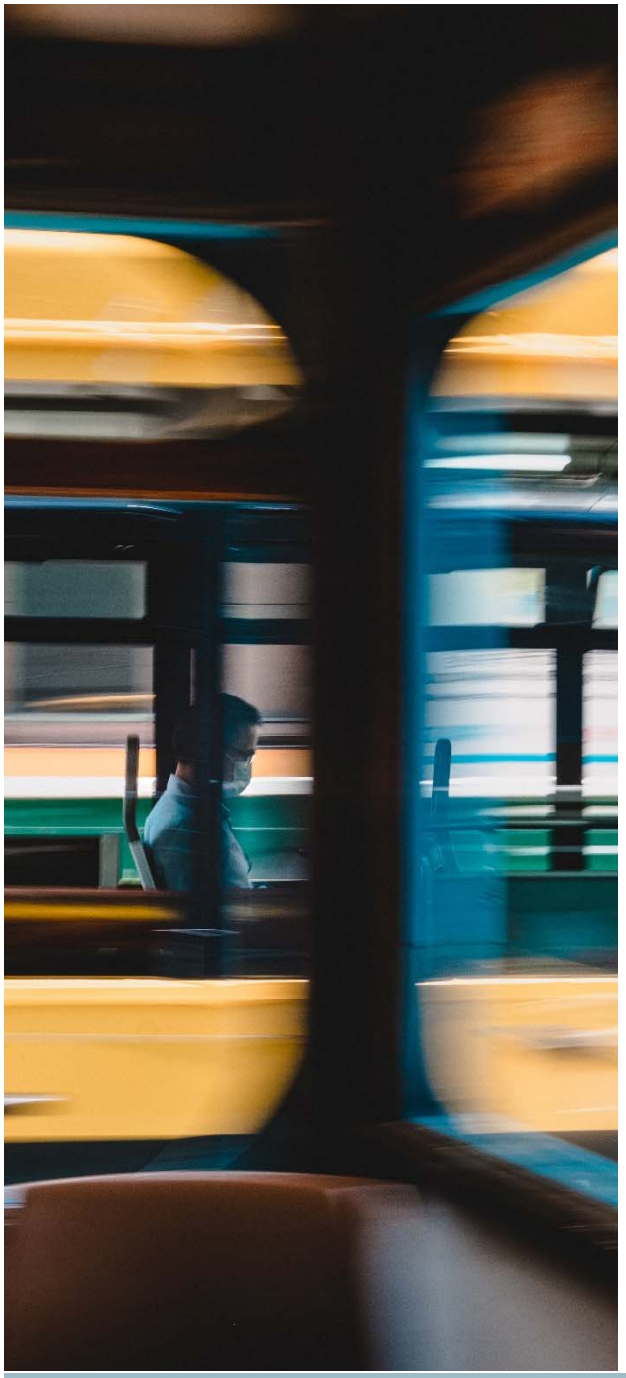
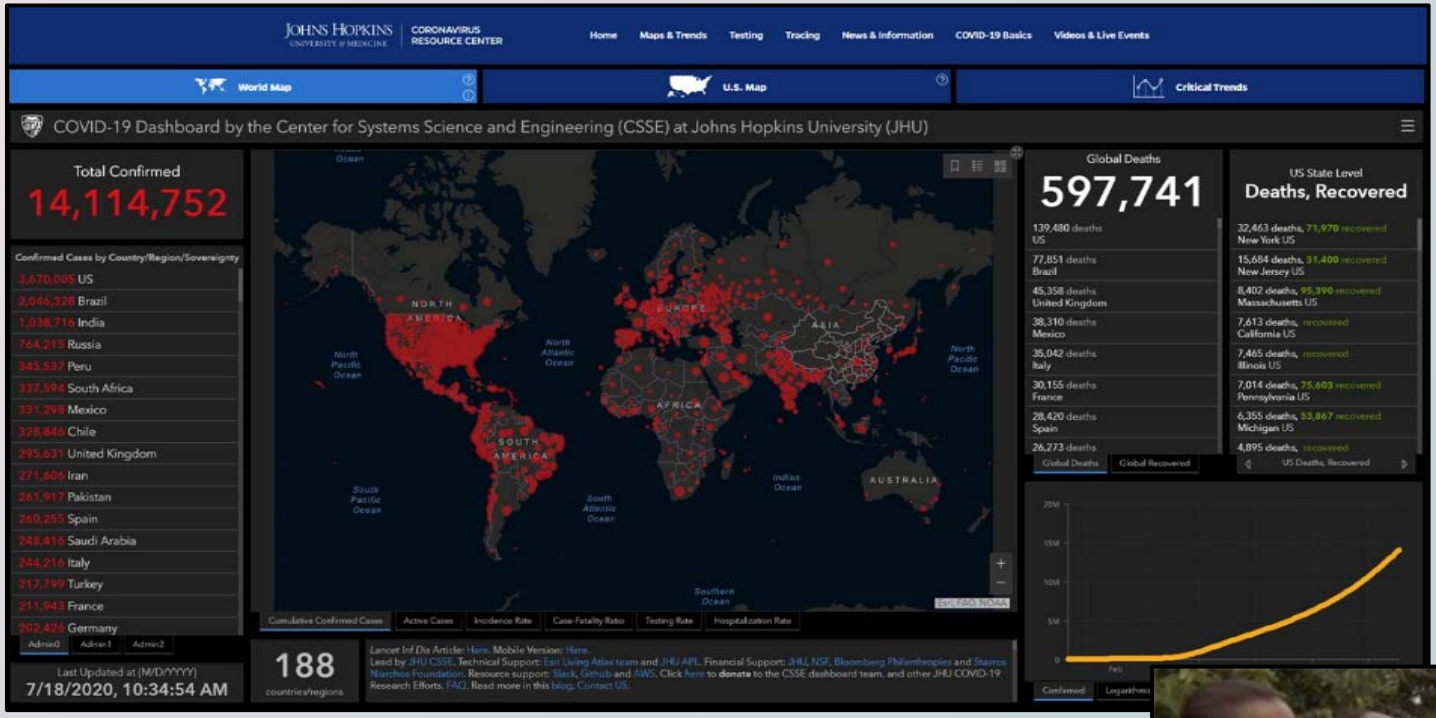


COVID-19: COLORADO & BEYOND

A FREE SUMMER LECTURE SERIES PRESENTED BY THE CU DENVER COLLEGE OF LIBERAL ARTS AND SCIENCES

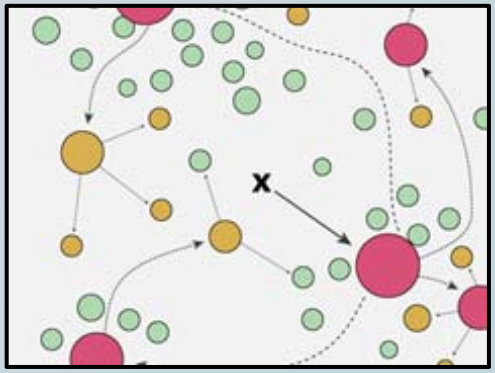
Mon. June 8	The COVID-19 Epidemic: Epidemiology, Models, and Policy
Mon. June 15	How to Avoid Misinterpreting Data About an Epidemic
Wed. June 17	Pandemics in History
Mon. June 22	Asian Americans as the Yellow Peril: From Coolie Competition to the COVID-19 Pandemic
Mon. June 29	Tradeoffs Between Contagion Protection and the Economy
Mon. July 6	The Ecology and Biology of Coronavirus
Mon. July 13	Outbreaks, Carriers, and Patient Zero: How Language Shapes our Understanding of Pandemic
Wed. July 15	Psychosocial Well-being During a Pandemic
Mon. July 20	Geographic Perspectives on Emerging Infectious Disease, Global Pandemics, and COVID-19
Wed. July 22	A Critical Medical Anthropological Perspective on COVID-19 Transmission and Response
Mon. July 27	The Mathematics and Statistics of COVID-19
Mon. August 3	In This Together: Herd Immunity, Vaccines, and Individual Choices

Geographic Perspectives on Emerging Infectious Disease, Global Pandemics, and COVID-19



Source: https://coronavirus.jhu.edu/map.html

Source: *CDC Image Archive*



Source: Anthamatten and Hazen 2011

Source: *Rx for Survival*

What is a "Geographic Perspective"?

In geography, we try to answer some questions about places:

Where are things?

Why are things where they are?

Why do we care?

"Geography is the science of place and space, examining the characteristics and distribution of physical, natural, and human systems across the surface of the Earth, along with how people interact with the environment. Geographers provide meaningful solutions to modern challenges faced by societies."

The Geography of Health

The **geography of health**, sometimes called **medical geography**, uses the tools and approaches of geography to tackle health-related questions.

Geographers focus on the importance of variations across space, with an emphasis on concepts such as location, direction, and place.

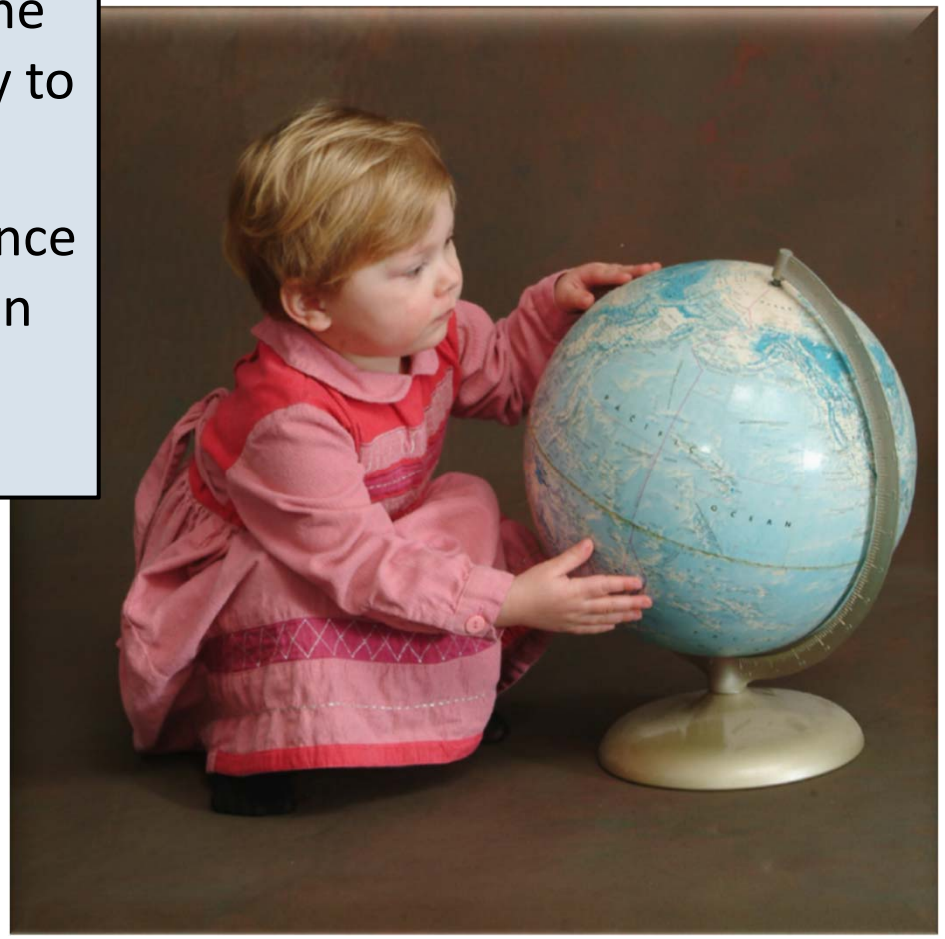
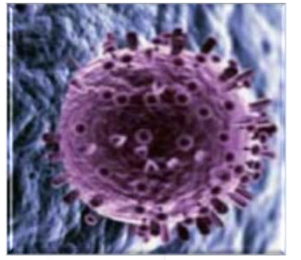
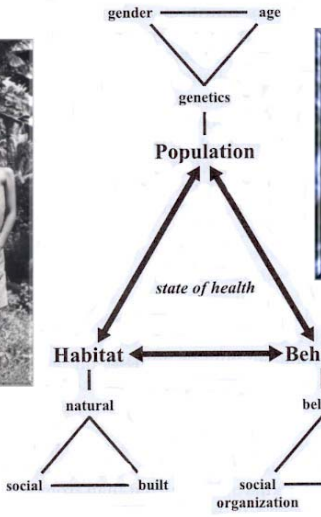


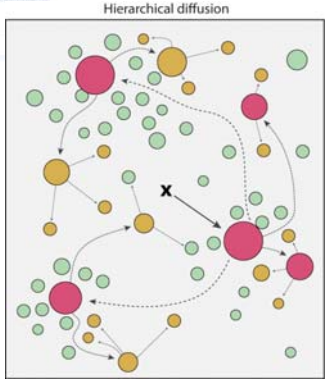
Photo by Peter Anthamatten

Some geographic research questions about pandemics

- What explains the **origin** of pandemics?
- What **environmental risk factors** contribute to risk of the emergence of pandemics?
- What **social and political factors** contribute to this risk?
- How can we use this knowledge to develop **environmental policies** that mitigate the risk for pandemics?

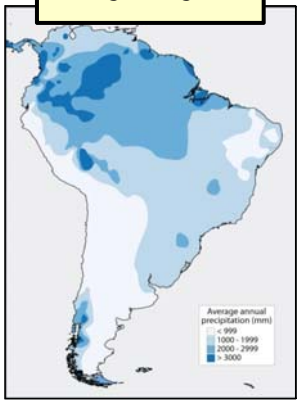






Elevation

Rainfall



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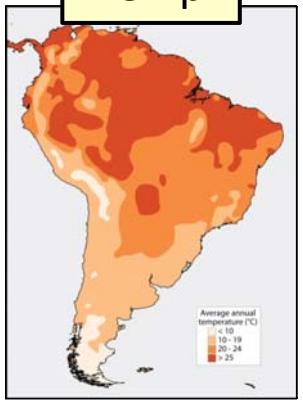
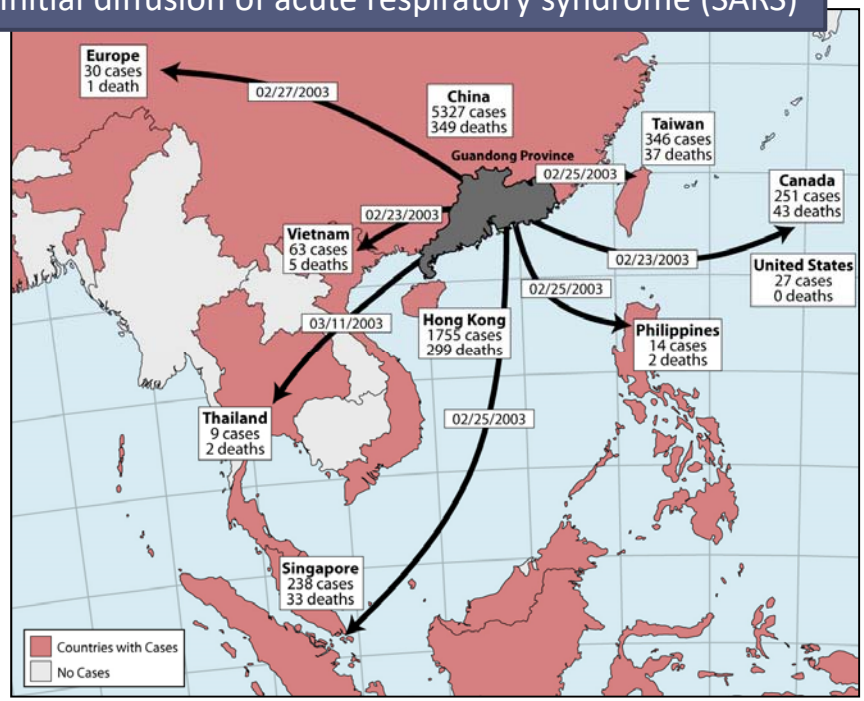


Emerging and Resurging Infectious Disease

Infectious disease continue to be responsible for more than one-third of deaths worldwide.

Additionally, a large number of new infectious diseases have emerged since the 1940s.

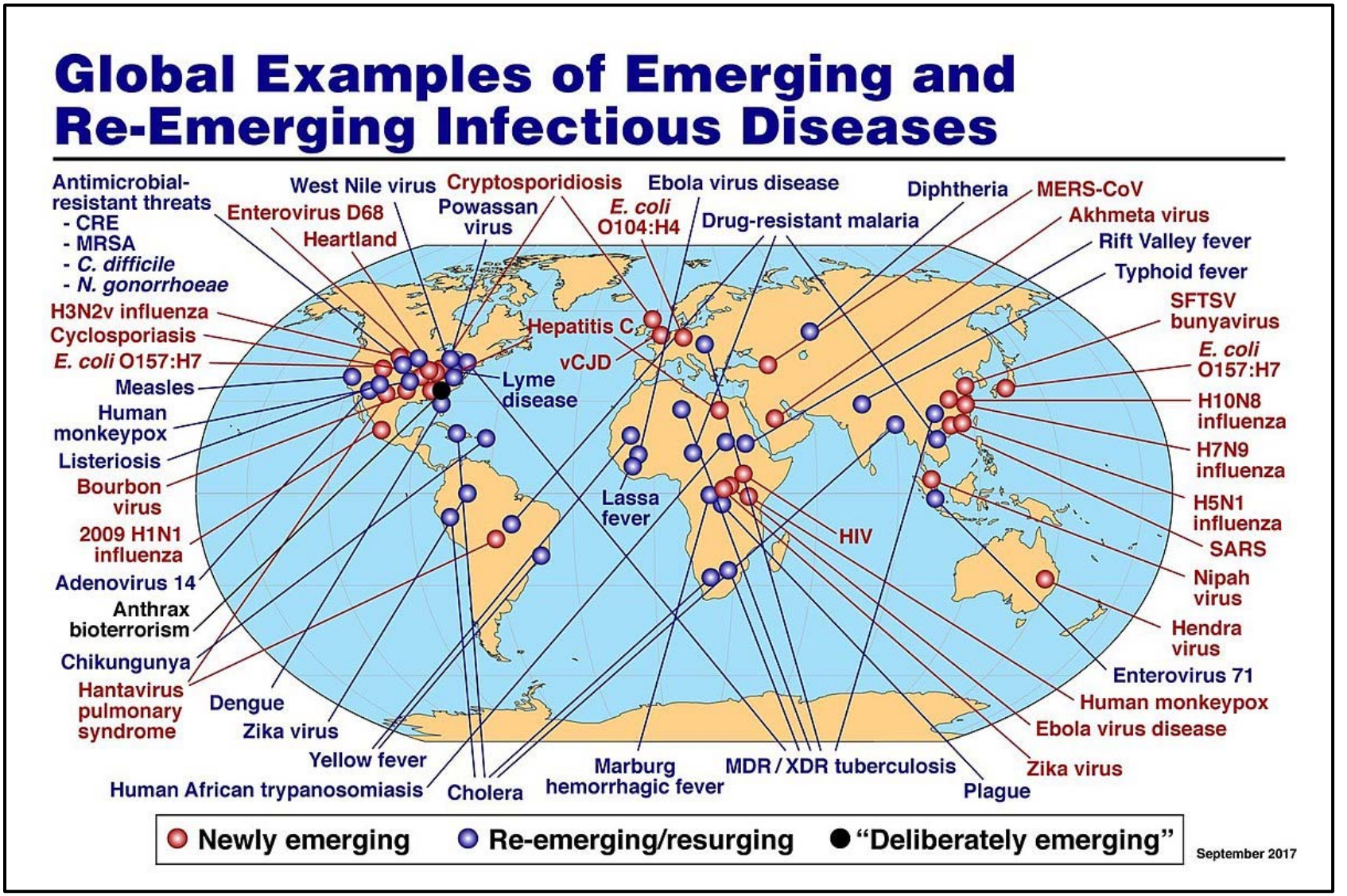
Initial diffusion of acute respiratory syndrome (SARS)



Source: Anthamatten and Hazen 2011

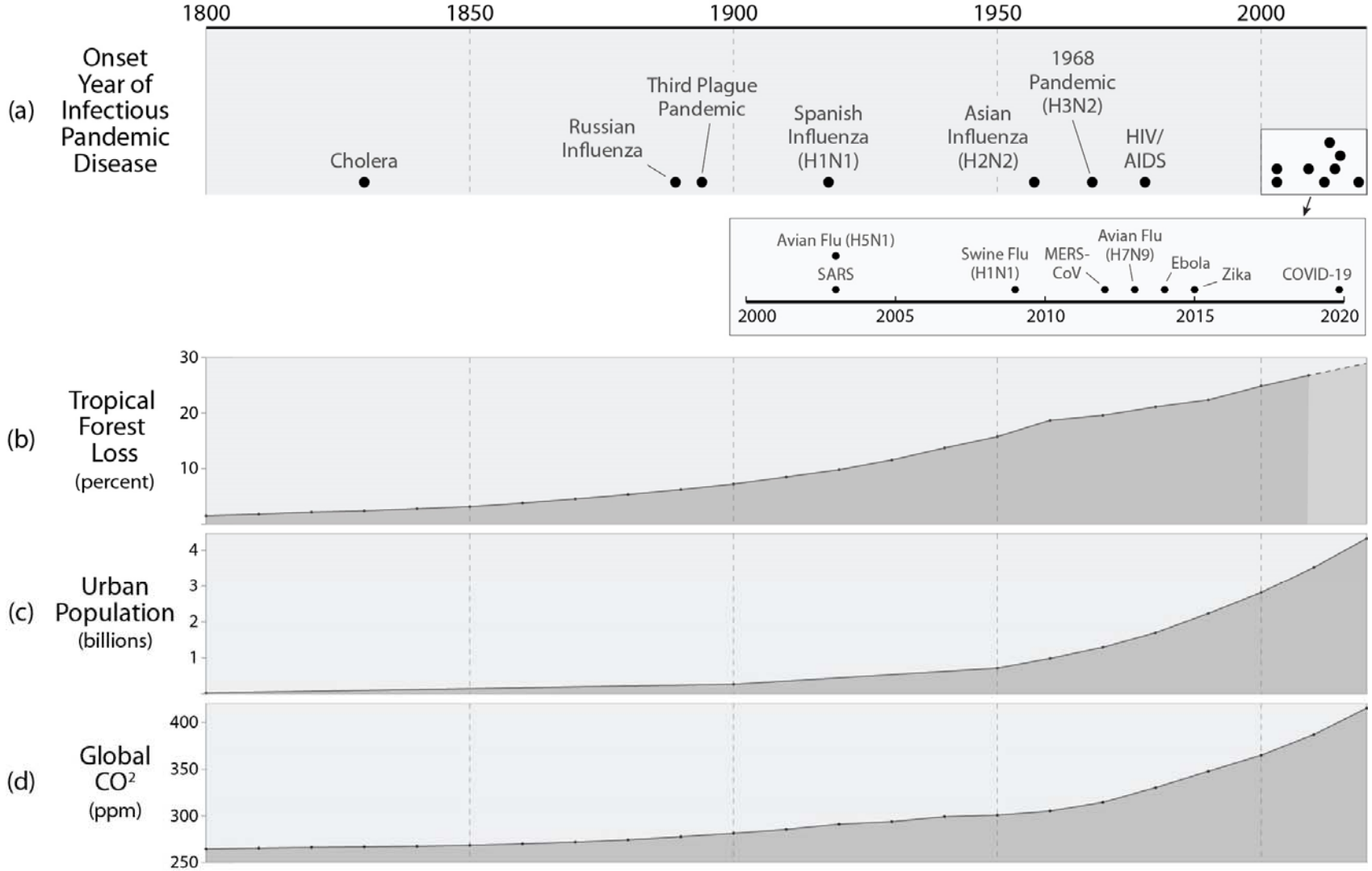
Emerging and Resurging Infectious Disease (EIDs) refer to diseases that humans view as novel; they are dangerous because human populations have little history of exposure to them.

Emerging and Resurging Infectious Disease (EIDs)



Source: https://www.niaid.nih.gov/sites/default/files/main%20map.jpg

Trends in Global Pandemics over Time

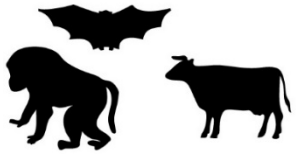


Source: Chin, Simon, Anthamatten, Kelsey, Crawford, and Weaver 2020 (in review)

Emerging and Resurging Infectious Disease (EIDs)

Stage 1: Pre Emergence

Encroachment into wildlife habitat
Change in land use

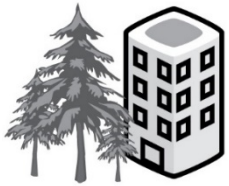


Nearly all novel infectious disease originates in animal populations when it crosses the human-animal barrier.

"spillover event"

Stage 2: Localized Emergence

Expansion of the wildlife-human interface



E.g.,
Nipah virus
Ebola virus

In many cases, these pathogens have existed for a long time in animal populations but only to a small extent in humans.

"epidemic" to "pandemic"

Stage 3: Pandemic Emergence

International trade and travel

E.g.,
HIV / AIDS
SARS

In a globalized world, where places around the globe are tightly connected through trade and travel, highly *transmissible* (diseases that evolve to pass easily among humans) EIDs run significant risk of becoming a pandemic, a disease outbreak that extends across multiple regions.

Source: Hazen and Anthamatten 2019;
Adapted from Morse et al. 2012

Emerging and Resurging Infectious Disease (EIDs)

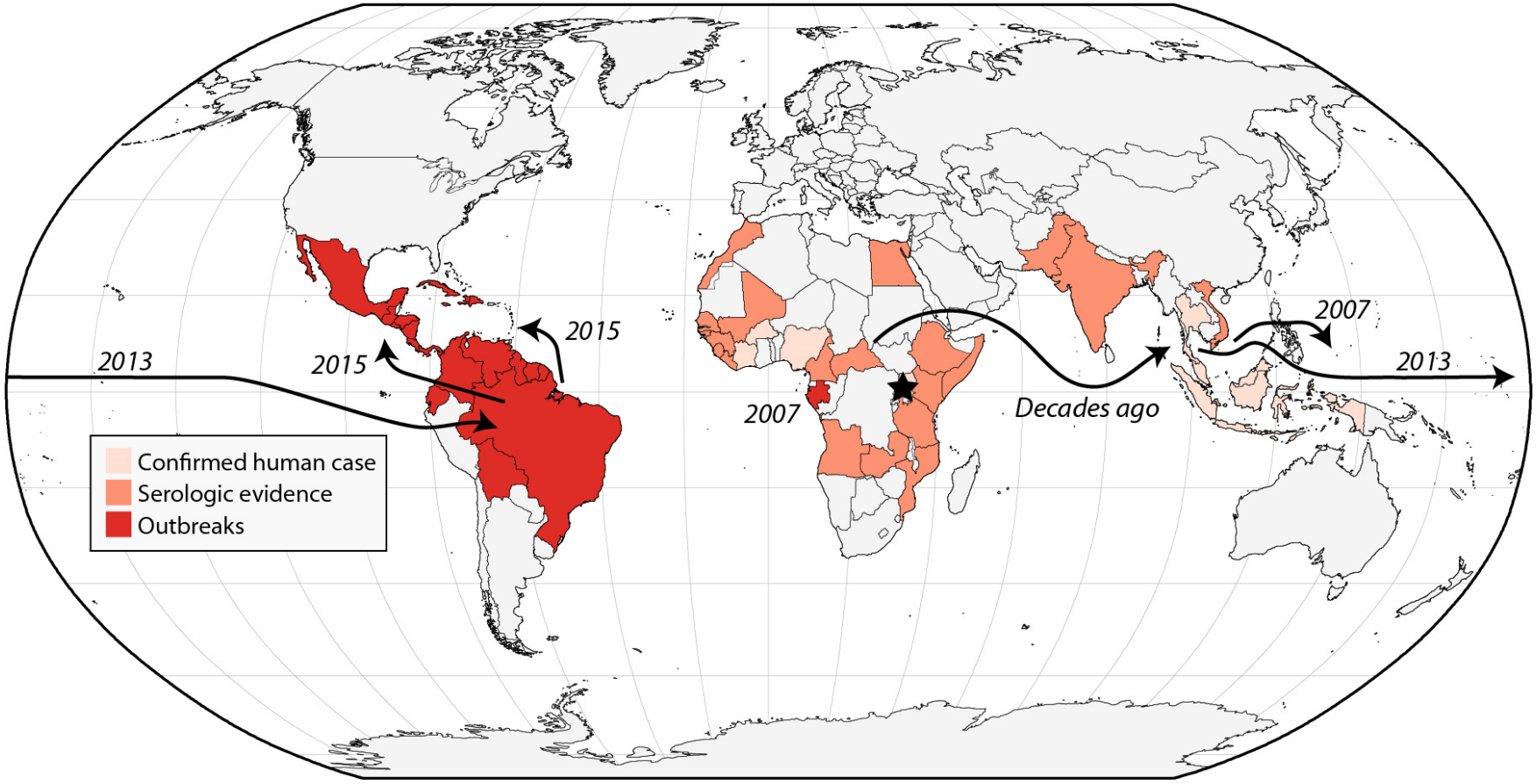
Emerging infectious diseases have been a serious concern for decades.

Veterinarian Jerome Walters wrote in 2003 that "*it is only a matter of time, many epidemiologists warn, until another epidemic on the scale of the Spanish Influenza outbreak of 1918-1919, or the current HIV / AIDS pandemic, sweeps across the globe*" (p 147). In many ways, the emergence of a disease like COVID-19 was inevitable.

This raises the questions of **where**, **why**, and **what we can do about it**.

Source: https://www.the-scientist.com/news-opinion/coronaviruss-genetics-reveal-its-global-travels-67183

Case Example: Zika Virus



Zika, a flavivirus, started as a sporadic infection Africa, first identified in Uganda in 1947. It has an animal reservoir in monkeys and is vector-borne.

Image: Hazen and Anthamatten 2019; adapted from Weaver 2016

Case Example: Zika Virus

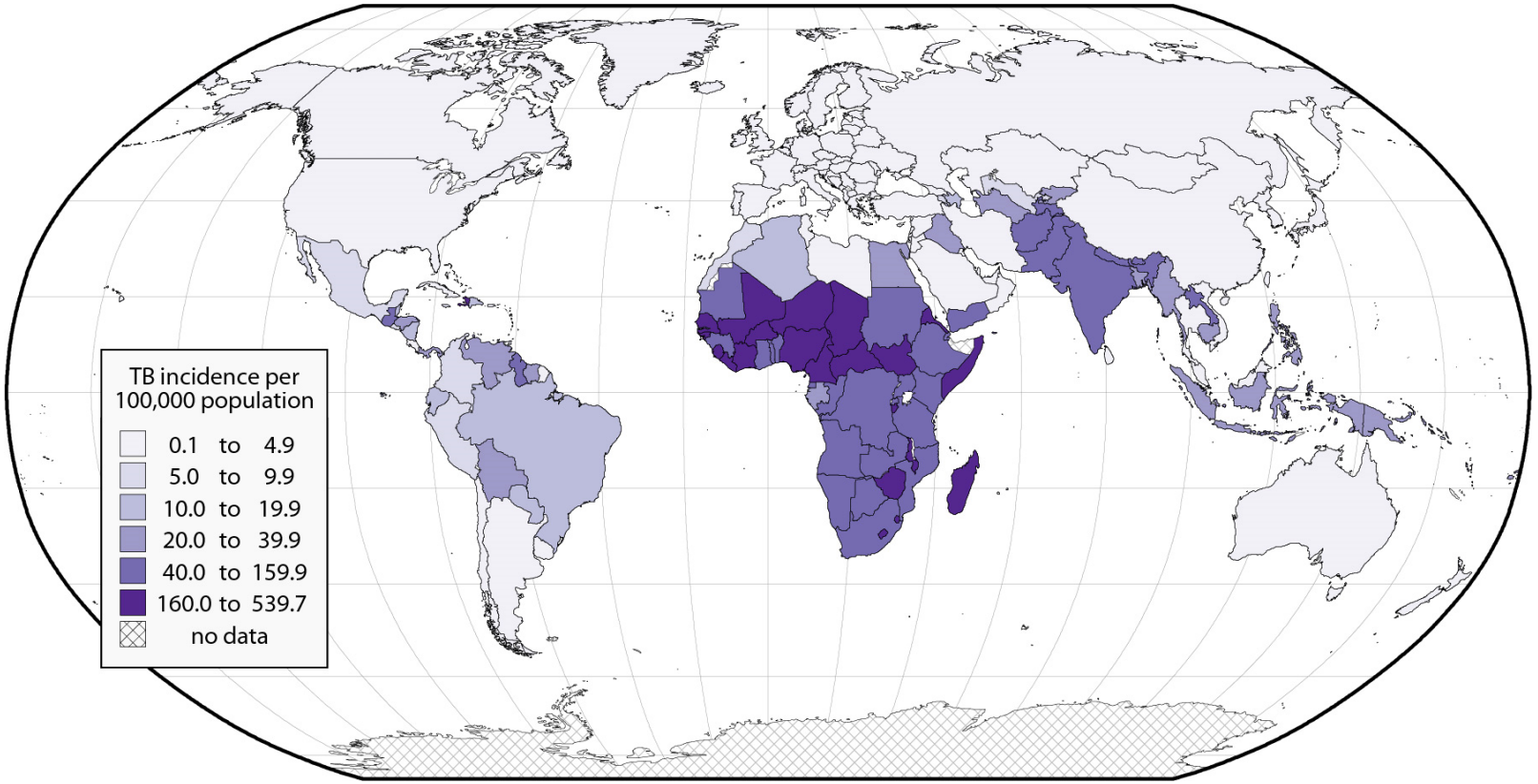
Reasons for the transition to an epidemic disease:

- rapid human movement
- urbanization
- poor vector control
- exacerbated by the 2014 World Cup

(a) Transmission: mosquito vector
(b) Spread through travel and trade, exposure to infected mosquitos
(c) Spatially constrained my mosquito habitat
(d) Policies could include vector control, monitoring

Image: Johns Hopkins Medicine

Case Example: Tuberculosis



Tuberculosis has existed since the antiquity. The bacterium is widespread among humans and has no known animal reservoir; it is a disease of poverty and manifests in poor living conditions.

Image: Hazen and Anthamatten 2019; data from World Bank 2018

Case Example: Tuberculosis

Reasons for the transition to an epidemic disease:

- asymptomatic latency
- anti-biotic resistance
- conditions of poverty
- lack of political will…

(a) Transmission: close personal contact
(b) Spread through travel and trade, exposure to infected individuals
(c) No significant spatial constraints – driven by poverty
(d) Policy response include monitoring, careful treatment

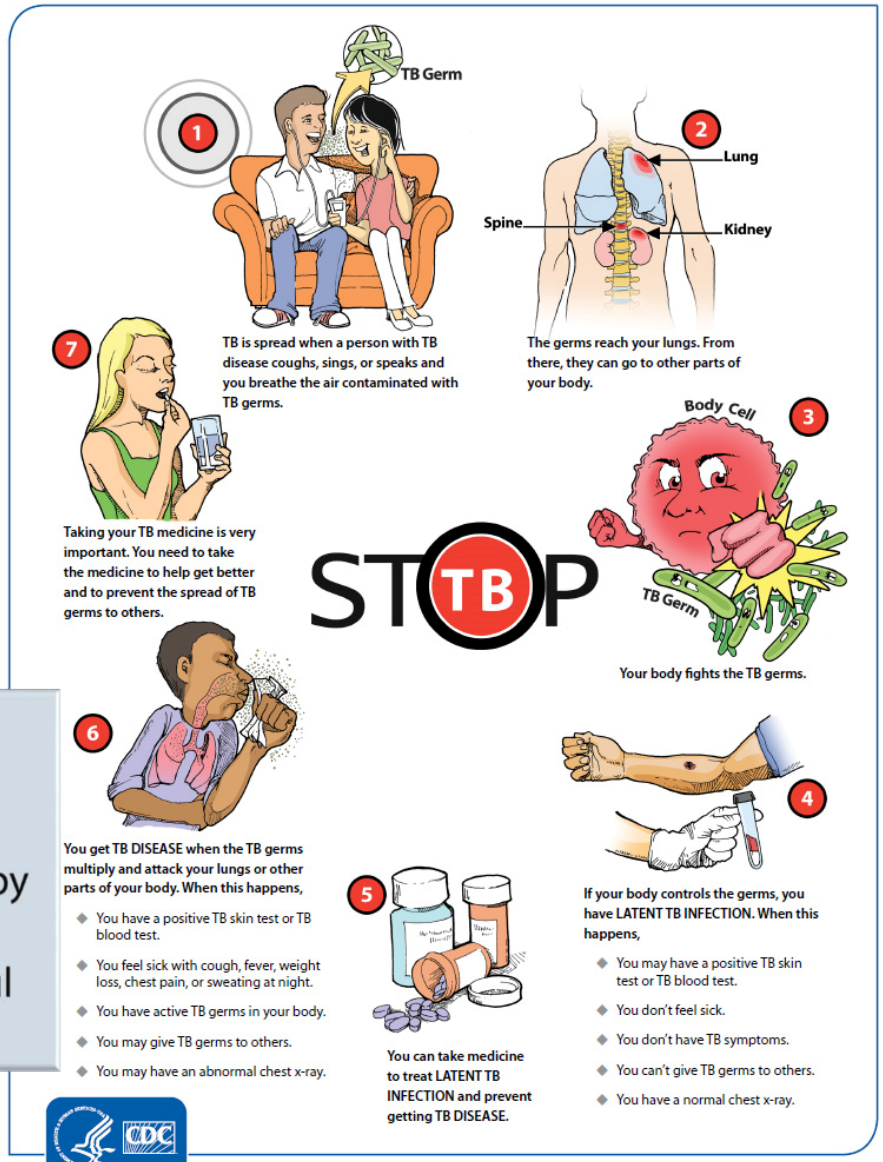


Image: Centers for Disease Control

Case Example: SARS

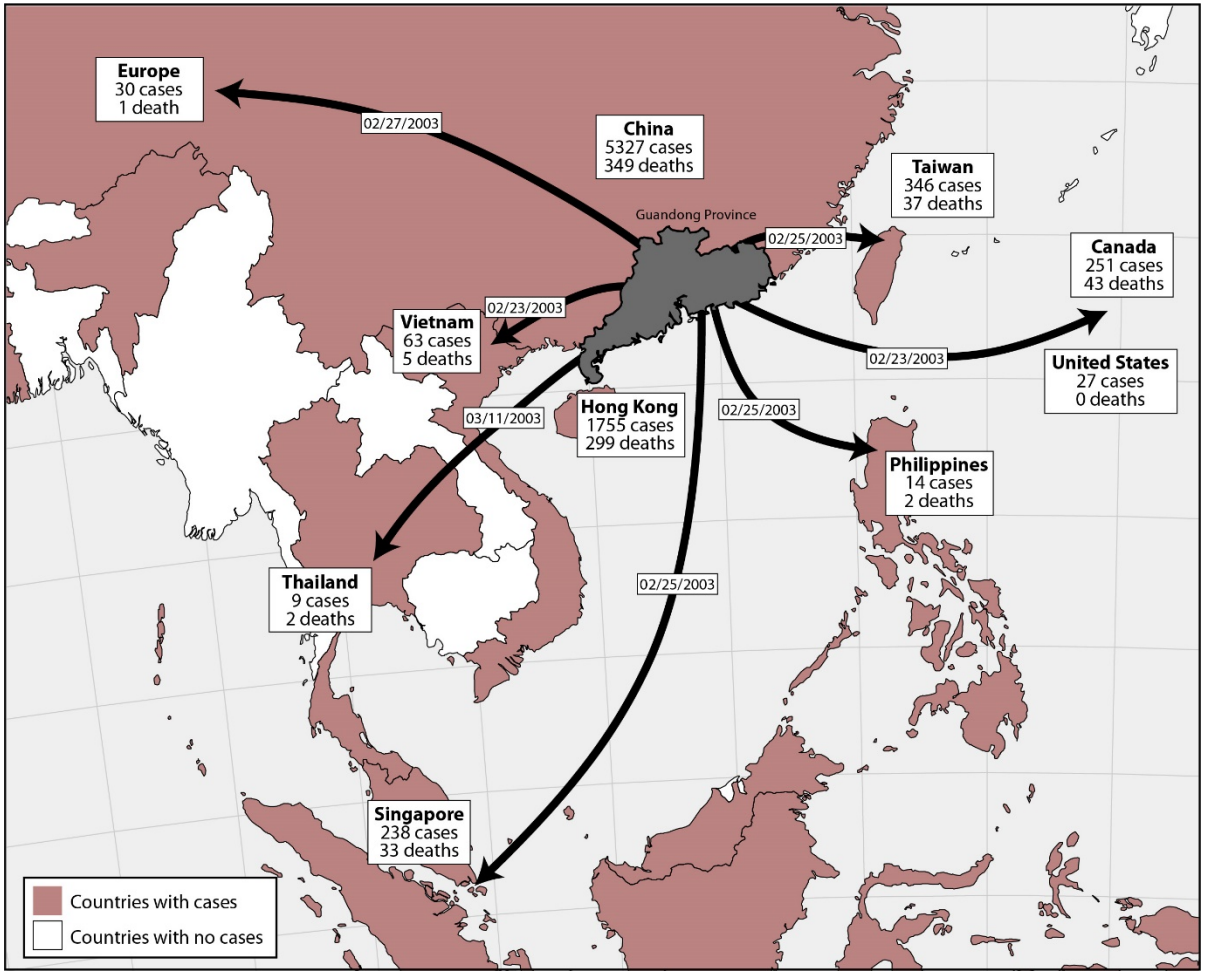


Image: Hazen and Anthamatten 2019; data from World Bank 2018c

Severe acute respiratory syndrome (SARS) is a coronavirus that lead to a (relatively minor) pandemic in 2003.

It is believed to have originated from an animal reservoir in Guangdong; bats are suspected.

Case Example: SARS

SARS was ultimately controlled but resulted in only 774 deaths. Chew (2006) identifies transparency and good scientific collaboration as the key reasons for successful control.

(a) Transmission: personal contact
(b) Spread through travel and trade, community spread
(c) No significant spatial constraints
(d) Policies could include careful monitoring, avoiding personal contact, education

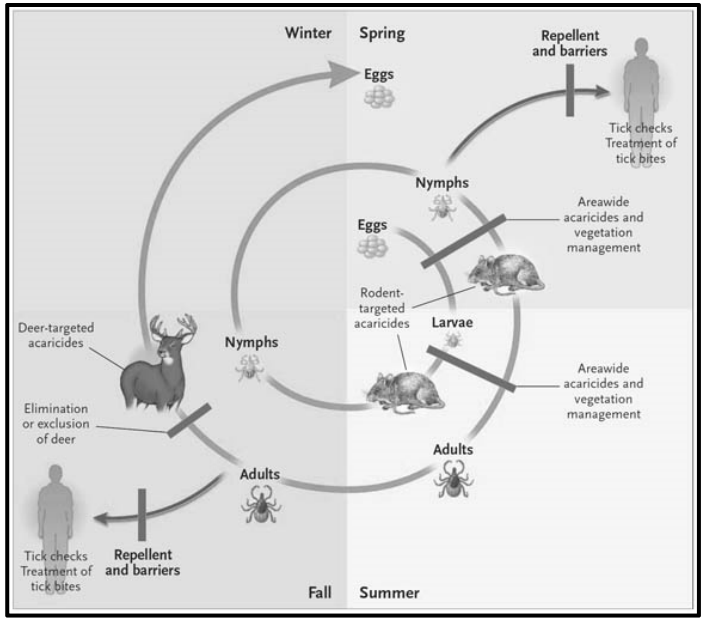
Image sources: Daily Herald 2003; Yijiu and Zhihao 2003

Case Example: Lyme Disease

Image source: Hazen and Anthamatten 2019; Adapted from CDC 2019.

The Lyme disease cycle is complex, involving a variety of hosts and vectors. In North America, Lyme disease is caused by the bacterium *Borrelia burgdorferi*, transmitted to humans through the bite of infected ticks (Bacon et al. 2007).

Case Example: Lyme Disease



(a) Transmission: tick vectors
(b) Spread through exposure to environments with infected tics
(c) Constrained by tick habitats with sufficient conditions
(d) Policies could include tick avoidance, education, countering ecosystem simplification

Ecosystem simplification is occurring rapidly in many parts of the world as natural ecosystems are replaced with less complex, species-poorer agricultural and urban landscapes.

Thankfully, some diseases, such as Lyme disease, are constrained by the range and extent of the disease vectors (ticks) and its animal reservoirs (deer, mice).

As such, it is unlikely to transition into a significant global pandemic.

Case Example: Nipah Virus

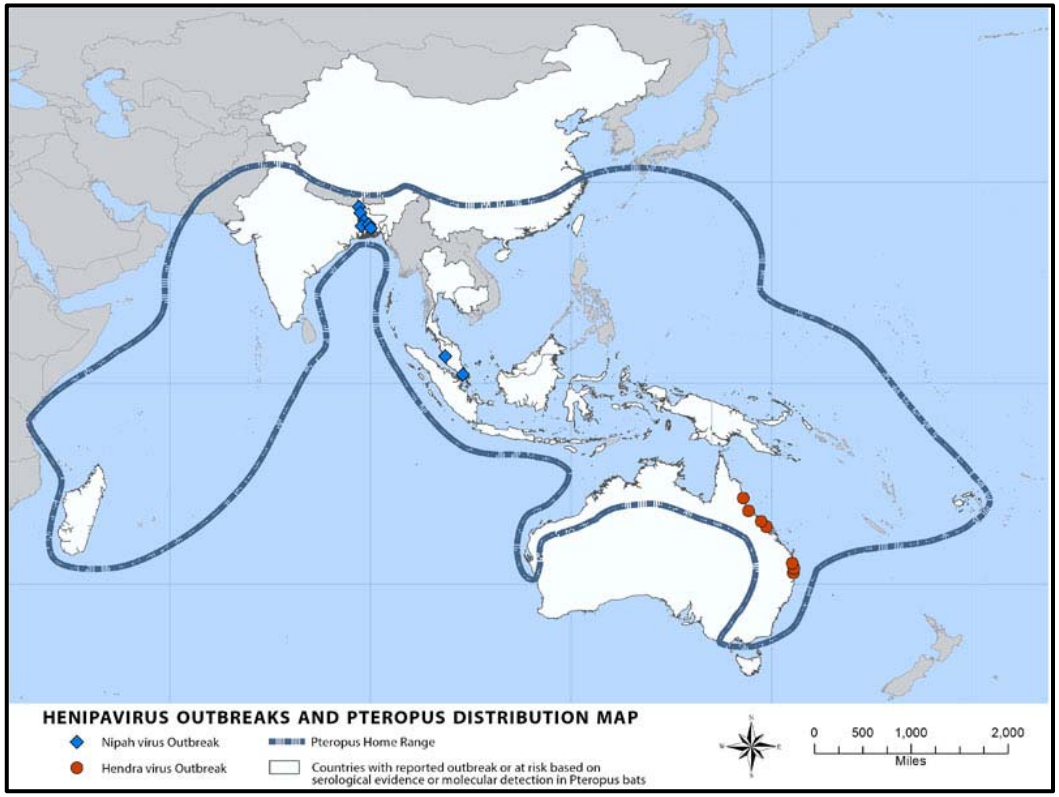


Image source: https://www.cdc.gov/vhf/nipah/outbreaks/distribution-map.html

A continual risk is posed from diseases that pass easily between animals and humans, however, such as the Nipah virus.

The first known outbreak occurred in Malaysia in 1998-1999. The disease is prevalent in bats and can be passed to humans through infected animals or exposed fruit.

Case Example: Nipah Virus

Nipah virus demonstrates how human disruptions of the natural environment raise the risk for spillover events—of zoonotic disease transforming into human ones. For example, it is suspected that some of the outbreaks have been driven by deforestation, which forces the bats out of their natural habitat and into contact with agricultural activities, such as pig farms and wet markets. The origin story of the virus was used in the film *Contagion*.

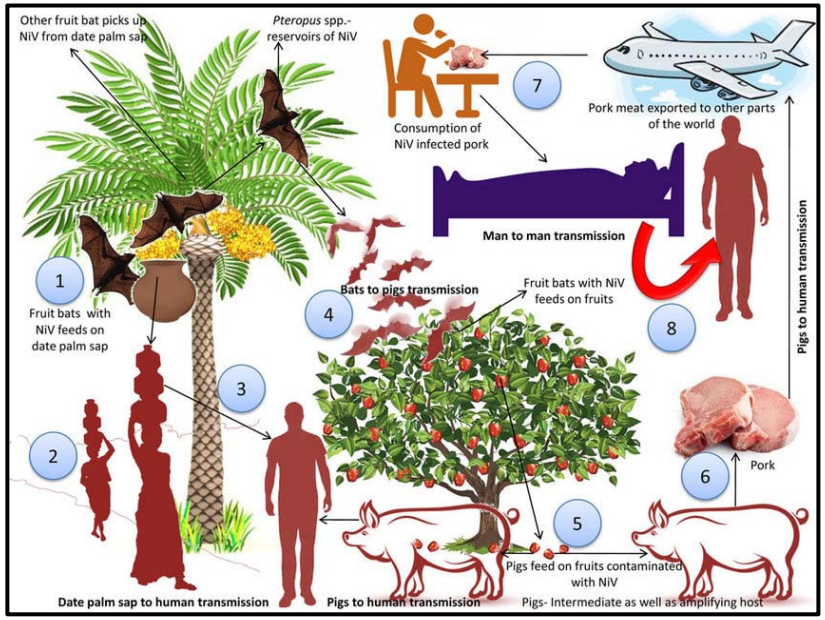


Image source: https://www.researchgate.net/figure/Transmission-of-the-Nipah-virus-1-Fruit-bats-acts-as-natural-reservoir-of-Nipah_fig2_332558975

Image source: https://www.kpbs.org/news/2020/mar/23/uc-san-diego-professor-uses-contagion-film-teach-e/

Case Example: Nipah Virus

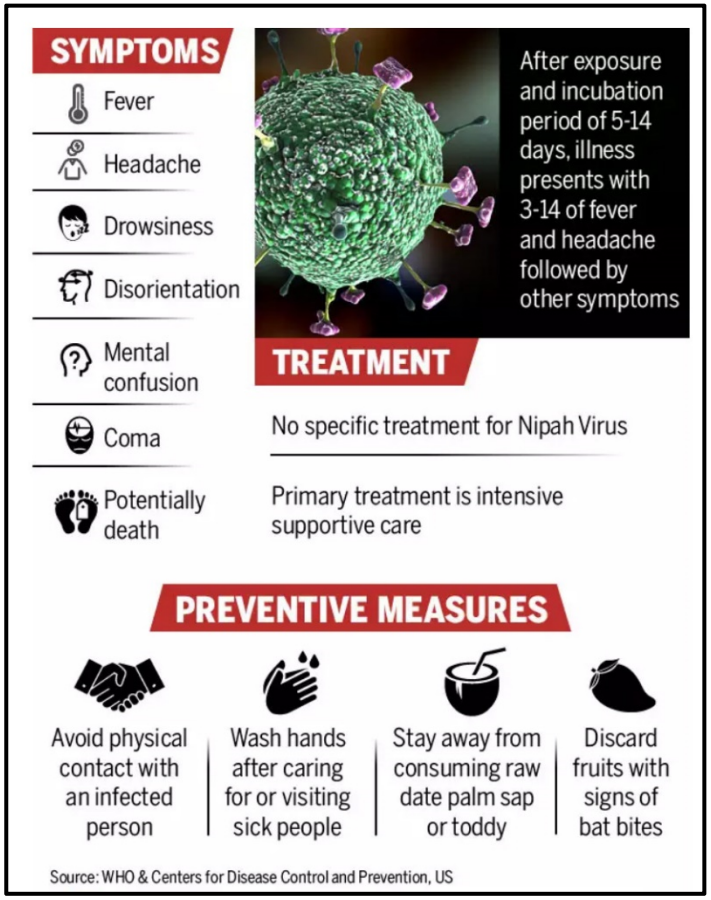


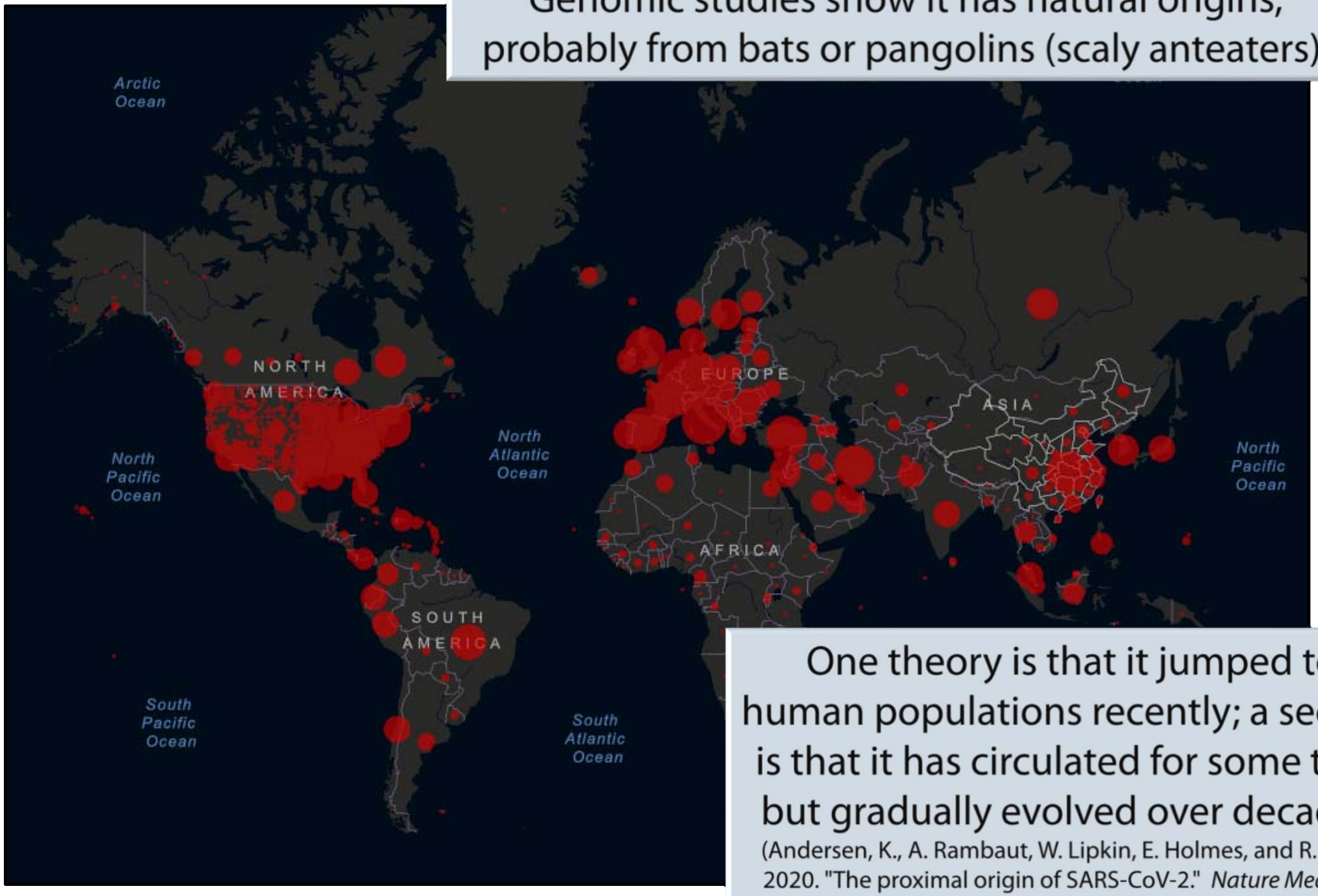
Image source: https://timesofindia.indiatimes.com/india/nipah-virus-all-you-wanted-to-know/articleshow/69647867.cms

In some ways we are fortunate that the COVID-19 epidemic is a relatively mild one, with a case fatality rate of around 0.5 to 1% (Mallapaty 2020; https://www.nature.com/articles/d41586-020-01738-2). The case fatality of Nipah virus is between 50 and 75% (Epstein et al. 2006; Wlaters 2014; WHO 2018). Fortunately the WHO and regional governments are actively monitoring the disease, taking it very seriously.

(a) Transmission: exposure to birds
(b) Spread through agricultural exposure
(c) Constrained to regions with significant fowl infection
(d) Policies could include minimizing contact with birds, very careful monitoring; the world will need to spring into action very quickly if the pathogen acquires the ability for person-to-person transmission

COVID-19

COVID-19 is similar in structure and story to SARS. Genomic studies show it has natural origins, probably from bats or pangolins (scaly anteaters).

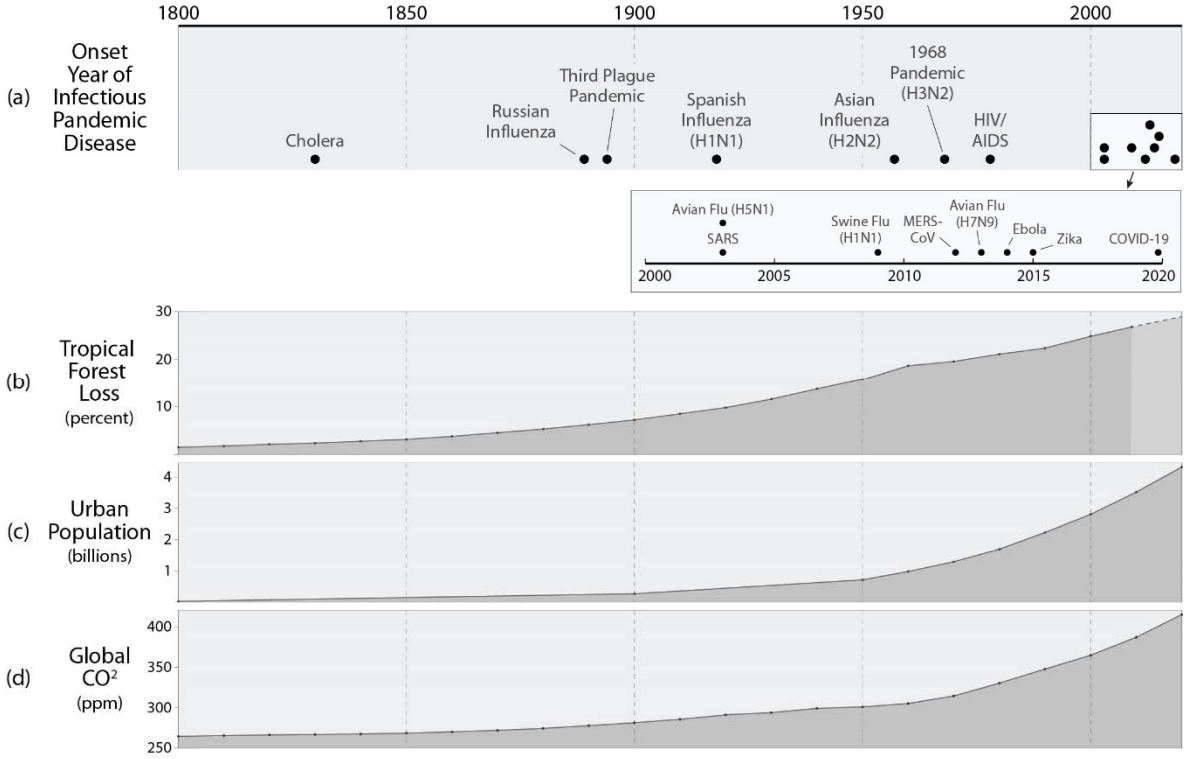


One theory is that it jumped to human populations recently; a second is that it has circulated for some time but gradually evolved over decades.

(Andersen, K., A. Rambaut, W. Lipkin, E. Holmes, and R. Garry. 2020. "The proximal origin of SARS-CoV-2." *Nature Medicine*)

Image: Johns Hopkins Center for Systems Science and Engineering

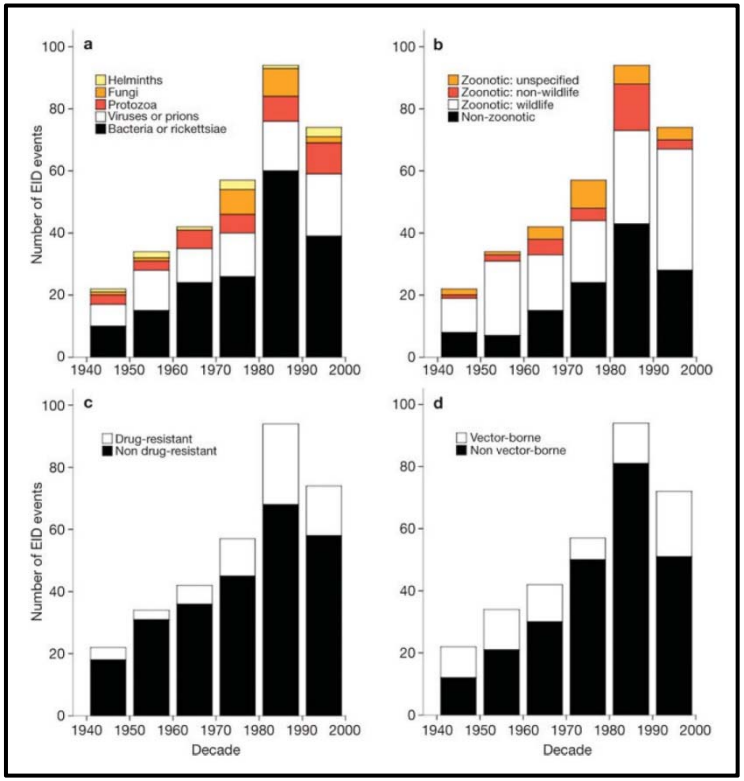
What are the environmental risk factors?



Source: Chin, Simon, Anthamatten, Kelsey, Crawford, Weaver 2020 (in review)

The key driver of risk for EIDs and pandemics is human exposure to animals and the pathogens they carry. Relevant processes include **environmental degradation**, **agricultural intensification**, and **urban expansion**. Additionally, there is some concern about diseases becoming resistant to human efforts to control them.

What are the environmental risk factors?



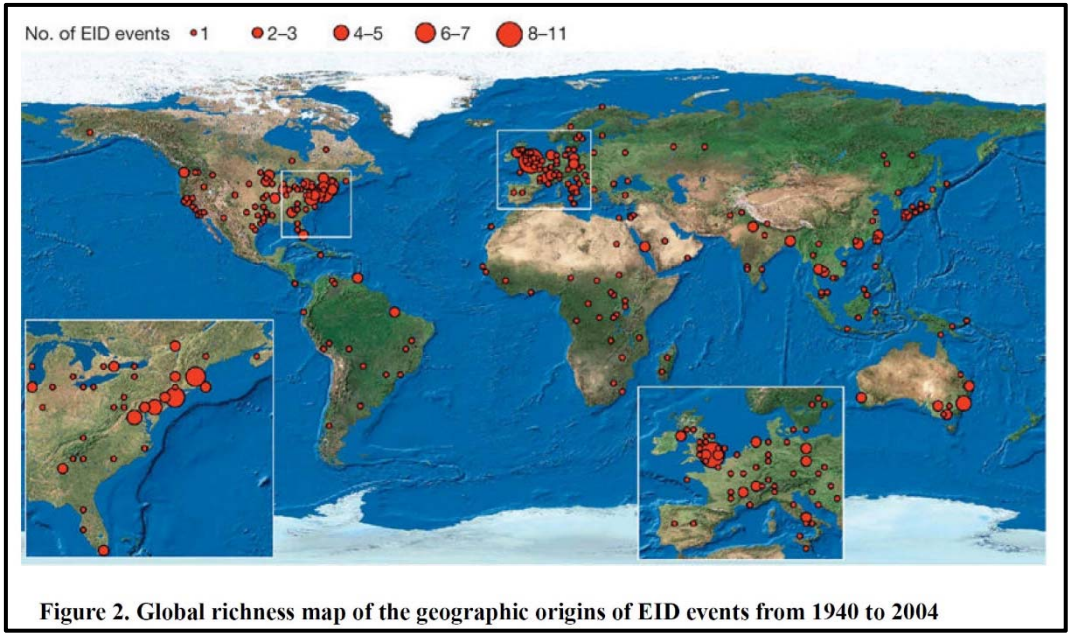
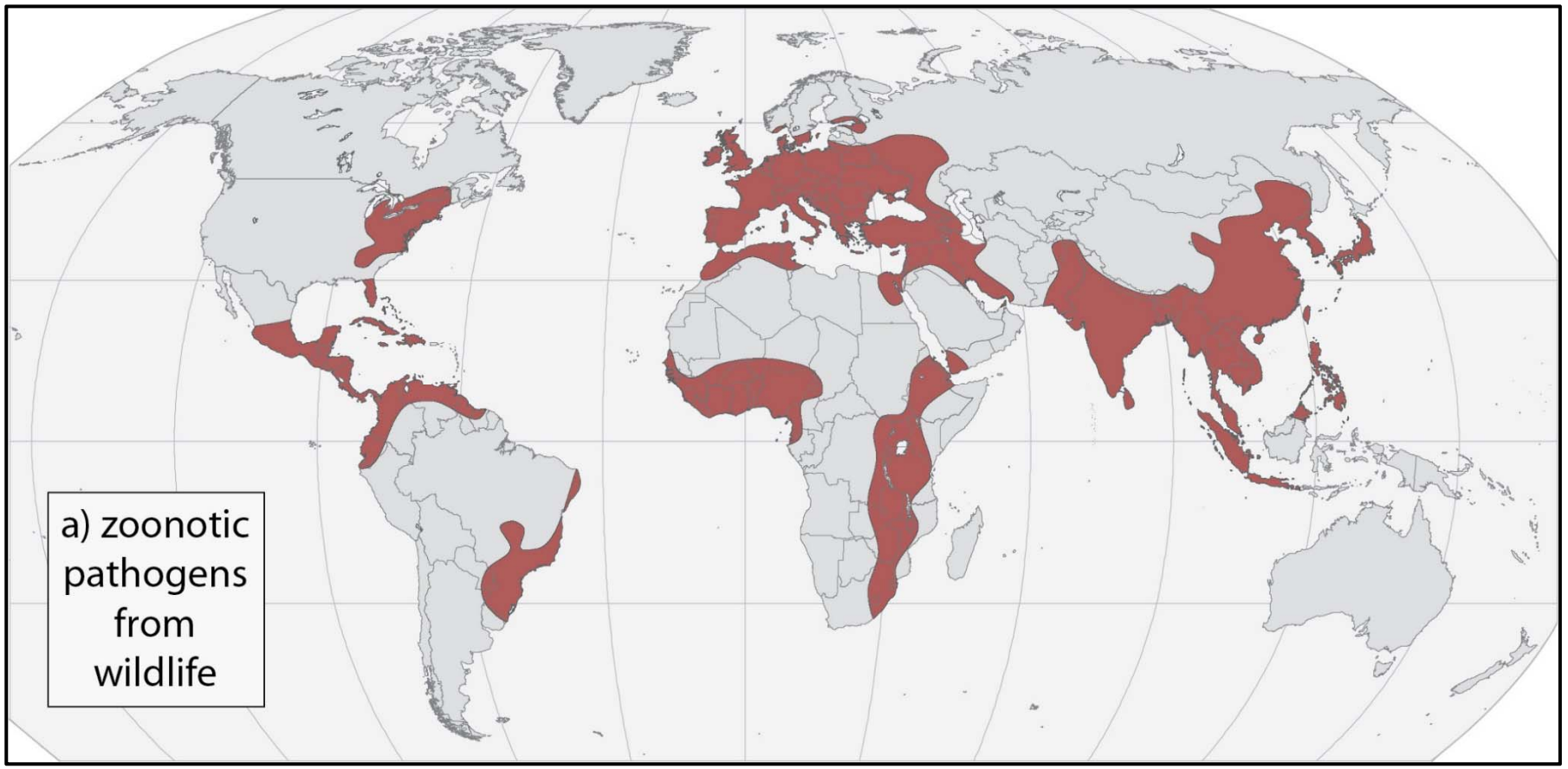


Figure 2. Global richness map of the geographic origins of EID events from 1940 to 2004

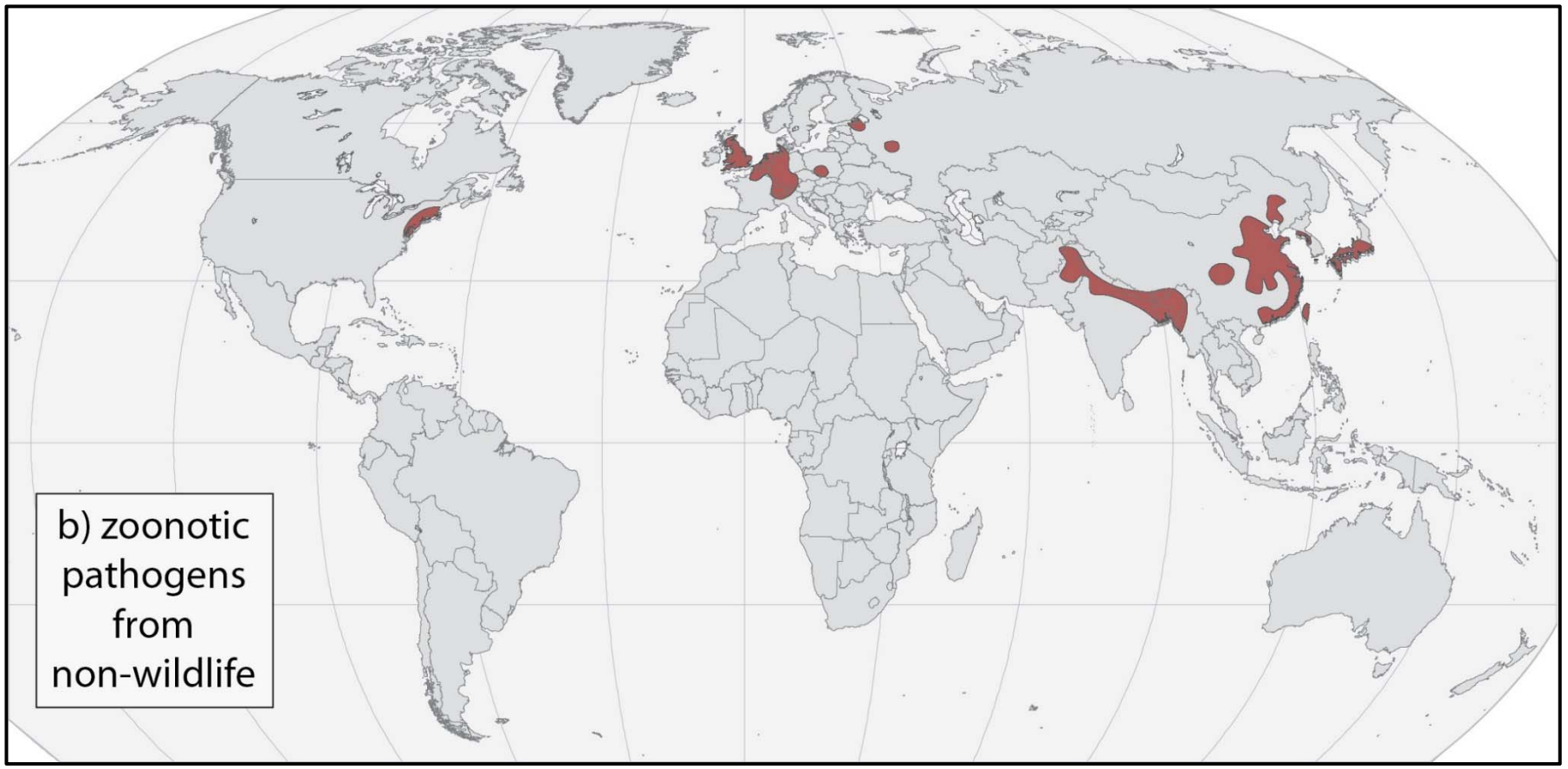
Source: Jones et al. 2008

We can learn about the geographic risk factors behind pandemics by analyzing outbreaks and regional epidemics from recent decades.



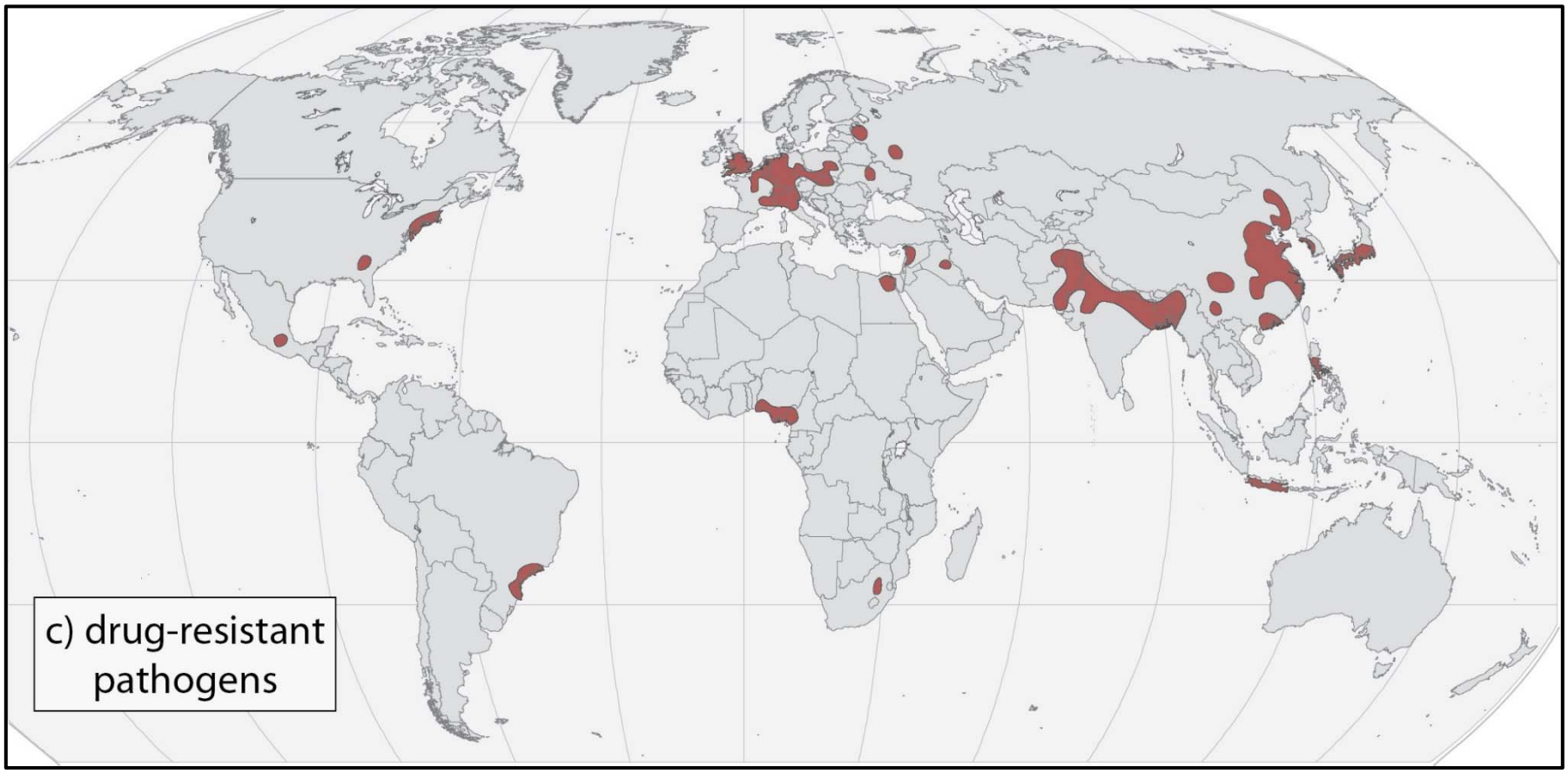
Hazen and Anthamatten 2019. Adapted from Jones et al. (2008: 993). Adapted with permission from Macmillan Publishers Ltd: [*Nature*] (Jones, K. et al. Global trends in emerging infectious diseases." *Nature* 451(7181): 990-994) © 2008

Zoonotic pathogens can cross from wildlife to human populations when **humans settle or hunt in wildlands**. Examples include Lyme Disease, HIV/AIDS.



Hazen and Anthamatten 2019. Adapted from Jones et al. (2008: 993). Adapted with permission from Macmillan Publishers Ltd: [*Nature*] (Jones, K. et al. Global trends in emerging infectious diseases." *Nature* 451(7181): 990-994) © 2008

Zoonotic pathogens from non-wildlife sources typically cross into human populations from **agricultural systems**. Examples include avian flu outbreaks, bovine spongiform encephalitis (Mad Cow's Disease), and COVID-19.



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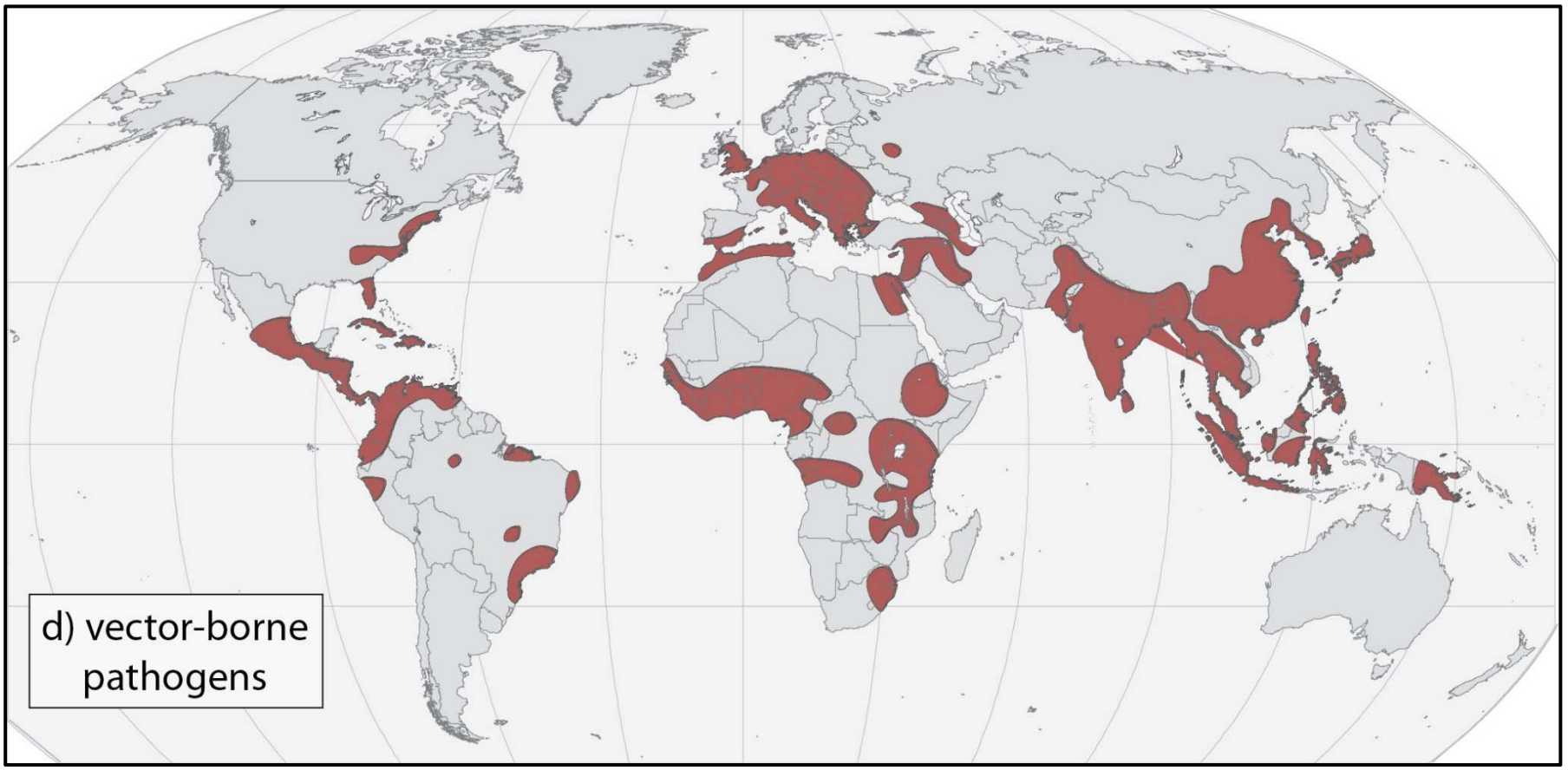
The emergence of drug resistant pathogens is often associated with **overuse or misuse of antibiotics**. Examples include tuberculosis and multi-drug resistant staphylococcus aureus (staph).



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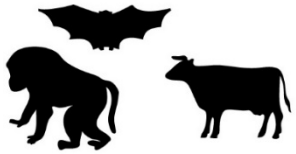
Many vector-borne diseases are resurging diseases as resistance develops in **pathogen and vector populations**. Examples include malaria, zika, and dengue.

What are the environmental risk factors?

Stage 1: Pre Emergence

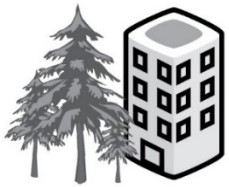
Encroachment into wildlife habitat
Change in land use



"spillover event"

Stage 2: Localized Emergence

Expansion of the wildlife-human interface



E.g.,
Nipah virus
Ebola virus

Stage 3: Pandemic Emergence

International trade and travel

E.g.,
HIV / AIDS
SARS

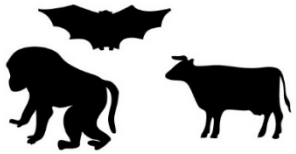
Human activities that increase the risk for spillover events—increased contact with animals

- Population growth
- Decreased biodiversity
- Agricultural intensification
- Urban encroachment
- Hunting and bush meat trade
- Poverty and inequality

What are the environmental risk factors?

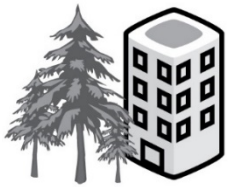
Stage 1: Pre Emergence

Encroachment into wildlife habitat
Change in land use



Stage 2: Localized Emergence

Expansion of the wildlife-human interface



E.g.,
Nipah virus
Ebola virus

"epidemic" to "pandemic"

Stage 3: Pandemic Emergence

International trade and travel

E.g.,
HIV / AIDS
SARS

Human activities that increase the risk for conversion of an EID into a pandemic

- Population growth
- Global trade and travel
- Overuse of antibiotics
- Use and overuse of prophylactic antibiotics in agriculture
- Poverty and inequality

The One Health Perspective

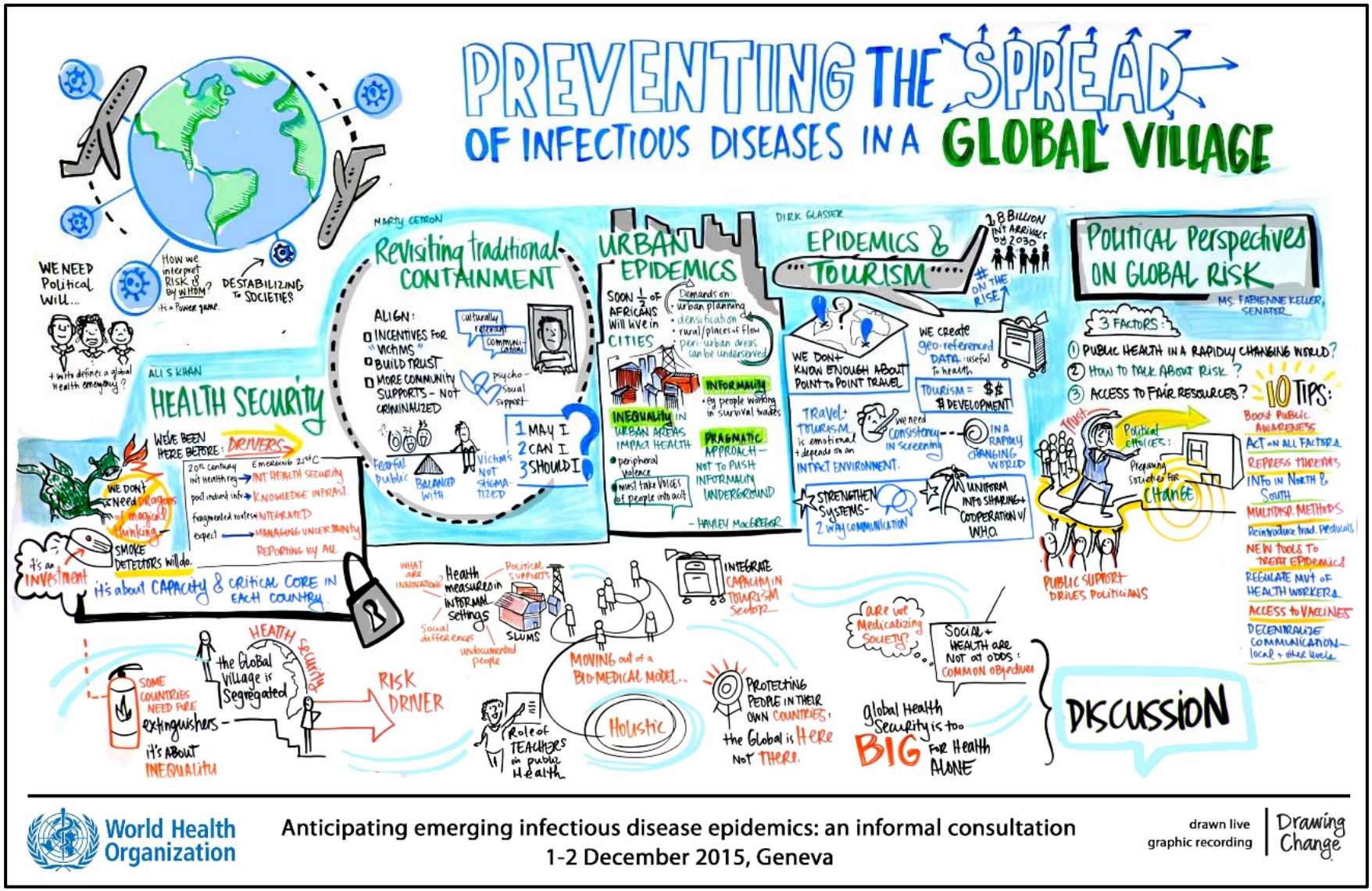


Image: World Health Organization

The One Health Perspective

"Over the past century or more, humans have so disrupted the global environment and its natural cycles that we risk evicting ourselves from the shelter of our relative ecological stability… If the upsurge in new diseases is any indication, microscopic predators are taking full advantage of the instability." (Walters 2004, *Six Modern Plagues*)

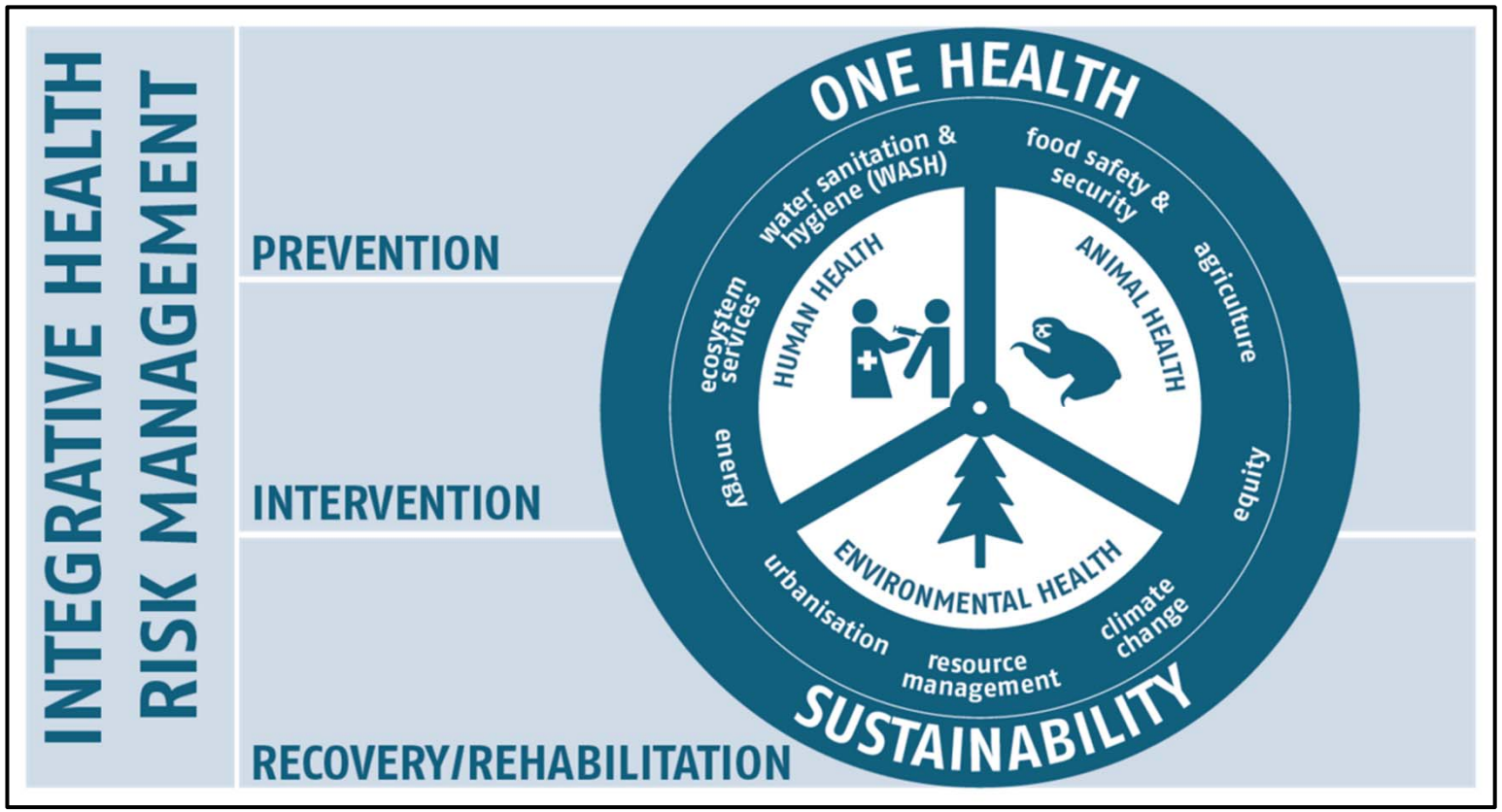


Image: http://onehealth.grforum.org/about/about-one-health/

Learning from COVID-19

The COVID-19 pandemic has thrust the dangers of emerging infectious disease and global pandemics into the forefront of the world's attention. A *hopeful* note from this experience is that governments, societies and policy makers can *learn some lessons* about controlling risk for EIDs and mitigating pandemics.

The COVID-19 pandemic underscores the tight link between the health of the environment and human health.

What have we learned from the COVID-19 pandemic?

Image source: https://www.bloomberg.com/opinion/articles/2020-04-15/covid-19-health-crisis-has-origins-in-human-activity

Thought Questions

What can the international community do to mitigate risk for future pandemics?

What can regional and national governments do?

What actions can we, as individuals, take to mitigate these risks?

Are we ready for the next global epidemic?

By Meera Senthilingam, for CNN

Photos: Are we ready for the next global outbreak?

Source of images: CNN, 2015 (https://www.cnn.com/2015/02/13/health/are-we-ready-for-global-outbreak/index.html)

COVID-19: COLORADO & BEYOND

A free summer lecture series presented by the CU Denver College of Liberal Arts and Sciences

Q&A