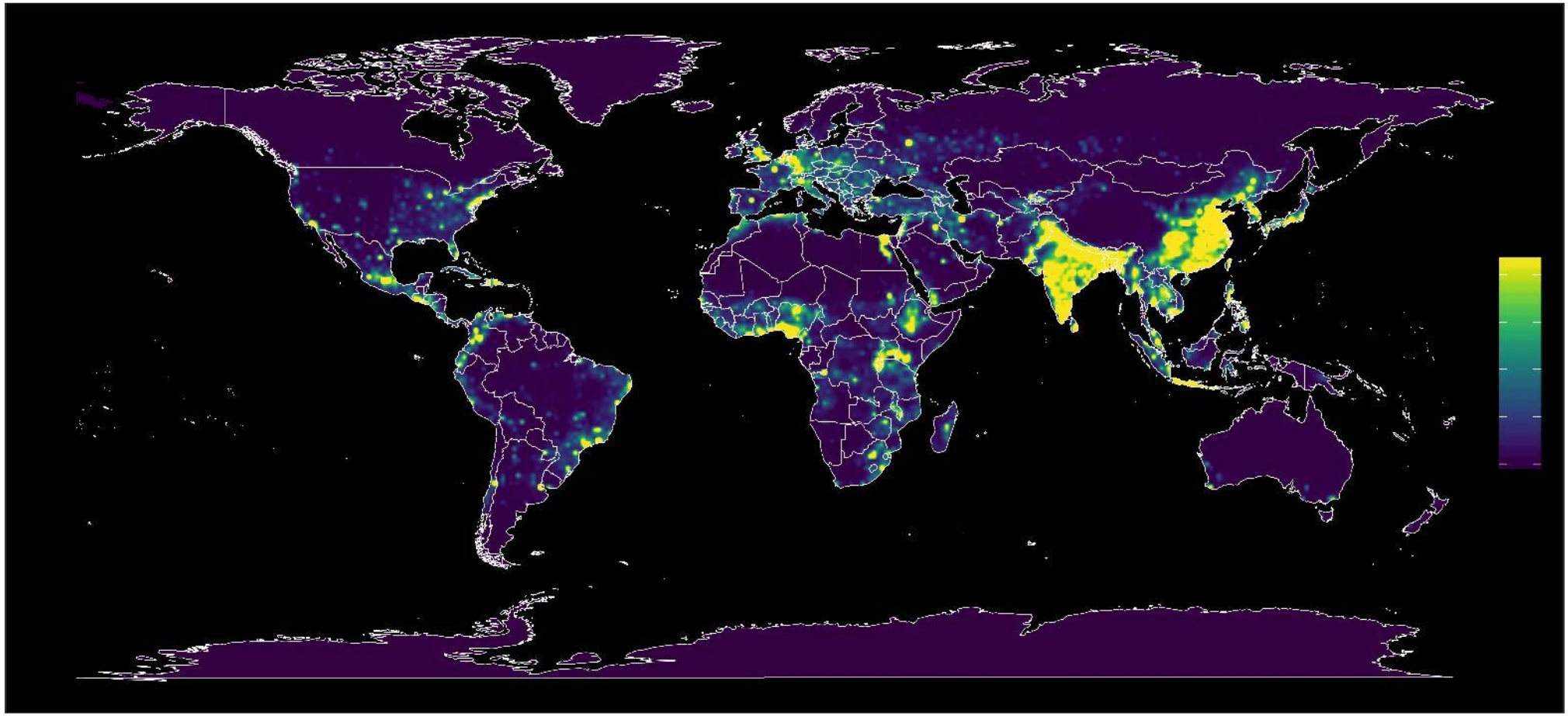
Emerging Zoonoses Hotspots



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

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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Acknowledgements

EcoHealth Alliance: P. Daszak, K. Olival, T. Hughes, A. Islam, C. Machalaba, W. Karesh, P. Biswas, G. Sheikh, S.A. Khan

icddrb: S. Luby, J. Hossain, E. Gurley, S.U. Khan

IEDCR: M. Rahman

Columbia University CII: W. Ian Lipkin, Simon Anthony, Maria Sanchez

CSIRO AAHL: A. Hyatt, P. Daniels, K. Halpin, L. Wang, G. Crameri

KB Chua (MOH), M.B. Misliah (Perhilitan), S.A. Rahman (VRI); S. Syed. Hassan (Monash U.)

Biosecurity QLD/DAFF: H. Field, C. Smith

A. M. Kilpatrick (UCSC); A. Cunningham (IOZ)

J. Pulliam (UF); Microwave Telemetry

Our Work is supported by:
NIH (FIC, NIAID); NSF; The Conservation Food and Health Foundation, USAID EPT

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What: All call recordings

Where: On the COCA Call webpage
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What's New for the 2017-2018 Flu Season: Recommendations for Children

Tuesday, November 7, 2017

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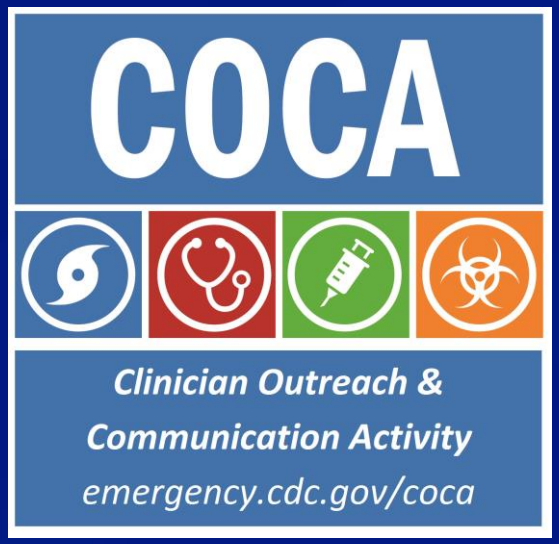

http://emergency.cdc.gov/coca