



Institute  
and Faculty  
of Actuaries

# Ecological impact on pandemic risk in the 21st century

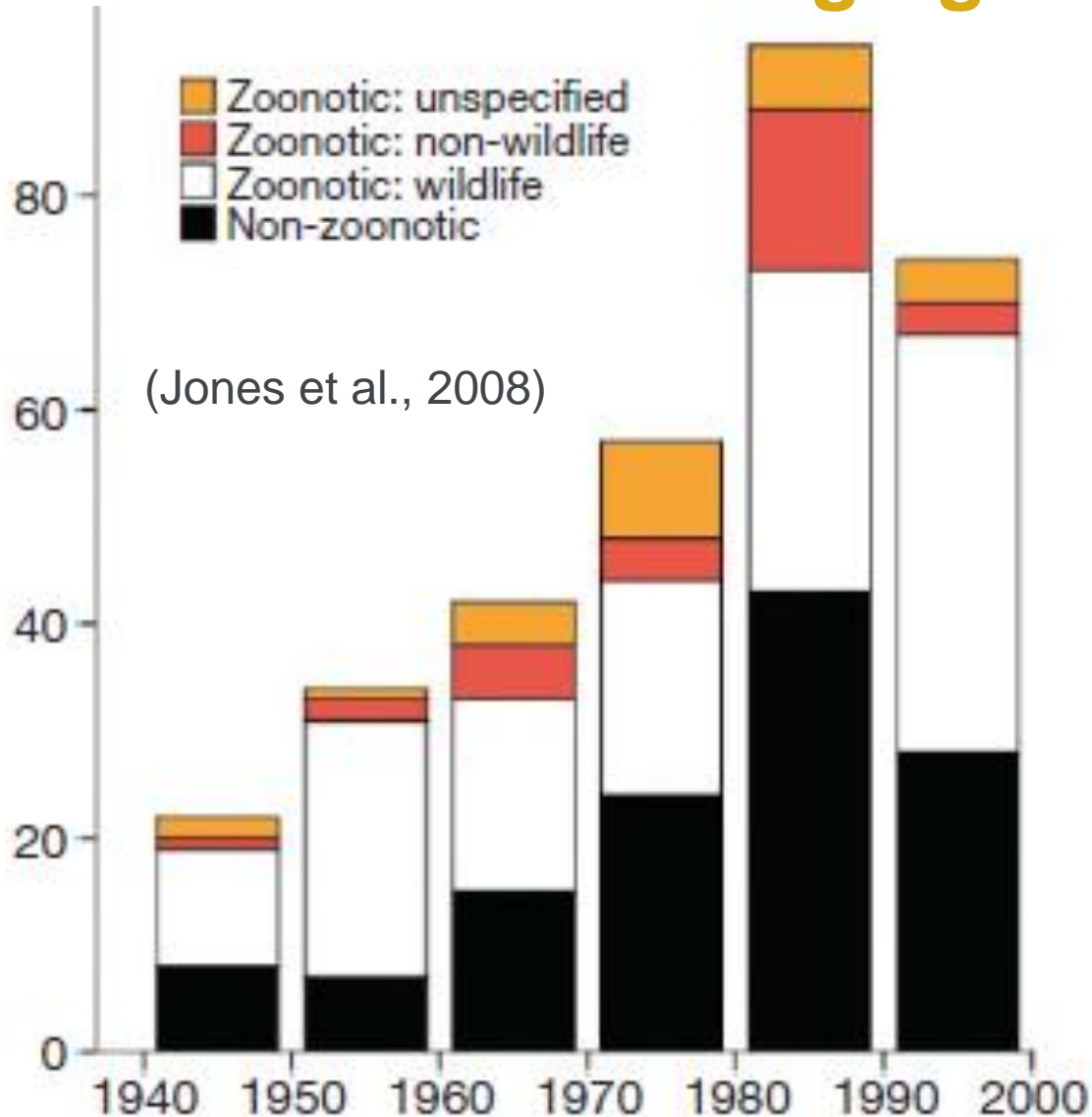
Gordon Woo  
RMS LifeRisks

Health and Care Hot Topics webinar

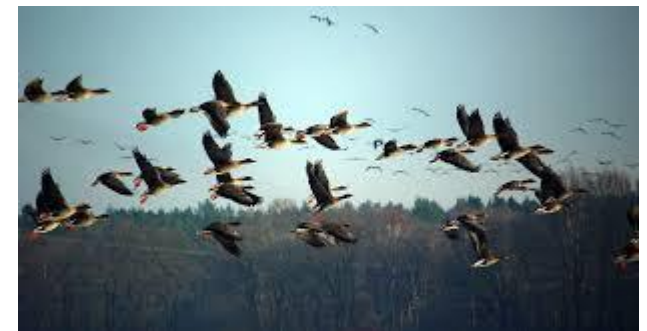
10th February 2021



# Global trend in emerging infectious diseases



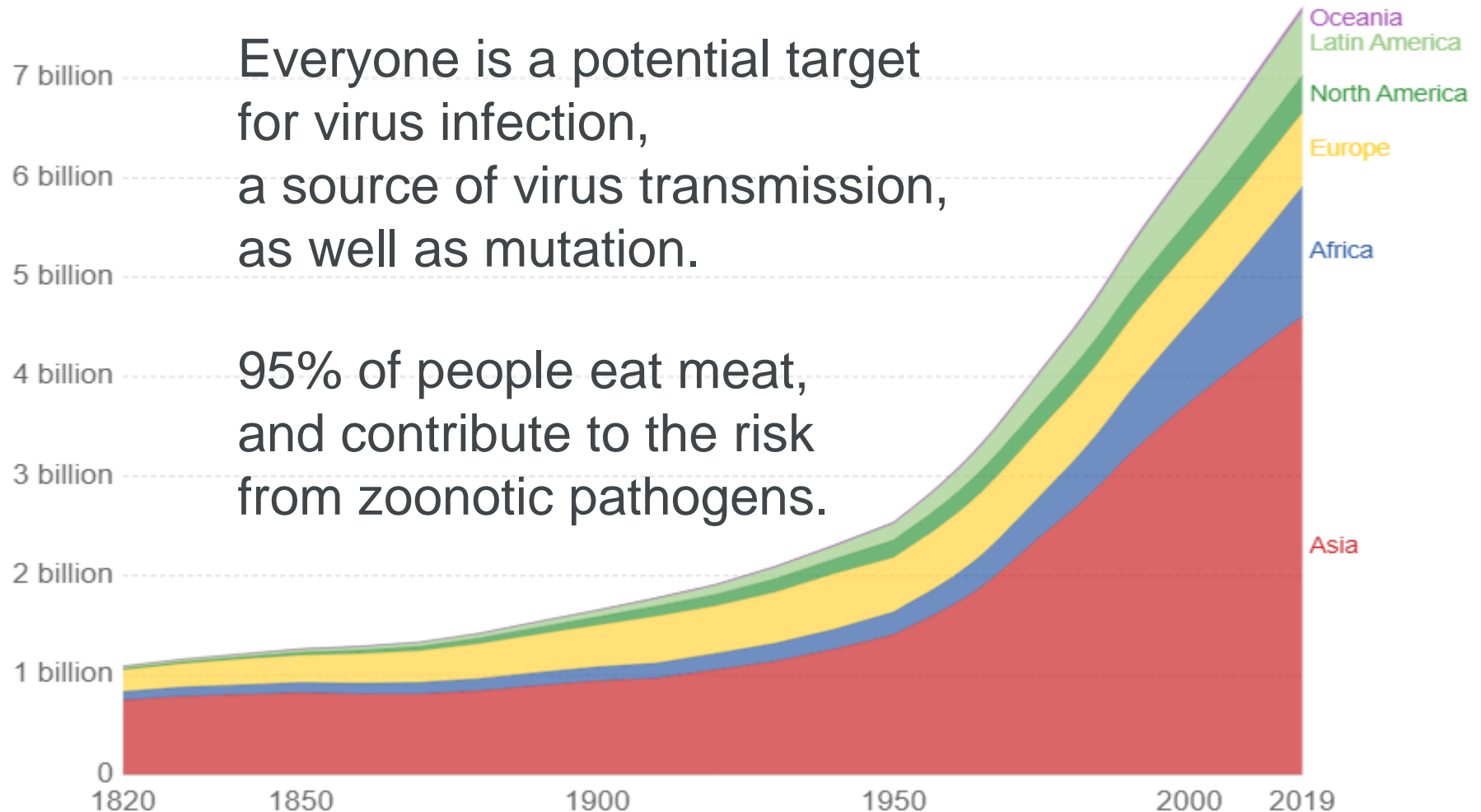
Number of Emerging Infectious Diseases (EID) per decade



# Rapid rise in world population since 1950

## World population by region

Our World  
in Data



Source: HYDE (2016) & UN (2019)

OurWorldInData.org/world-population-growth/ • CC BY

# Ecological harm as a cause of pandemics



Controlling deforestation (shown here, in a tropical rainforest in the Congo Basin) could decrease the risk of future pandemics, experts say.

## WHY DEFORESTATION AND EXTINCTIONS MAKE PANDEMICS MORE LIKELY

Nature: August 2020

Researchers are redoubling efforts to understand links between biodiversity and emerging diseases – and to use that information to predict and stop future outbreaks.

The ecological context of the COVID-19 pandemic is progressive global environmental harm caused by:

Human encroachment on wildlife habitats

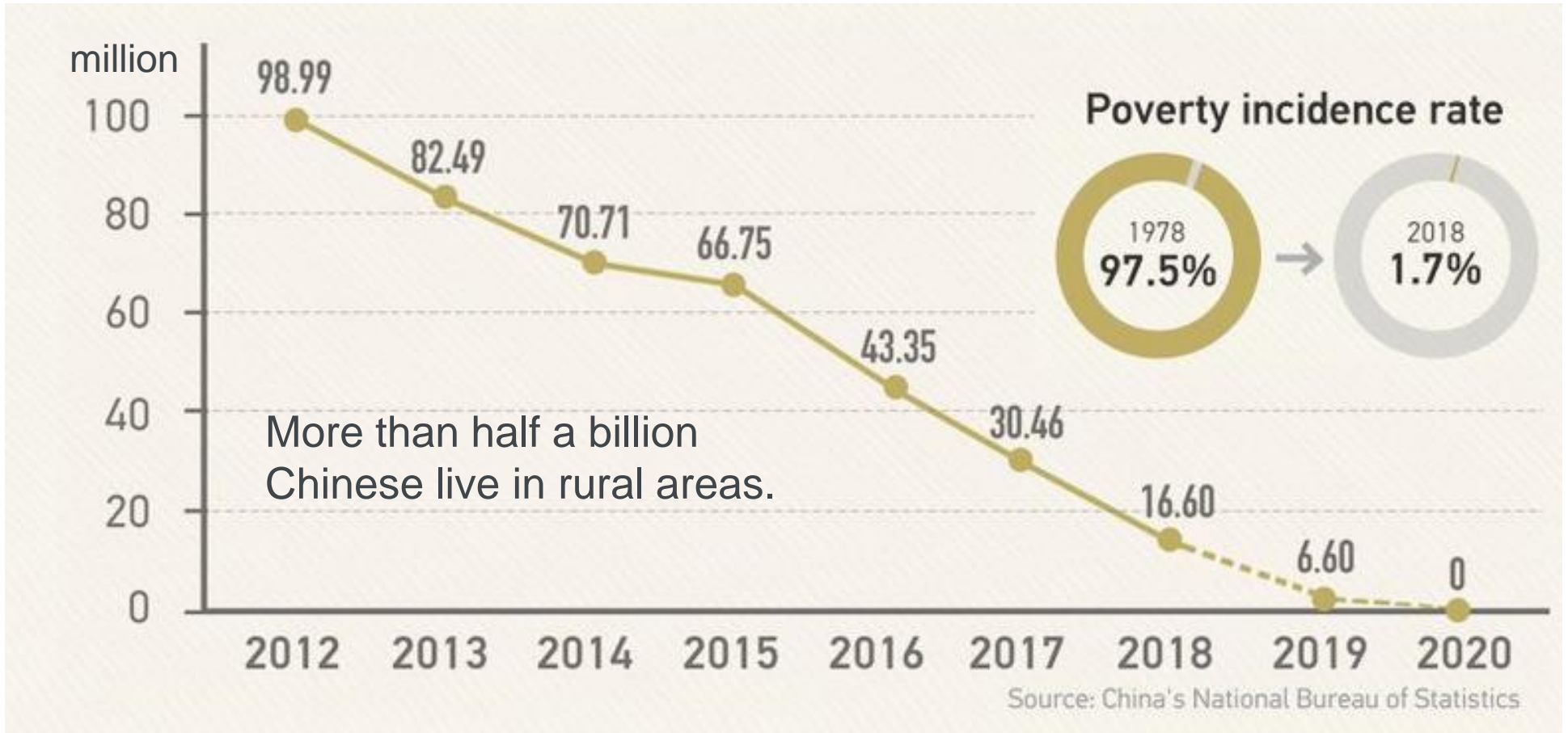
Deforestation

Intensive animal farming

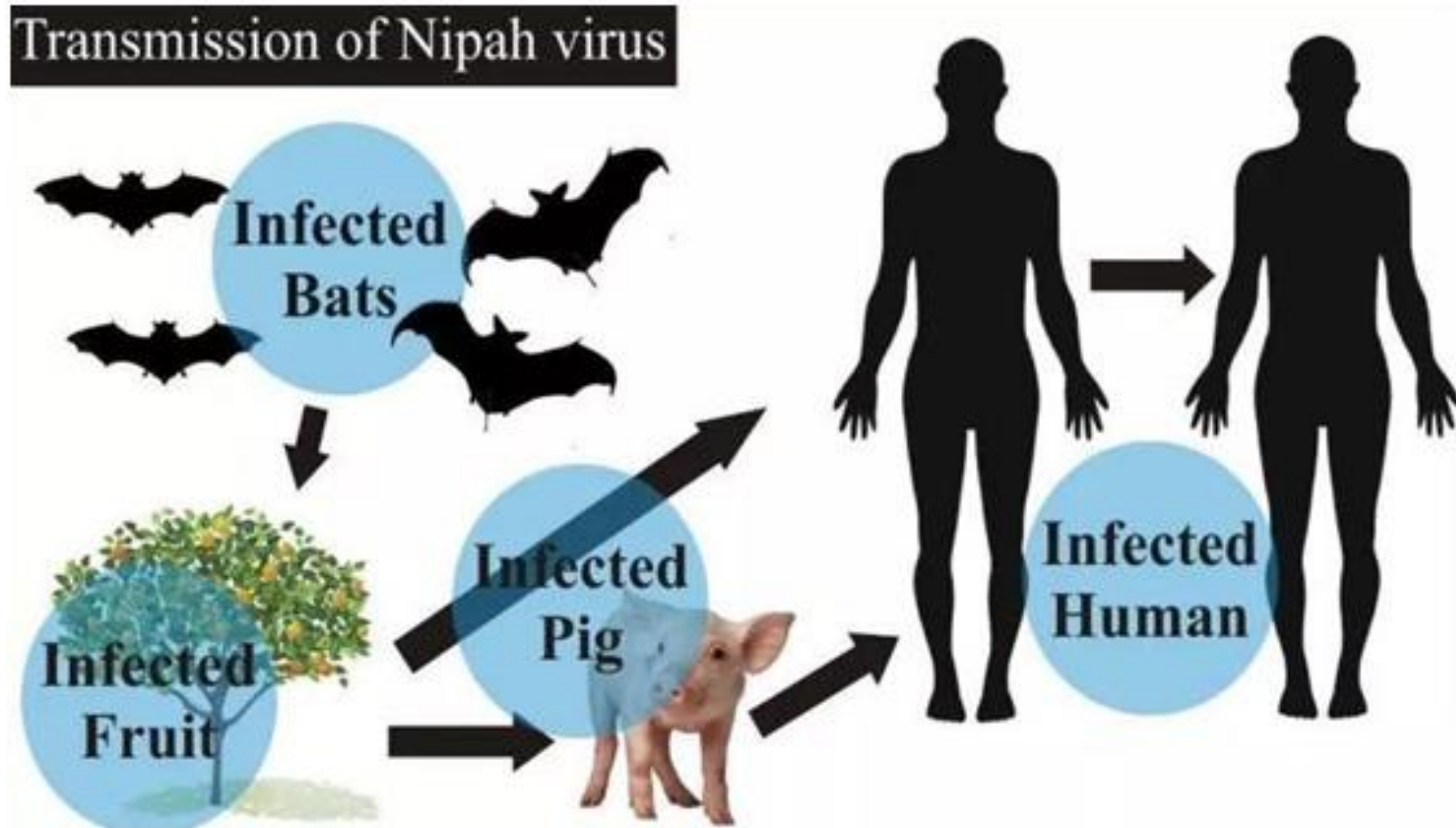
# Forty years of agricultural expansion in China

- **1981:** Deng Xiaoping reformed agricultural production in China, encouraging wildlife farming.
- **1996:** A domestic goose is found to have the highly pathogenic H5N1 virus. (95% of the world's geese are now supplied by China).
- **2003:** Wildlife markets were banned due to SARS, but reopened after three months.
- **2013:** H7N9 found in ducks in Zhejiang province, where duck-fish farming expanded greatly.
- **2017:** Wildlife trade is valued at \$77 billion, and employed 14 million.
- **2020:** Wildlife trade is banned again after SARS-CoV-2, but there are loop-holes in the law.

# Reduction in rural poverty in China



# Nipah virus transmission via bats and pigs



Nipah emerged in the late 1990s in Malaysia in the aftermath of slashing and burning forest to create pig farms.

# Bats harbouring dangerous coronaviruses



Global changes in the mode and intensity of land use are creating expanding interfaces between people, livestock and wildlife reservoirs of zoonotic disease.

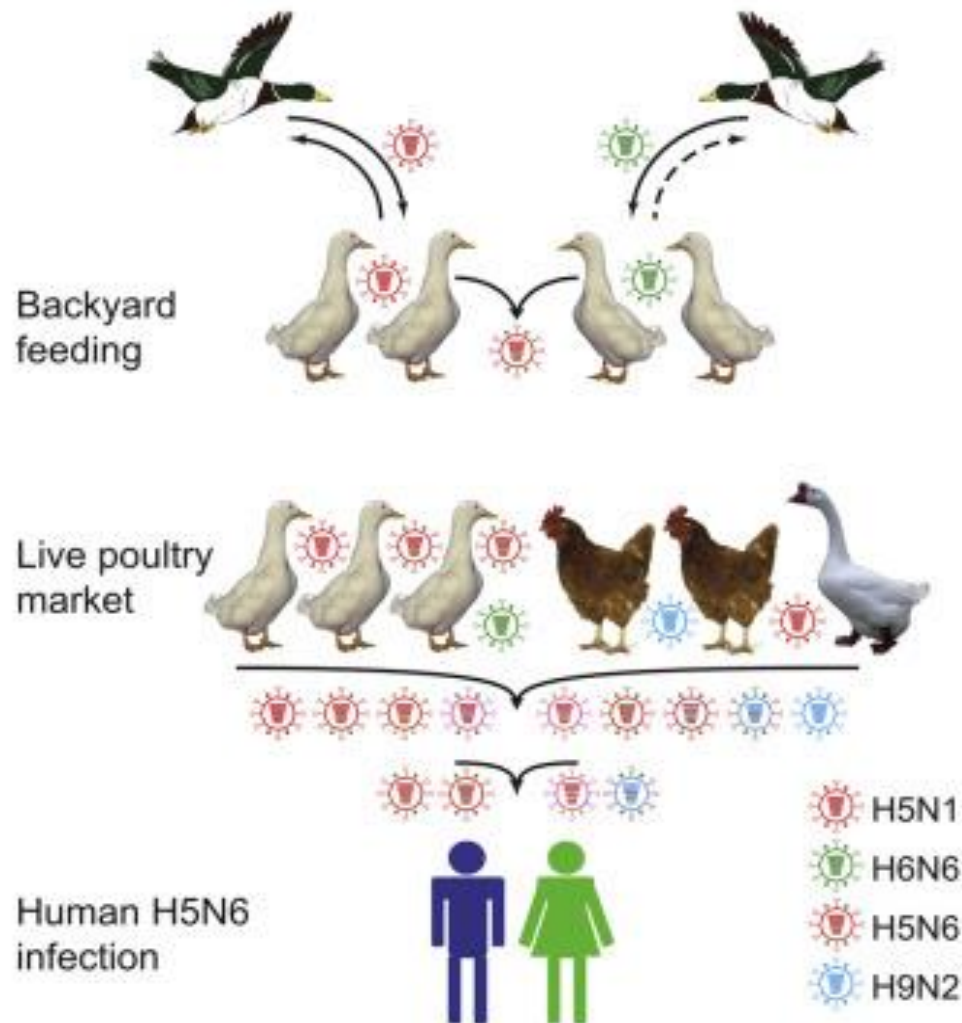
Bats in caves in the southwest Yunnan province have numerous SARS-like coronaviruses.



# Commercialising Yunnan province



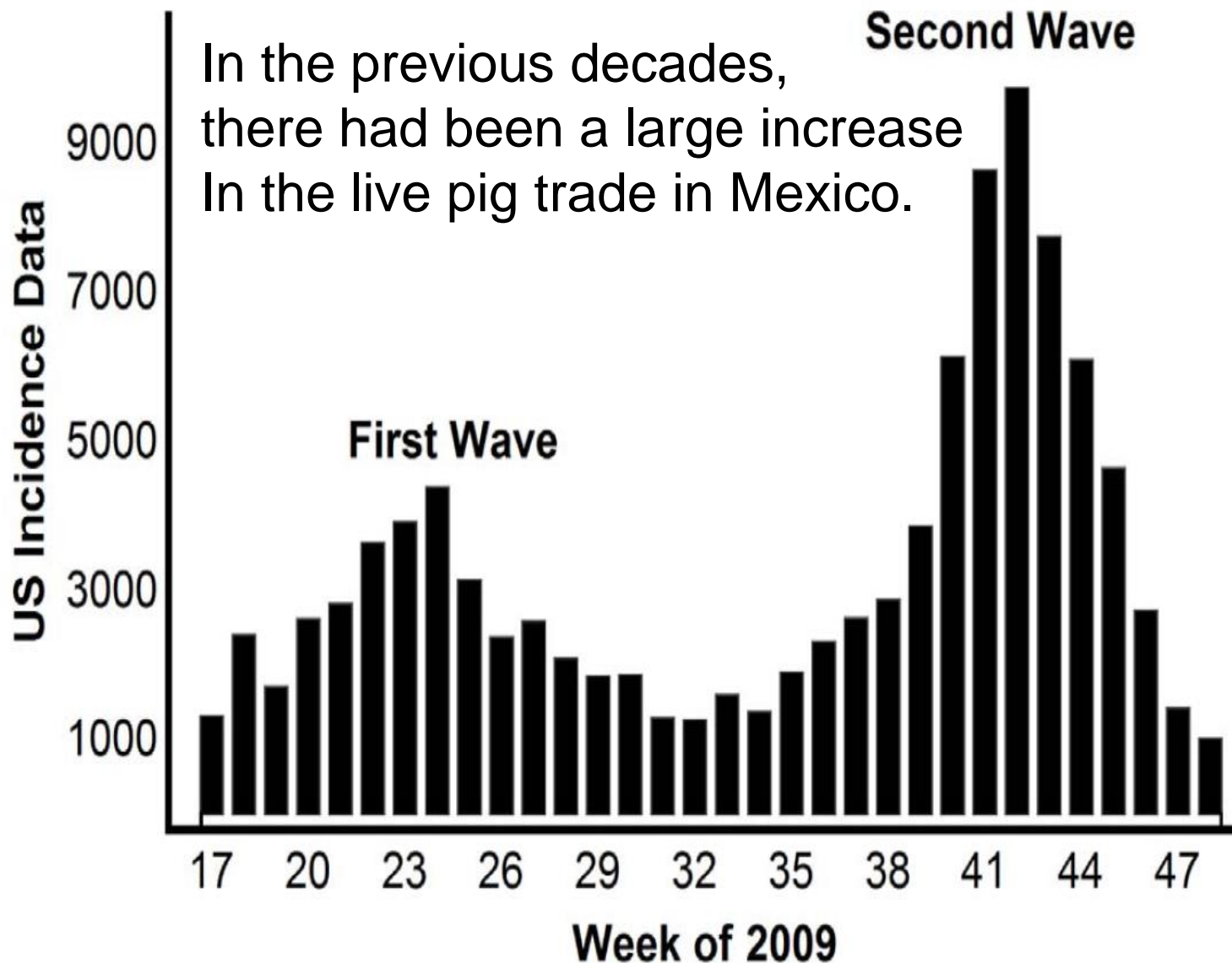
# Avian flu spillover pathogens from poultry



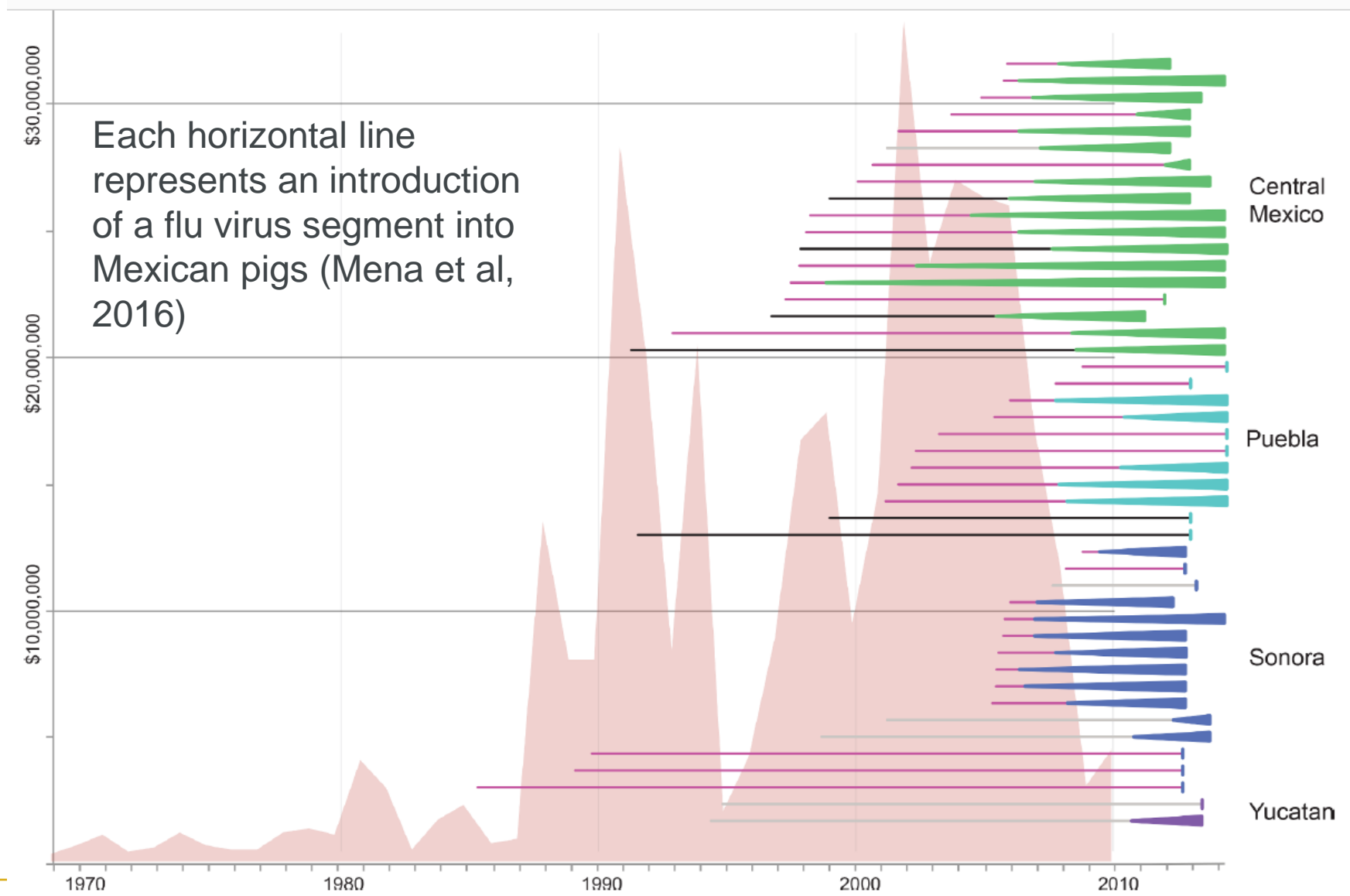
Southeast Asia's poultry production expanded over a decade from 5.9 million tons to 9.2 million tons in 2018.

Half of poultry in Southeast Asia are raised in backyards of small farmers, who keep less than a hundred chickens, geese, ducks or turkeys.

# Two waves of the 2009 swine flu pandemic



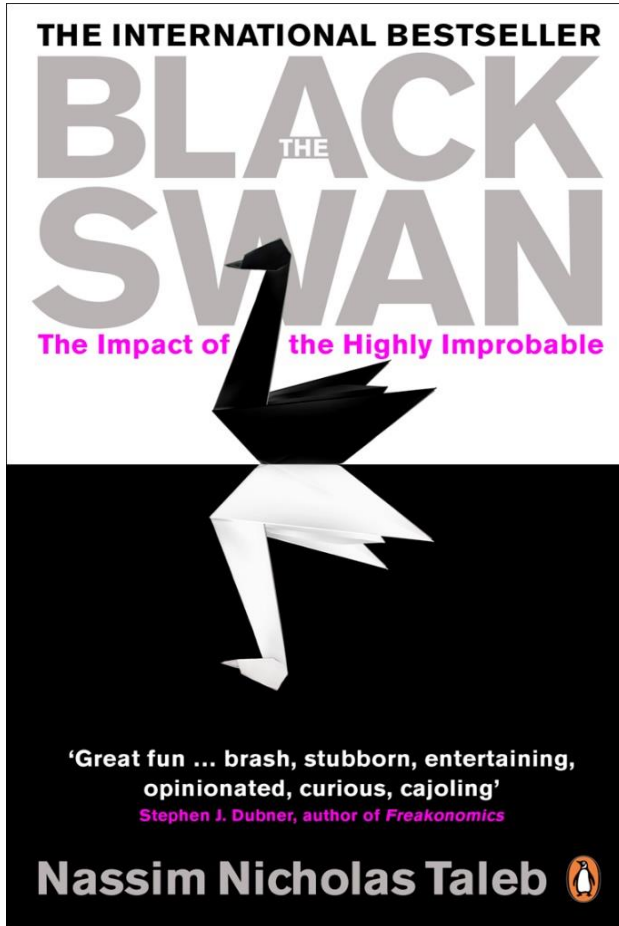
# Value of pig imports into Mexico before 2009



# Outcome and anchoring cognitive biases from recent mild UK pandemic experience

Date	Name of Flu	Strain	UK Case Fatality Rate
1889-1890	Russian	H3N8	0.5%
<b>1918-1919</b>	<b>Spanish</b>	<b>H1N1</b>	<b>2.3%</b>
1957-1958	Asian	H2N2	0.3%
1968-1969	Hong Kong	H3N2	0.5%
2009-2010	Mexican	H1N1	0.03%

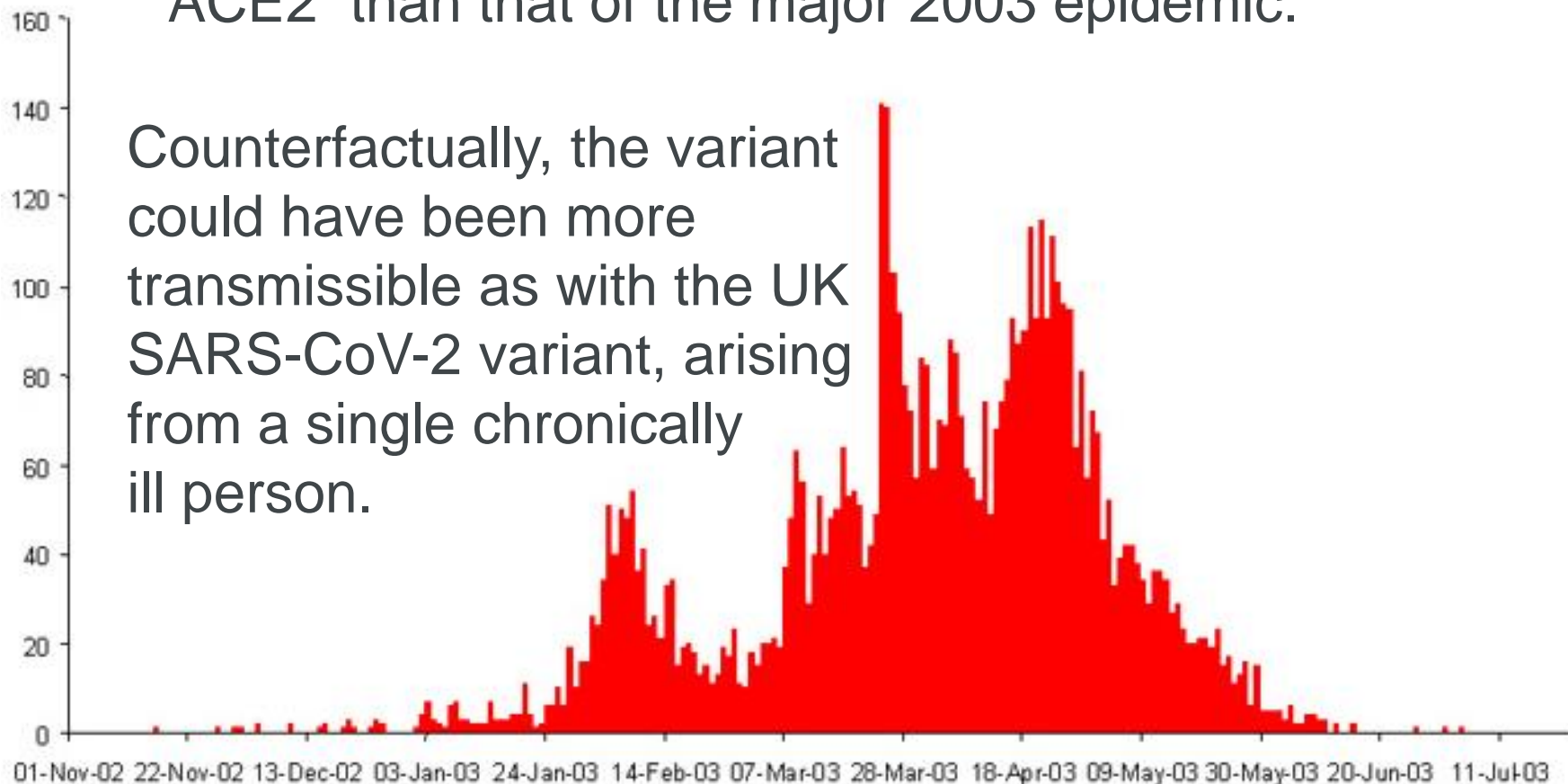
# Counterfactual pandemic risk analysis



# More transmissible variant of SARS

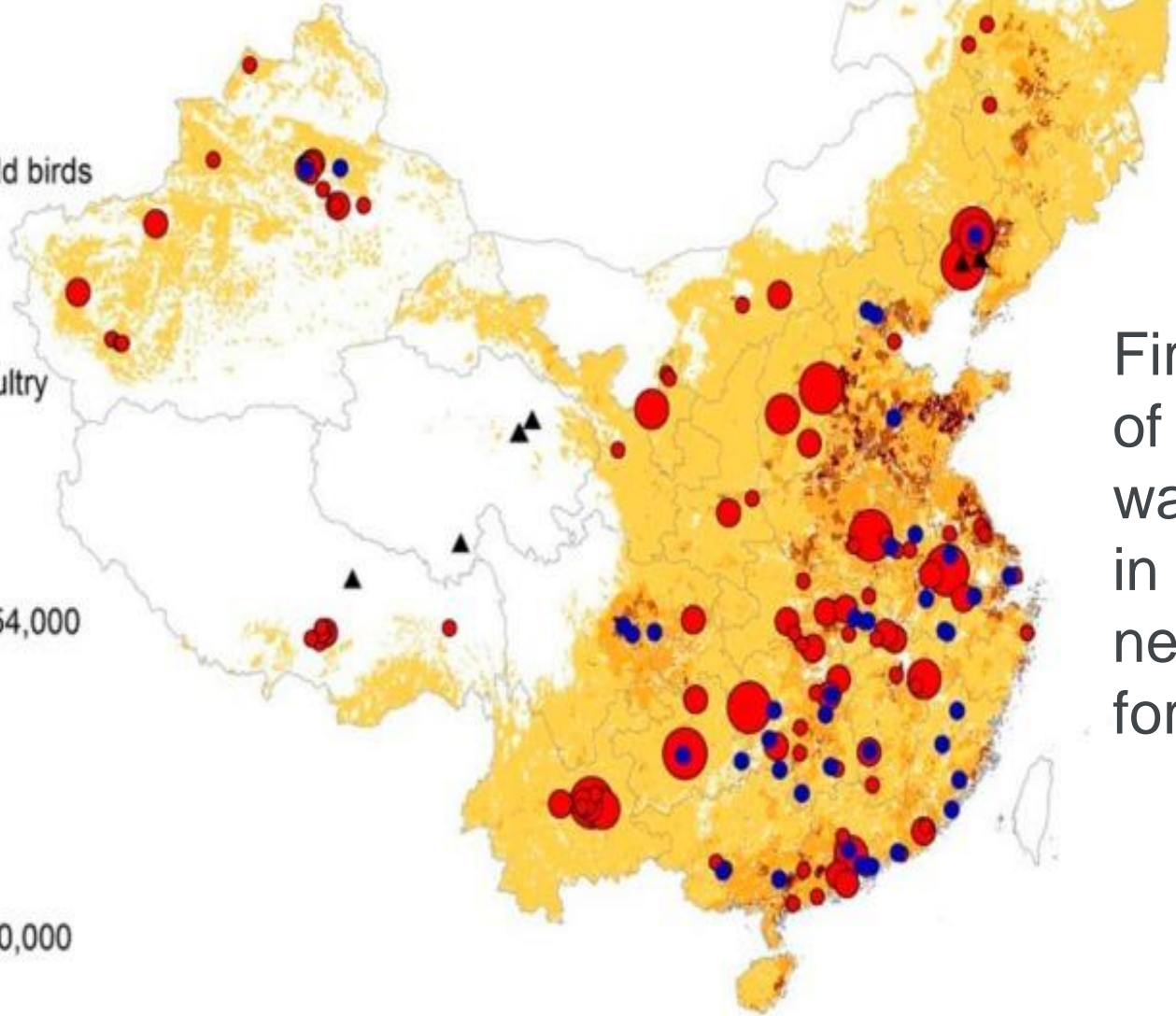
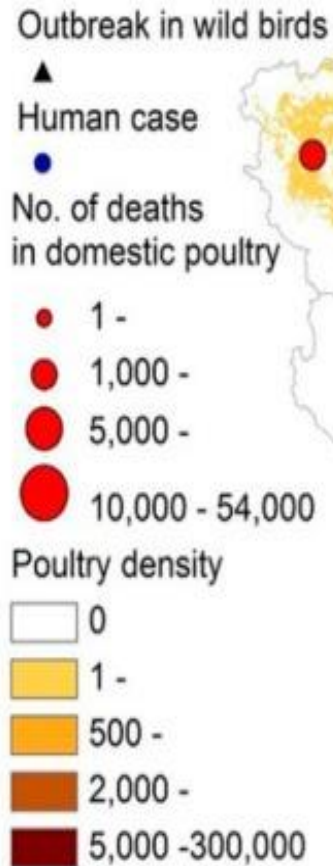
After the epidemic was over in July 2003, a second event occurred in late **2003** to early **2004**, resulting in the re-emergence of four human cases in China. The new virus had a much lower affinity for binding to the human receptor ACE2 than that of the major 2003 epidemic.

Counterfactually, the variant could have been more transmissible as with the UK SARS-CoV-2 variant, arising from a single chronically ill person.



# H5N1 avian flu outbreak in China

A



First human case of H5N1 in China was diagnosed in 2003, after negative test for SARS.



# Counterfactual avian flu H5N1 scenario: 2006

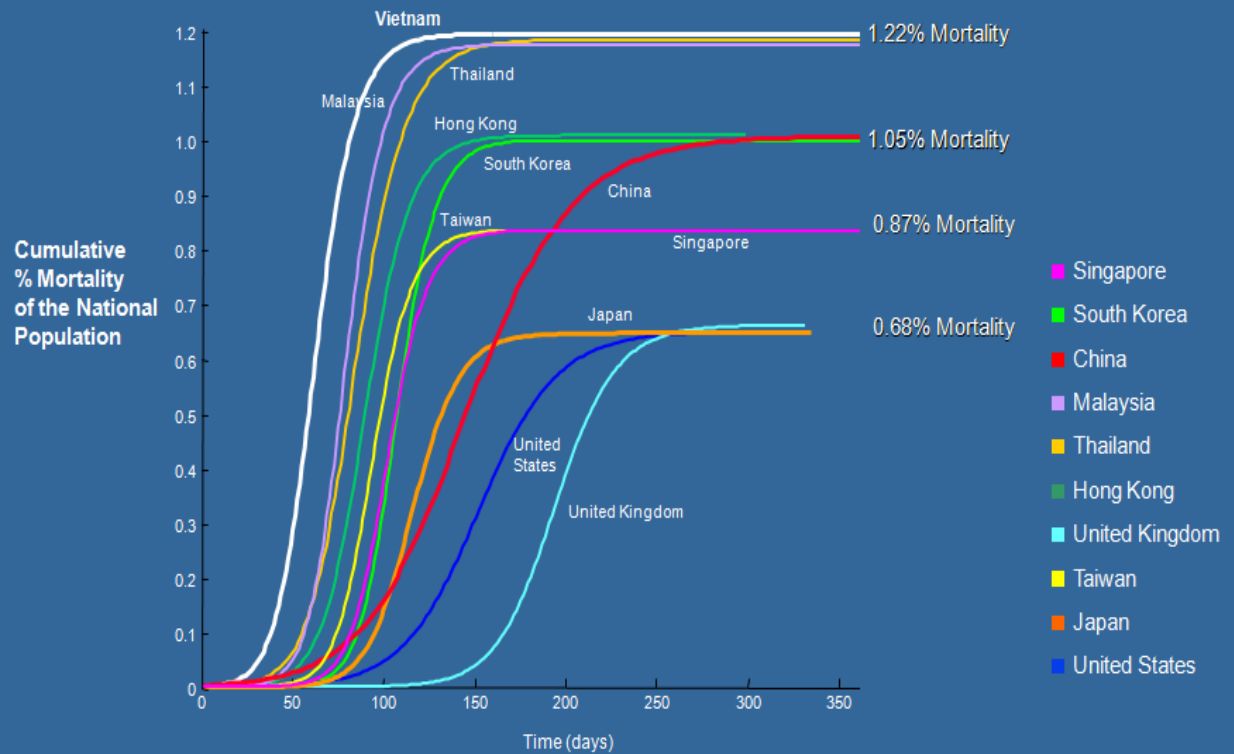
A reassortment of the H5N1 avian flu virus within a human infected with seasonal flu might have resulted in a global pandemic killing millions.



## Country Mortality Rates in Hanoi Flu Pandemic

S-I-R Modeling of infection spread

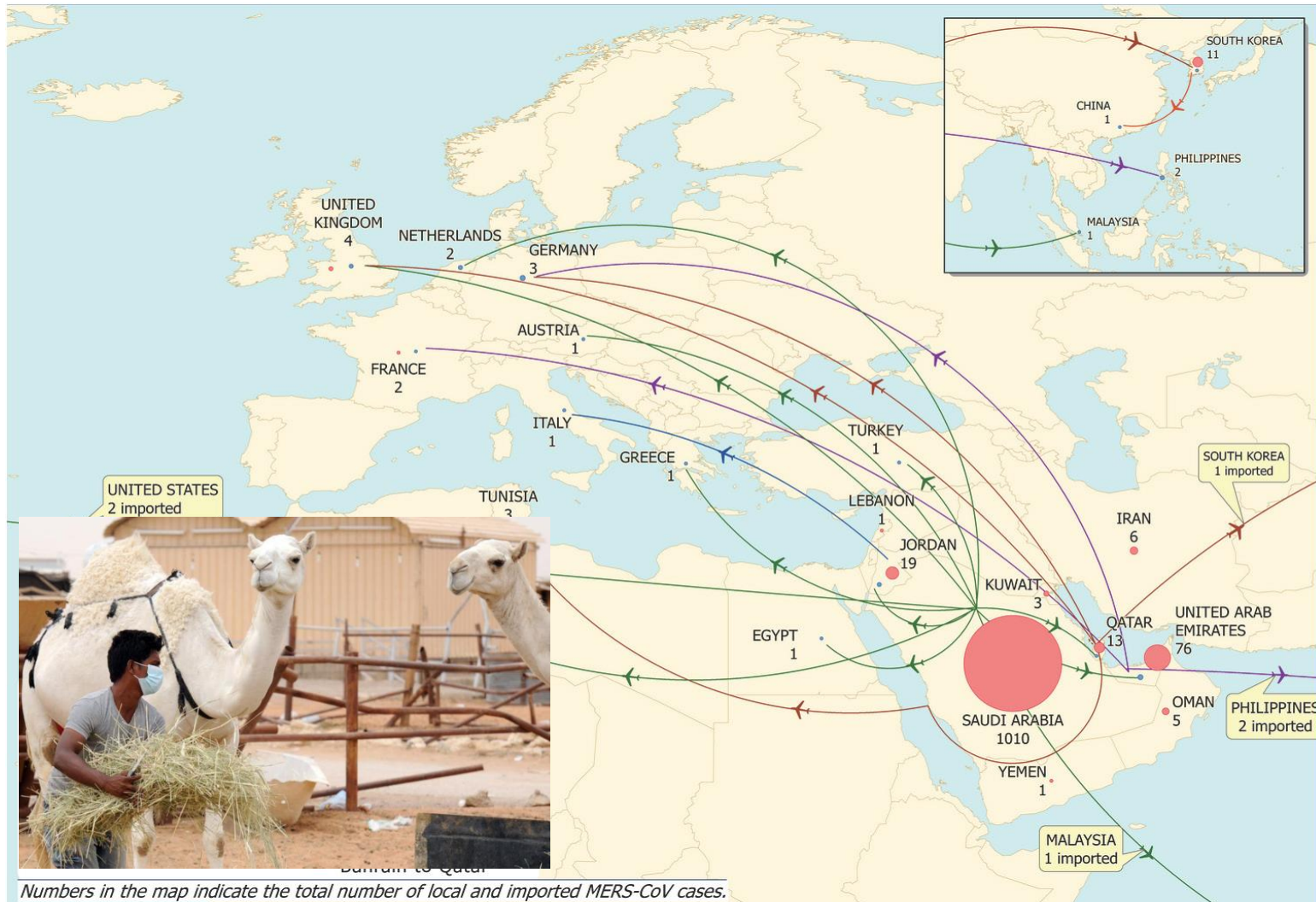
Illustrative



# Middle East Respiratory Syndrome (MERS) : 2012

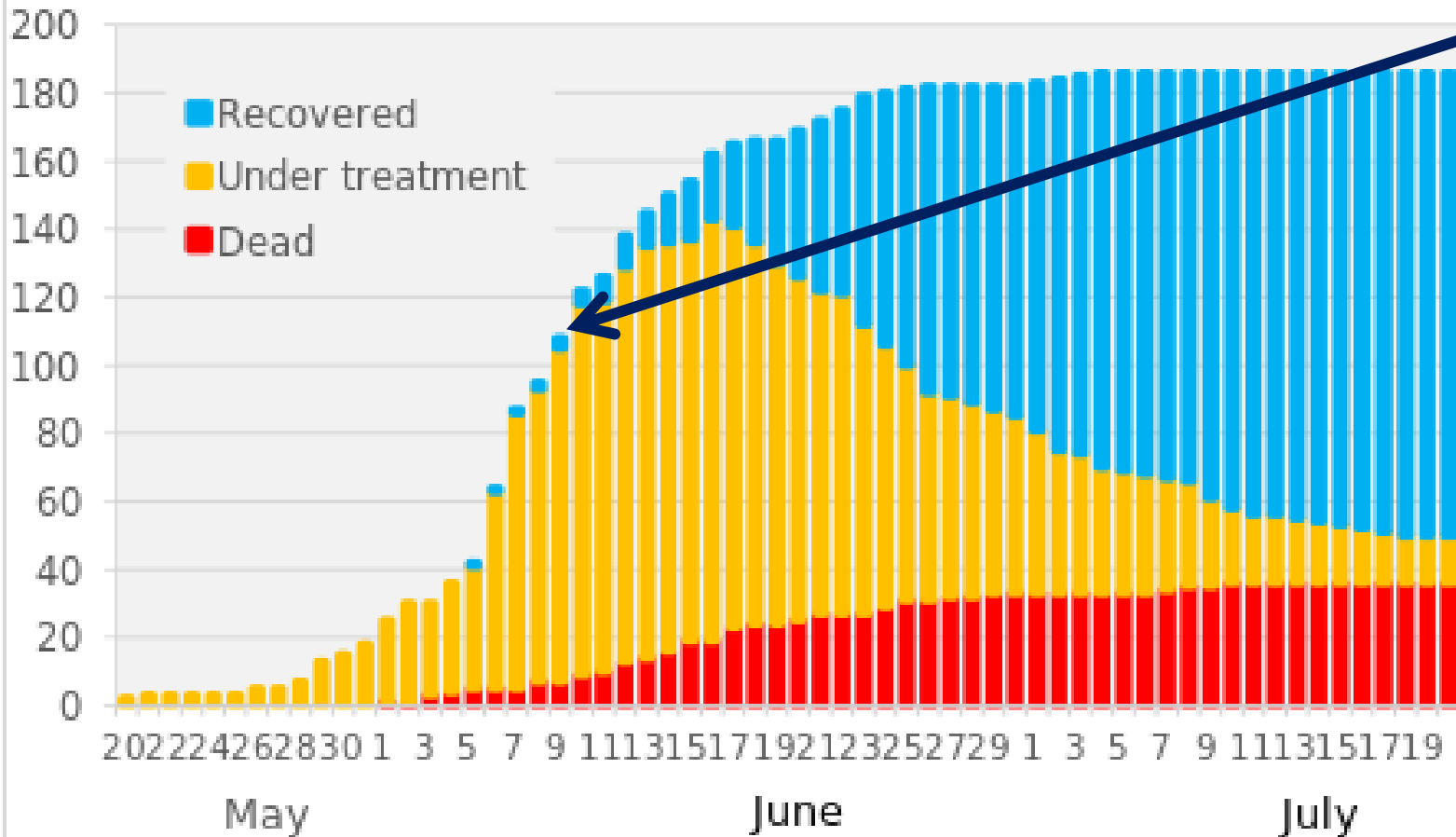
Since the 1960s, the urban population in Saudi Arabia has risen from about 20% to 85%,

and the camel population has increased an order of magnitude from 80,000 to 800,000.



# MERS outbreak in South Korea 2015

## 2015 MERS Cases in South Korea



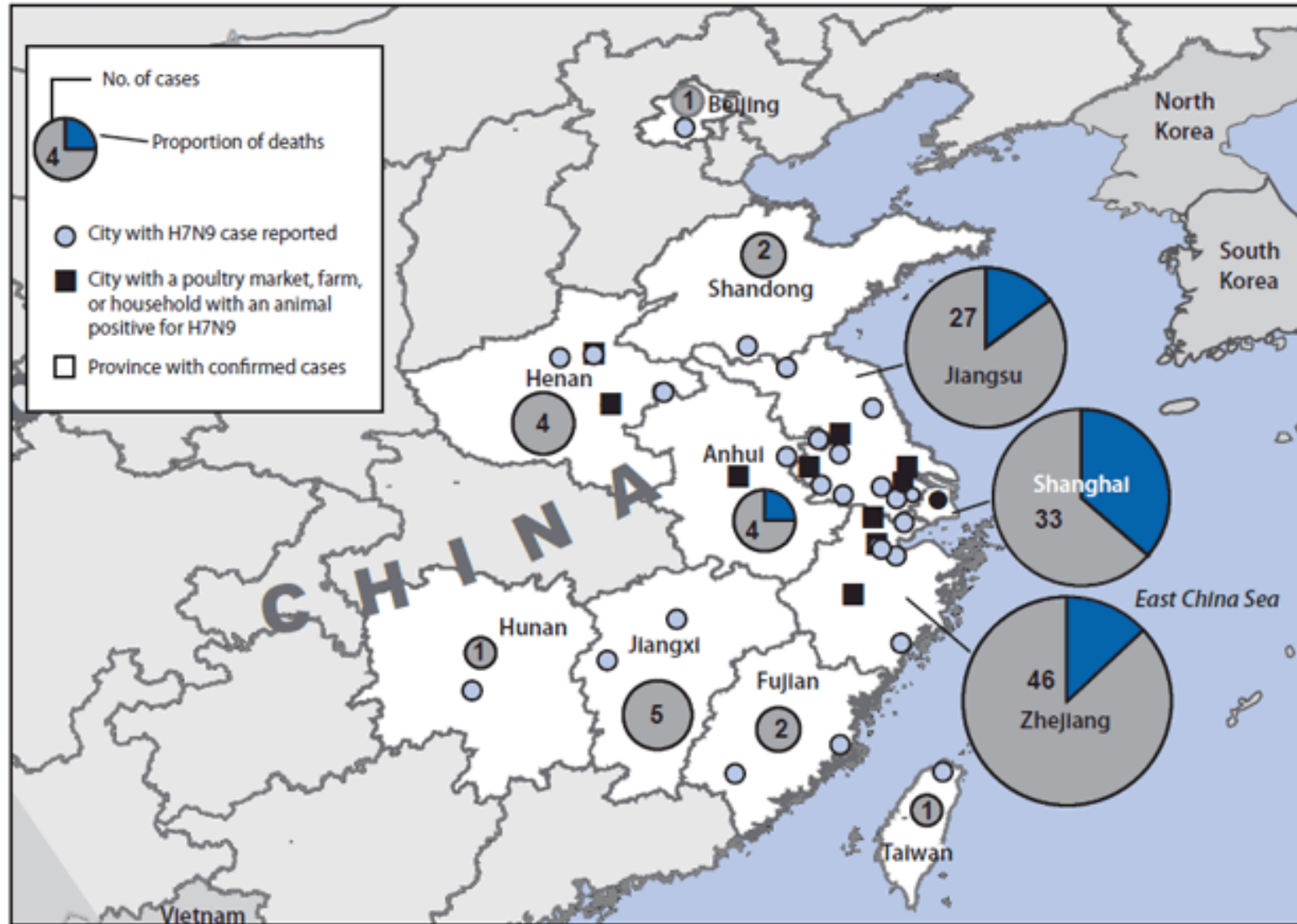
More MERS super-spreaders might have caused the outbreak in South Korea to spread out of control.

# H7N9 avian flu outbreak in China in 2013

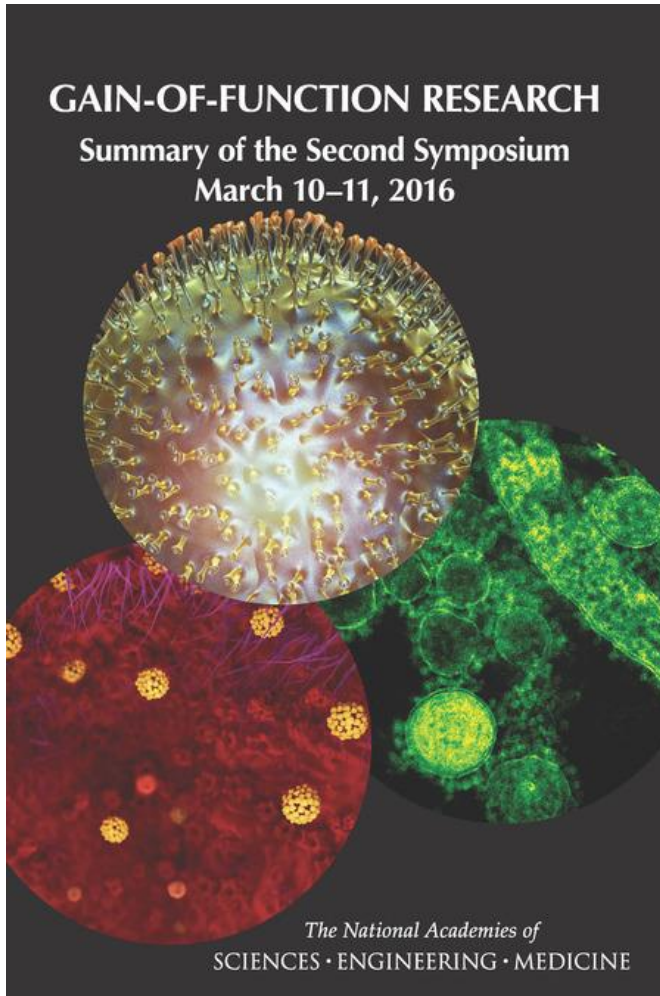
H7N9 was discovered in China in March 2013.

CDC rated H7N9 as having the greatest pandemic potential.

Most cases reported recent exposure to live poultry, or markets where live birds were sold.



# Gain-of-function research on more transmissible H7N9



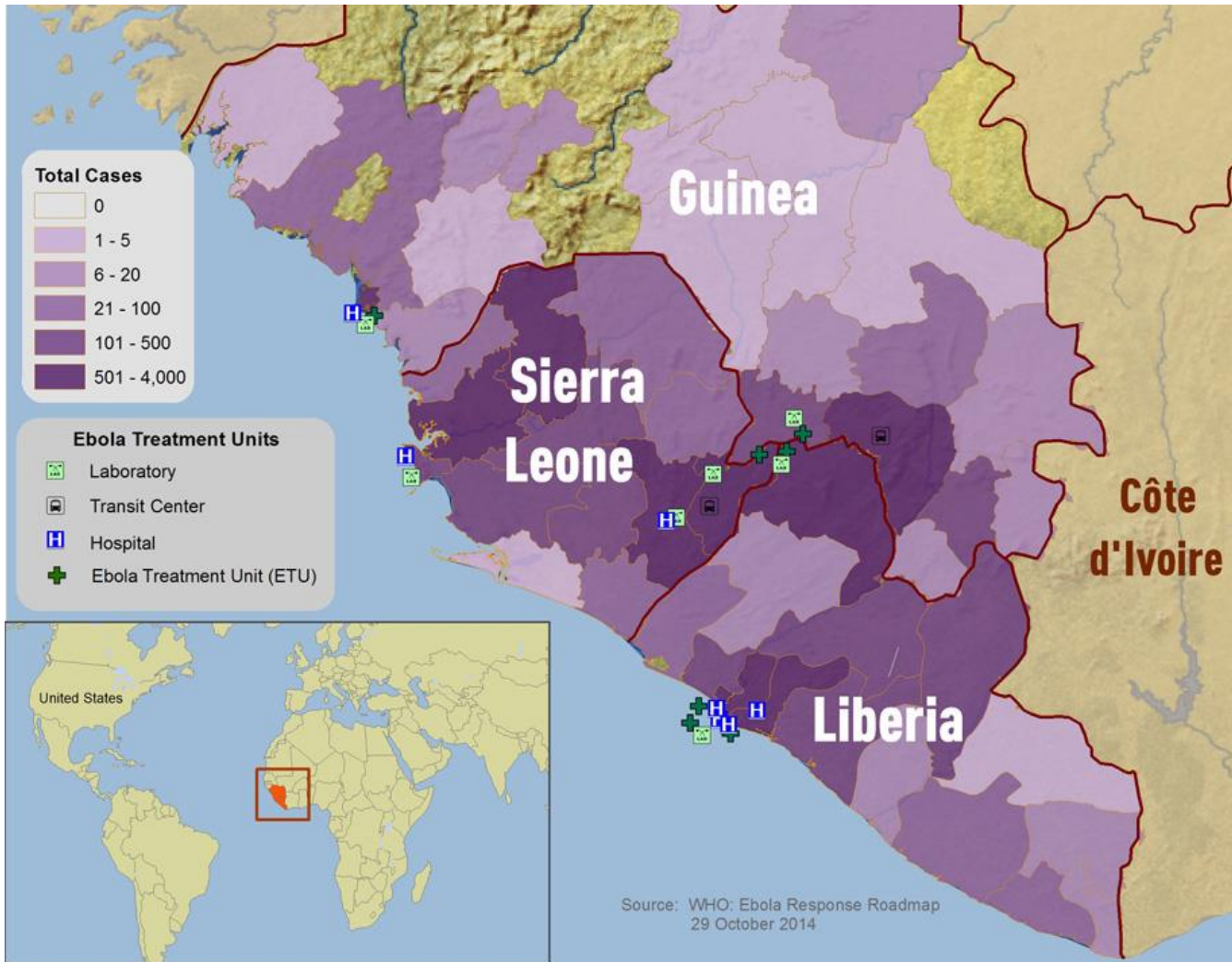
H7N9 was deemed to pose a bigger pandemic threat than H5N1, because it can easily affect human lung tissues, and has a limited ability to spread by airborne droplets.

Gain-of-function research addresses genetic changes which might alter virulence and transmissibility.



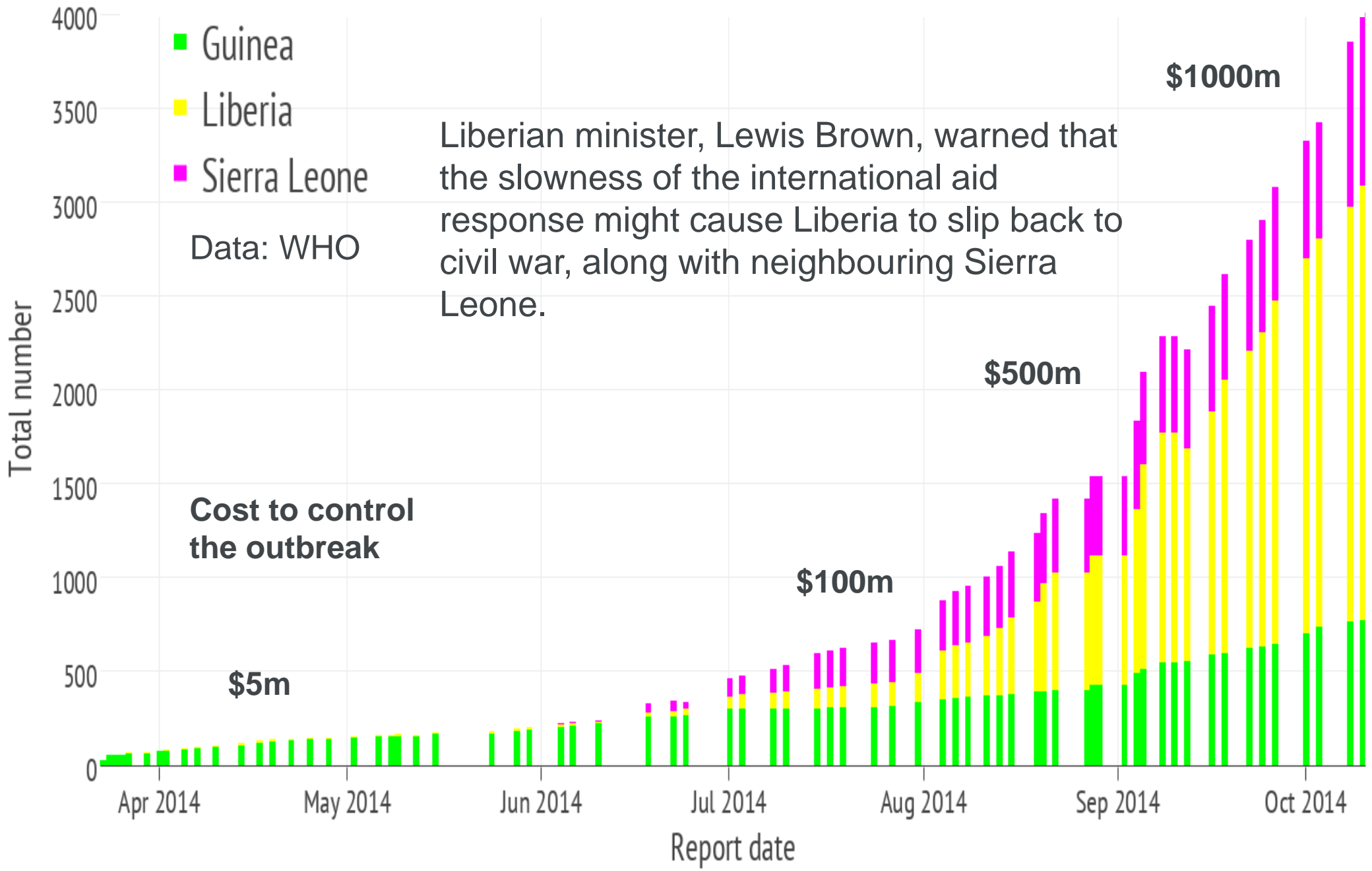
Ron Fouchier

# Ebola outbreak in West Africa 2014



The Ebola outbreak began in December 2013, with a 2 year old child, Emile, playing in a bat-infected tree in region subject to extreme deforestation, caused by mining and lumber operations.

# Ebola death count: April to October 2014



# Ebola and civil conflict: a perfect storm



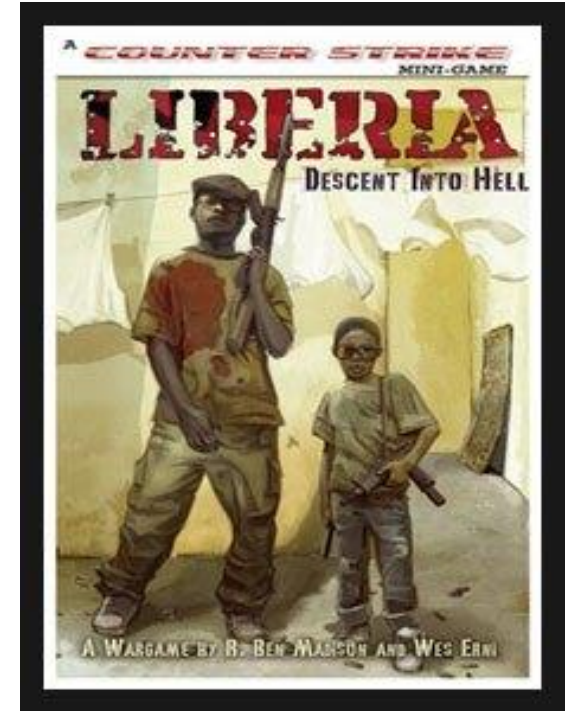
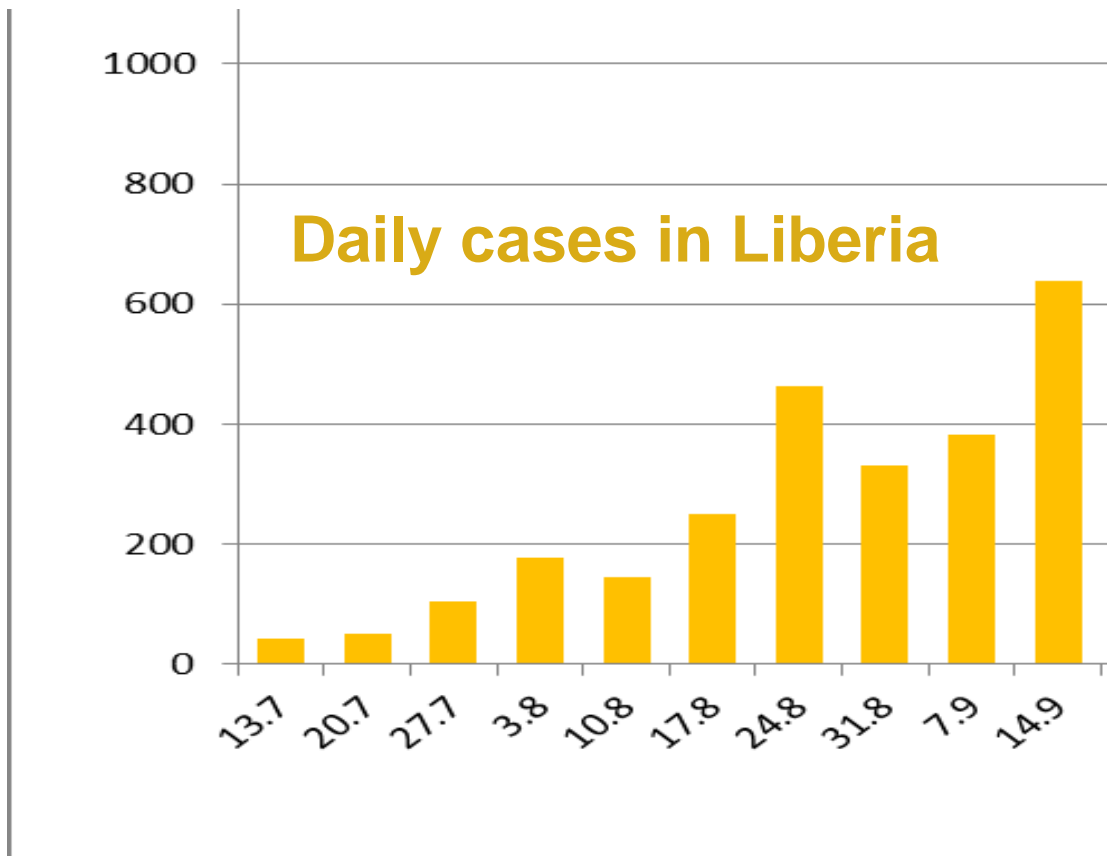
Chronic conflict in the DRC province of Kivu obstructed attempts to control an outbreak of Ebola in 2018.

Ebola response team vehicle attacked and burned



# Ebola outbreak in Liberia in 2014

Exponential growth in deaths might have triggered national civil disorder and conflict: a potential tipping point for international pandemic spread.



# WHO warning of ‘The Big One’

*‘The pandemic has been very severe. It has spread around the world extremely quickly, and has affected every corner of the planet. But this is not necessarily the big one.*

*This virus is very transmissible. But its current case fatality is reasonably low in comparison to other emerging diseases. This is a wake-up call.’*

Dr. Mike Ryan, executive director  
WHO emergencies program,

28 December 2020



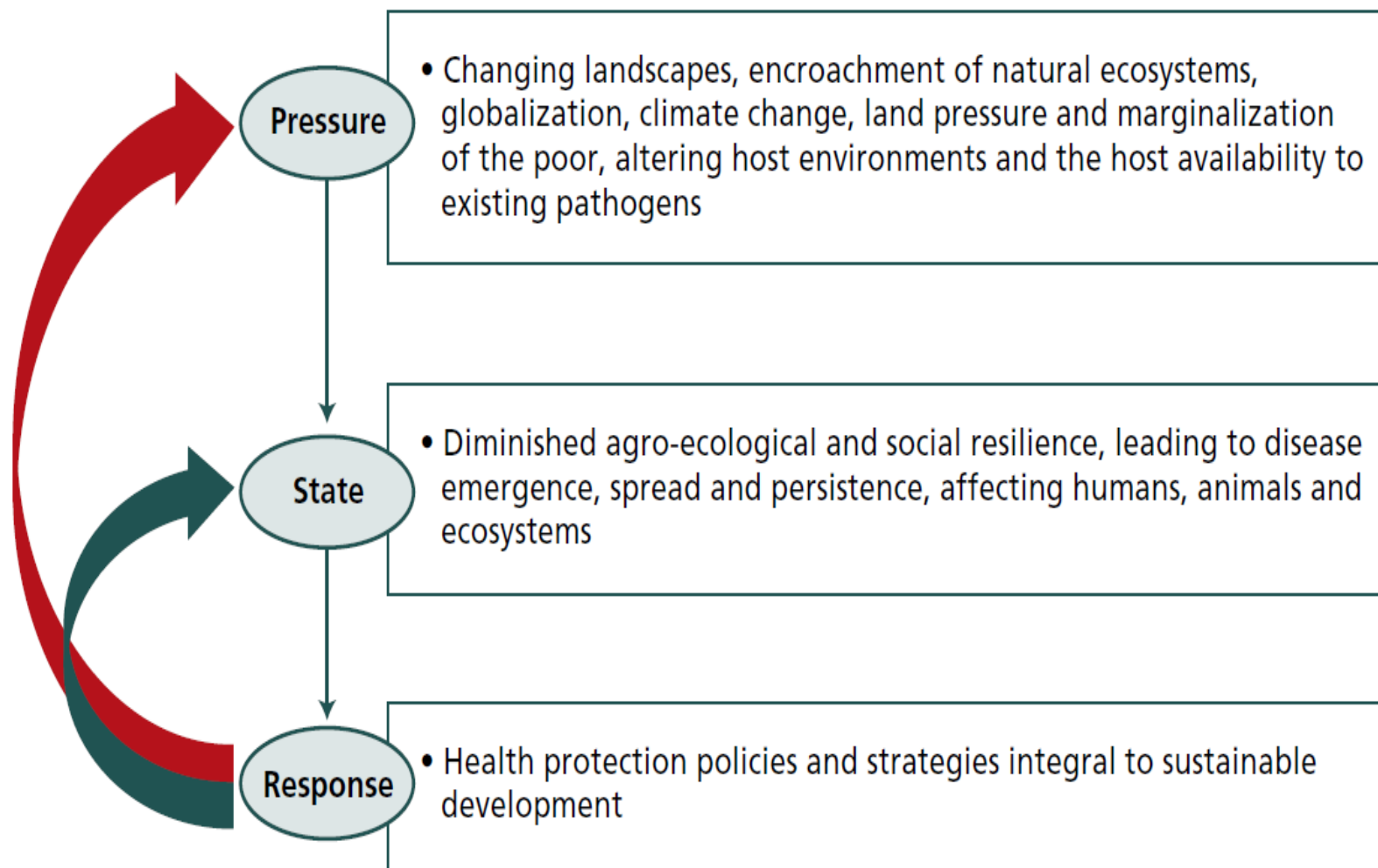
# Near-miss 21st century pandemic catastrophes

Emerging Contagion	Case Fatality Rate	Downward Counterfactual	Chance
<b>2003: SARS</b>	1 in 10	More Transmissible Mutation	1% to 5%
<b>2005: H5N1</b>	6 in 10	More Transmissible Mutation	1% to 5%
<b>2012: MERS</b>	3 in 10	More Transmissible Mutation	1% to 5%
<b>2013: H7N9</b>	3 in 10	Gain-of-Function Research	1% to 2%
<b>2014: Ebola</b>	4 in 10	Civil disorder triggered by Epidemic	1% to 3%

The aggregate chance of a major global pandemic disaster (aka The Big One) over the past 20 years has been in the range of 5% to 20%. This is equivalent to an annual return period of 100 to 400 years.

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# OECD framework for managing ecological risk



# Protecting humanity against another pandemic

**The G7 plan initiated under UK presidency in 2021 covers:**

- Global research into dangerous pathogens;
- Development of the manufacturing capacity of treatment and vaccines;
- Design of a global pandemic early warning system;
- Establishment of protocols for pandemic emergency response;
- Cancellation of tariffs on critical supplies such as protective equipment.

# Stabilising pandemic risk in the 21st century

- As with climate change, there needs to be international collaborative effort to combat ecological change.
- Major investment is needed in pandemic preparedness: pathogen surveillance, diagnostic testing, effective contact tracing, and electronic systems for ensuring isolation and quarantine compliance.
- Plug-and-play on demand vaccine technology can be both safe and effective, and provides encouraging evidence that a strong rapid response could be mounted against latter waves of a future pandemic.

# Beyond the 1918-1919 influenza and COVID-19 pandemics

- The great 1918-1919 influenza pandemic, and COVID-19 are broadly similar in basic reproduction number and case fatality rate.
- In the 1918-1919 pandemic, there were 230,000 UK deaths, most of which were in the second wave, associated with virus mutation. Scaling this up to the 2020 UK population, this would be equivalent to about 400,000 deaths. A national lockdown response would follow as with COVID-19 when a projection of 500,000 deaths was forecast.
- In December 2020, WHO warned that the case fatality rate of 2% to 3% of the 1918-1919 influenza pandemic or COVID-19 is reasonably low compared with 'The Big One'.

# 'The Big One' facing life insurers

- The occurrence of 'The Big One' with a higher case fatality rate than either 1918-1919 pandemic or COVID-19 , would most likely swamp NHS capacity, even with tough lockdown measures.
- With the global ecological changes of recent decades, the most relevant historical reference frame for 'Big One' risk analysis is not past centuries, but rather the first two decades of the 21st century.
- During this time, there were five near-miss 'Big One' events, each of which was precipitated by adverse ecological change.
- The counterfactual analysis presented here indicates a return period for 'The Big One' of between 100 and 400 years, which includes the standard return period for insurance Probable Maximum Loss.



# Historical reference frame for 'The Big One'



The Church of the Holy Sepulchre in Jerusalem was last closed in 1349 during the Black Death.

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# Questions



# Comments

Expressions of individual views by members of the Institute and Faculty of Actuaries and its staff are encouraged.

The views expressed in this presentation are those of the presenter.