



Knowledge Dialogue on International Cooperation to Prevent the "Next" Pandemic

➤ Emergence of zoonotic diseases and environmental changes

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Gwenaël Vourc'h

UMR EPIA

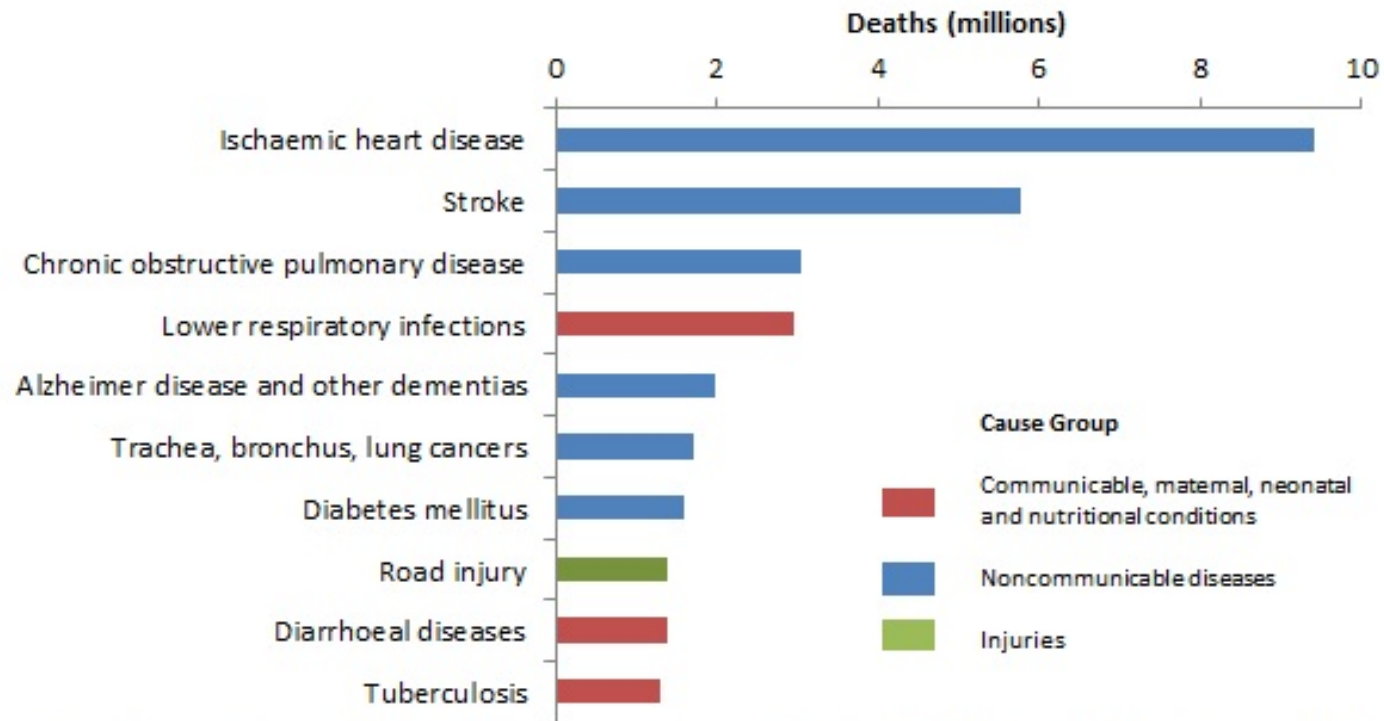
Epidemiology of animal and zoonotic diseases, France

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May 5th 2020

➤ Global causes of deaths

Top 10 global causes of deaths, 2016



Source: Global Health Estimates 2016: Deaths by Cause, Age, Sex, by Country and by Region, 2000-2016. Geneva, World Health Organization; 2018.

<https://www.who.int/en/news-room/fact-sheets/detail/the-top-10-causes-of-death>



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Emerging zoonoses

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➤ Emerging infectious diseases

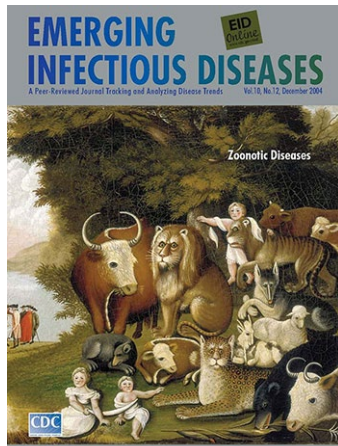
After WW II : vaccine, antibiotics, hygiene

→ infectious diseases fight is a matter of applying known measures of control

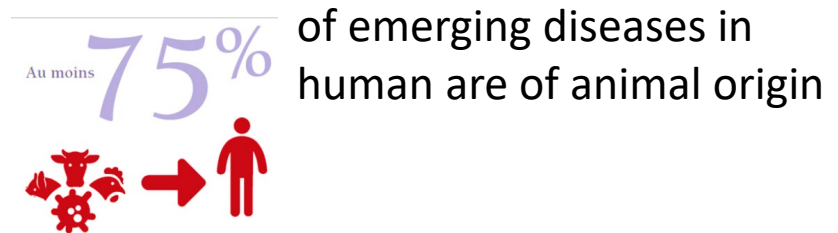
1980's : AIDS, Antimicrobial resistance

→ **Emerging Infectious Diseases**

(S Morse USA 1990)



https://wwwnc.cdc.gov/eid/article/10/12/ac-1012_article

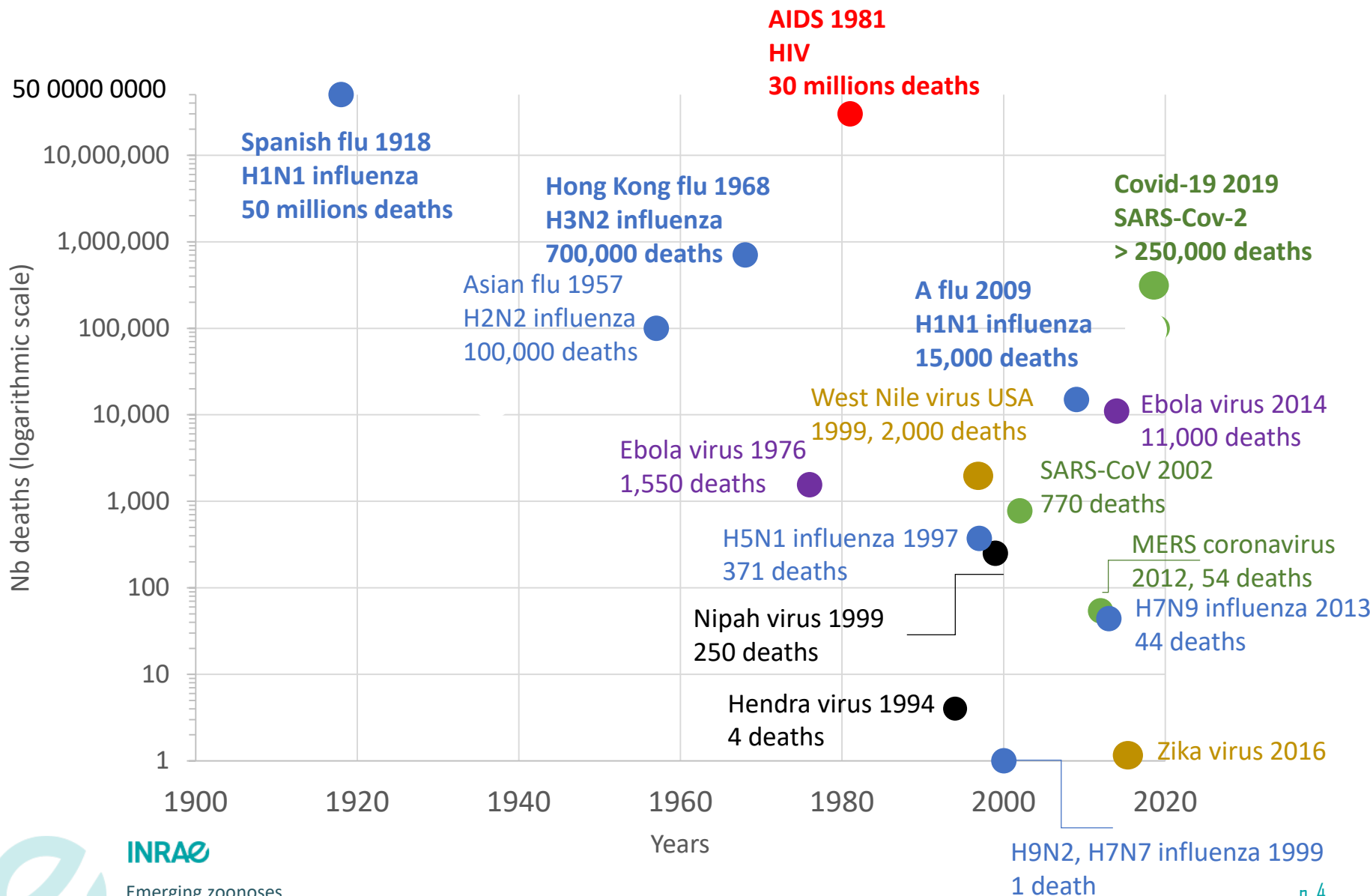


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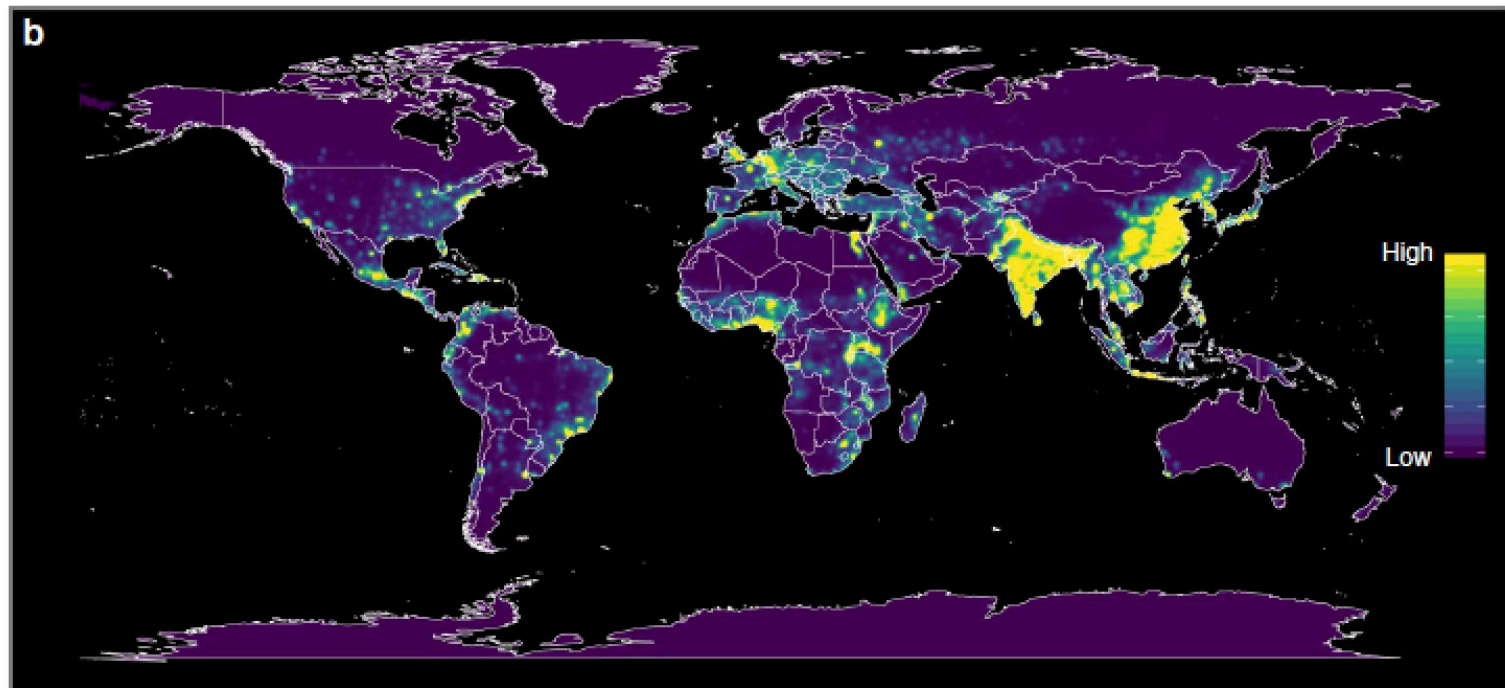
Emerging zoonoses

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Emergence of zoonotic diseases since 1900



➤ Risk of emerging zoonosis in humans



Allen et al 2017 Nature communication

- ✓ Tropical forest regions
- ✓ High species richness in mammals
- ✓ Links with changes in land use

Fig. 3 Heat maps of predicted relative risk distribution of zoonotic EID events. **a** shows the predicted distribution of new events being observed (weighted model output with current reporting effort); **b** shows the estimated risk of event locations after factoring out reporting bias (weighted model output reweighted by population).

➤ Emergence of zoonoses

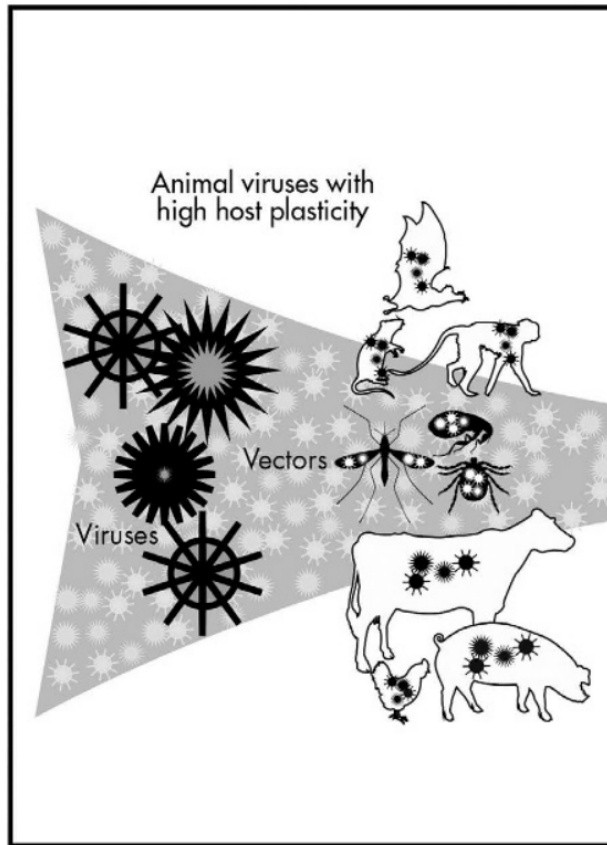


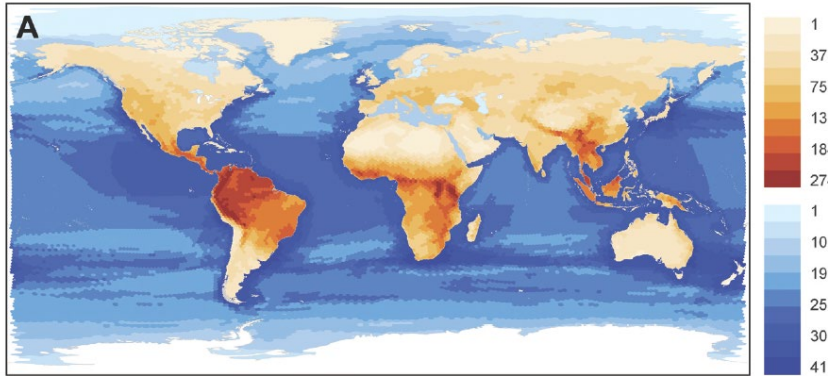
Figure 1. Pandemic properties of zoonotic viruses that spill over from animals to humans and spread by secondary transmission among humans.

➤ Source of pathogens

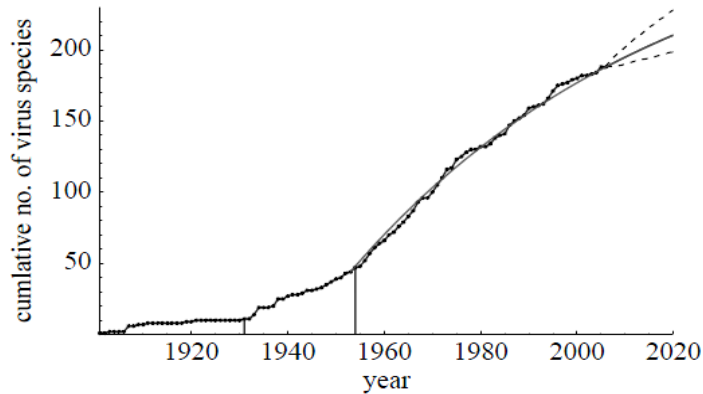
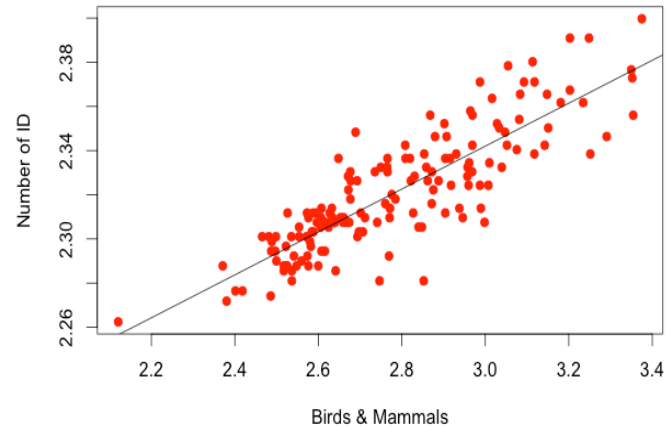
High biodiversity



High number of infectious diseases



Mammal species richness



Estimation of 320,000 mammalian viruses awaiting discovery (in nine virus families)

Anthony et al 2013 MBO

Woolhouse et al 2008. Proc Royal Soc Lond B

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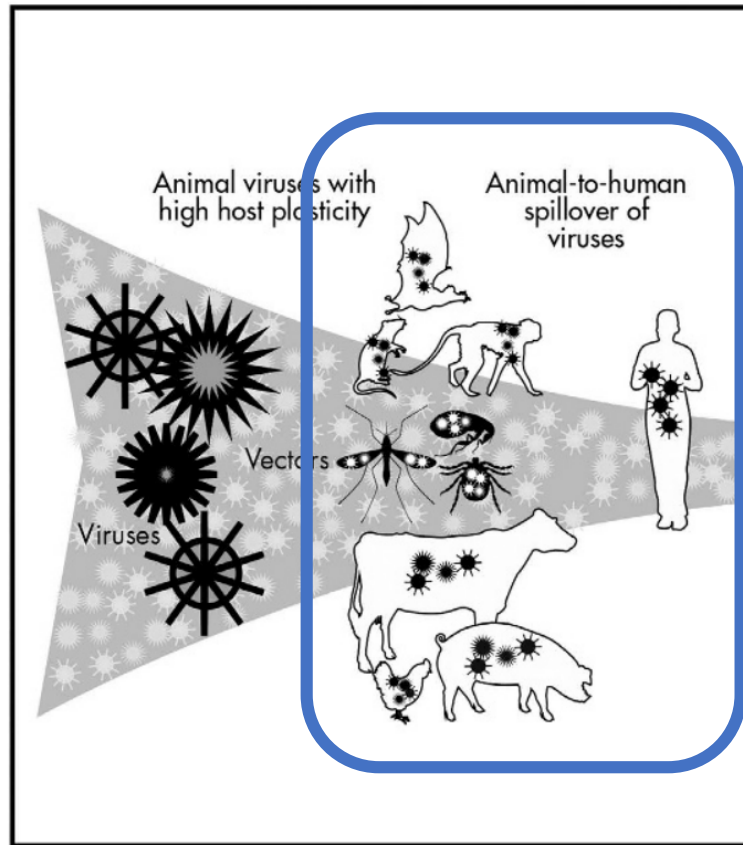
Emerging zoonoses

(Schipper et al. 2011)

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(Morand & Lajaunie 2017)

➤ Emergence of zoonoses



"Source" characteristics

- ✓ Phylogenetic distance between hosts
- ✓ Pathogen characteristics

Animal – human contacts

- ✓ Domestication & livestock
- ✓ Biodiversity & landuse changes
- ✓ Wildlife consumption and trade

Vulnerability of humans

Figure 1. Pandemic properties of zoonotic viruses that spill over from animals to humans and spread by secondary transmission among humans.

> Livestock

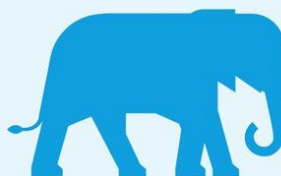
WEIGHT OF VERTEBRATE LAND ANIMALS



10,000 YEARS AGO



1% HUMANS



99% WILD ANIMALS

TODAY



32% HUMANS



1% WILD ANIMALS



67% LIVESTOCK

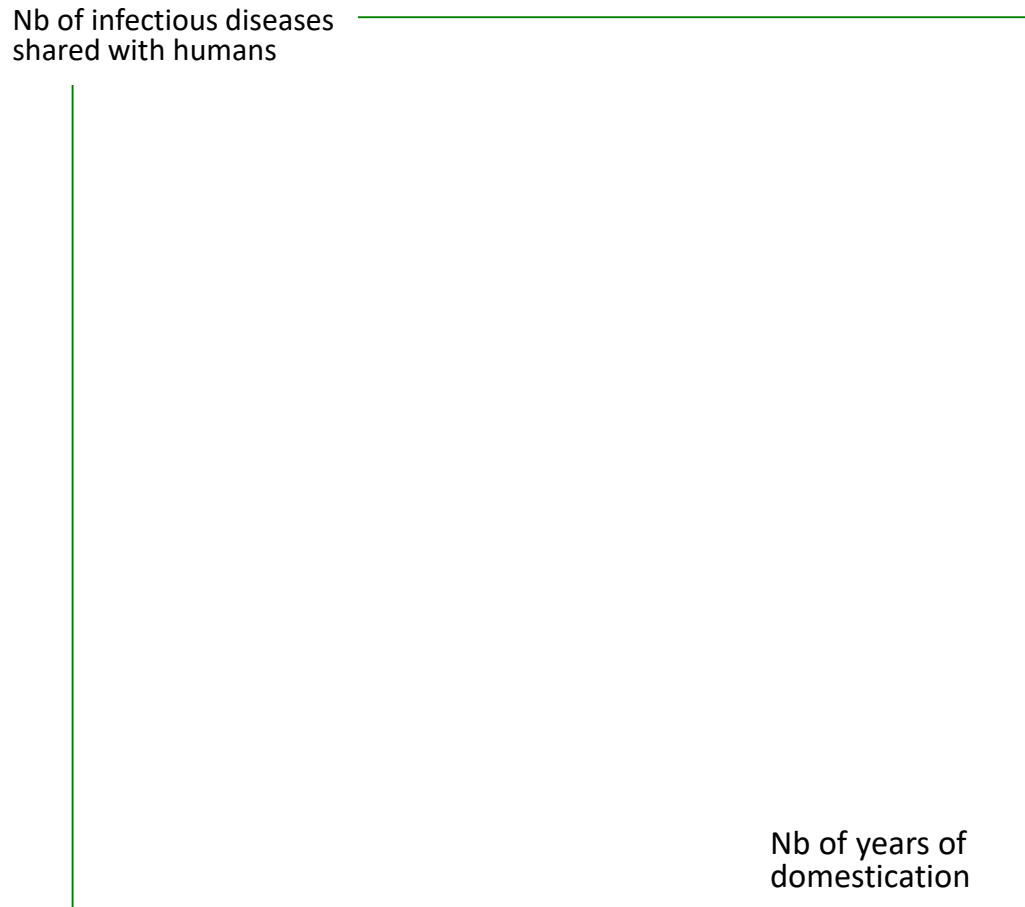
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Emerging zoonoses

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populationmatters.org
Calculations based on Smil (2011)

> Importance of domestication



Morand & Figuié 2016. Emergence de maladies infectieuses. Risques et Enjeux de société. Ed Quae



➤ Livestock

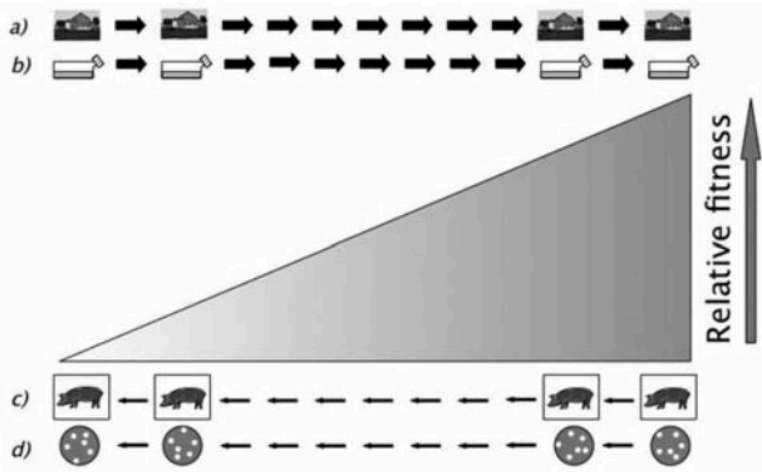
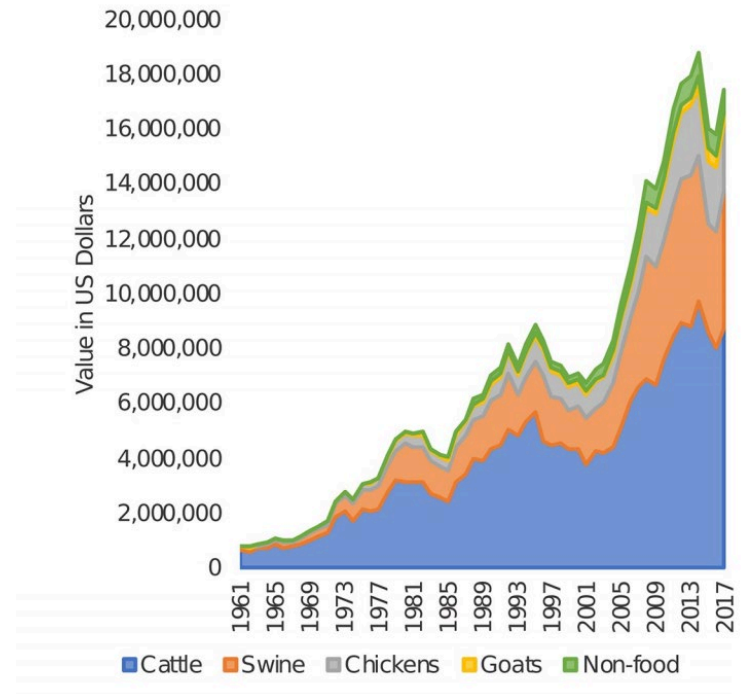


Fig. 1
A simplified schematic of fitness variation of a virus following replication in a constant environment

B. Global trade of live animals



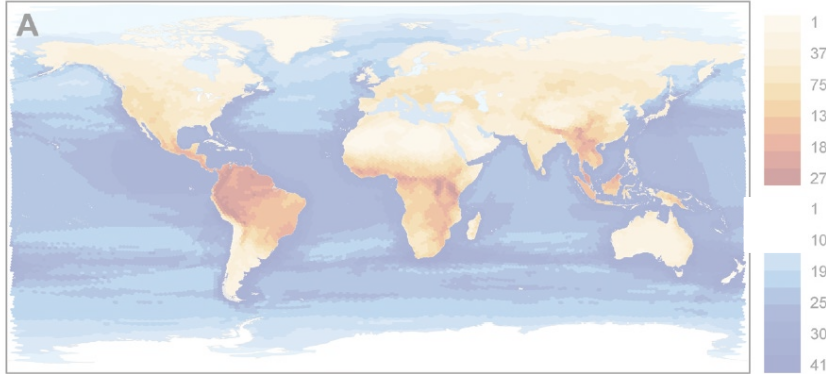
Travao & Nelson 2020 PloS Pathogens

Biodiversity loss

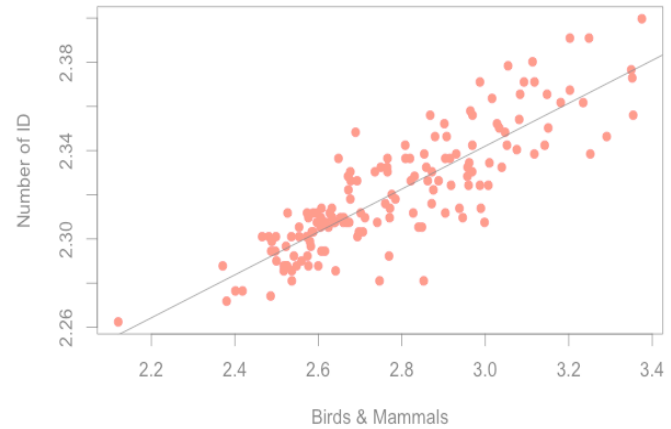
High biodiversity



High number of infectious diseases



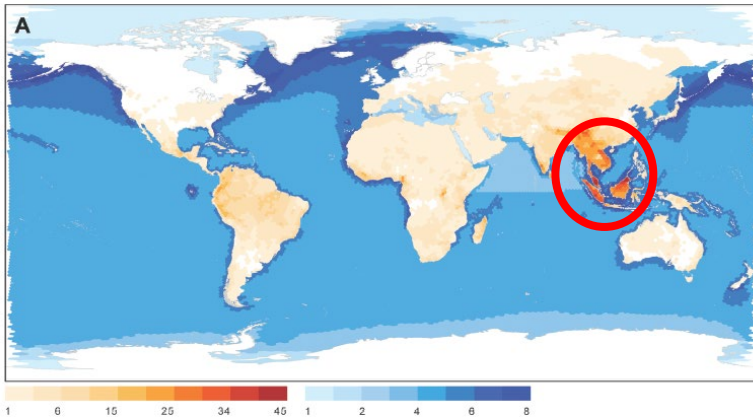
Richesse en espèces de mammifères



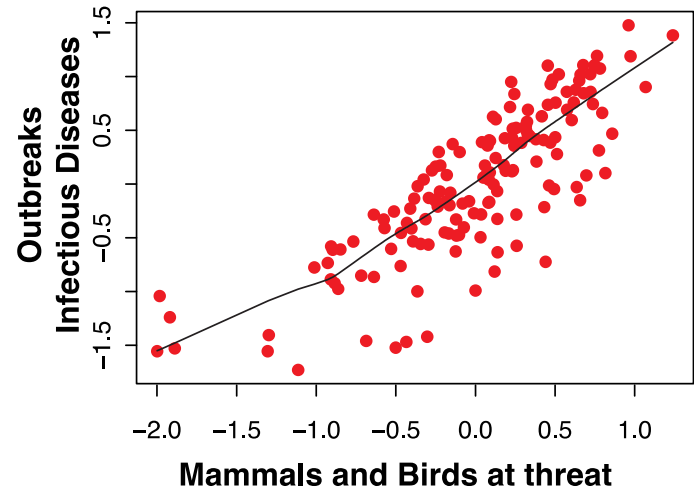
Threat on biodiversity



Higher nb of outbreaks

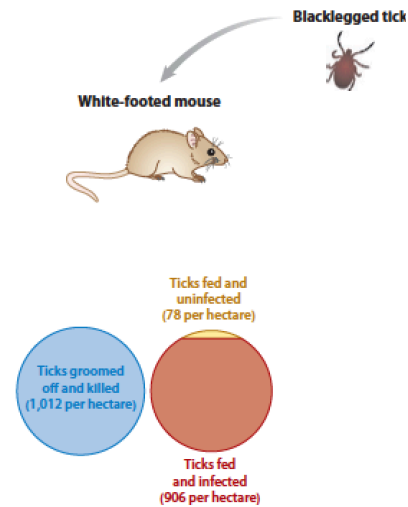


Mammal species at threat

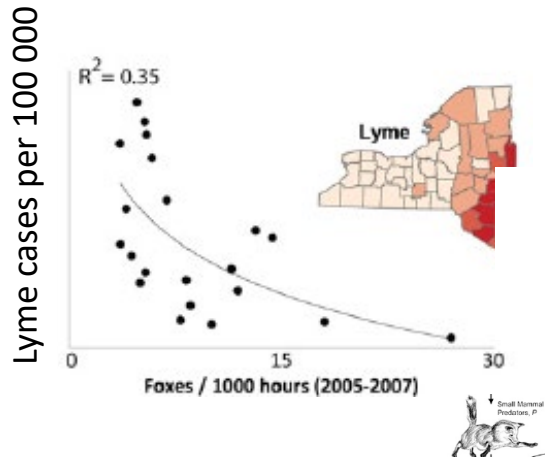


Mammals and Birds at threat

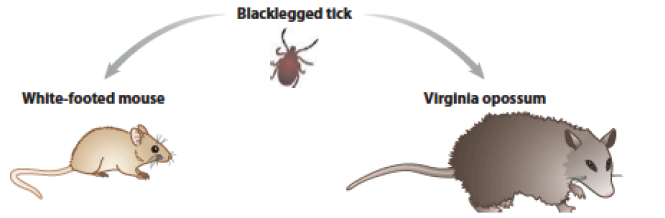
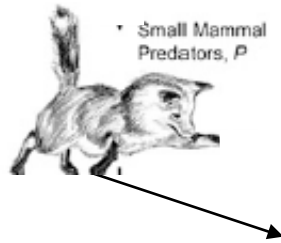
➤ Biodiversity loss – Regulation loss



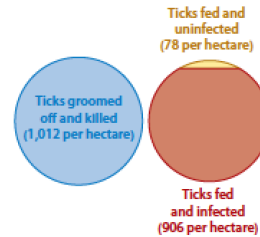
➤ Biodiversity loss – Regulation loss



Predation



Ostfeld 2012. Ann Rev Syst Evol
Levi et al 2012. PNAS



Dilution

Dilution effect is robust across biodiversity gradient involving biodiversity loss
Halliday et al BIORXIV



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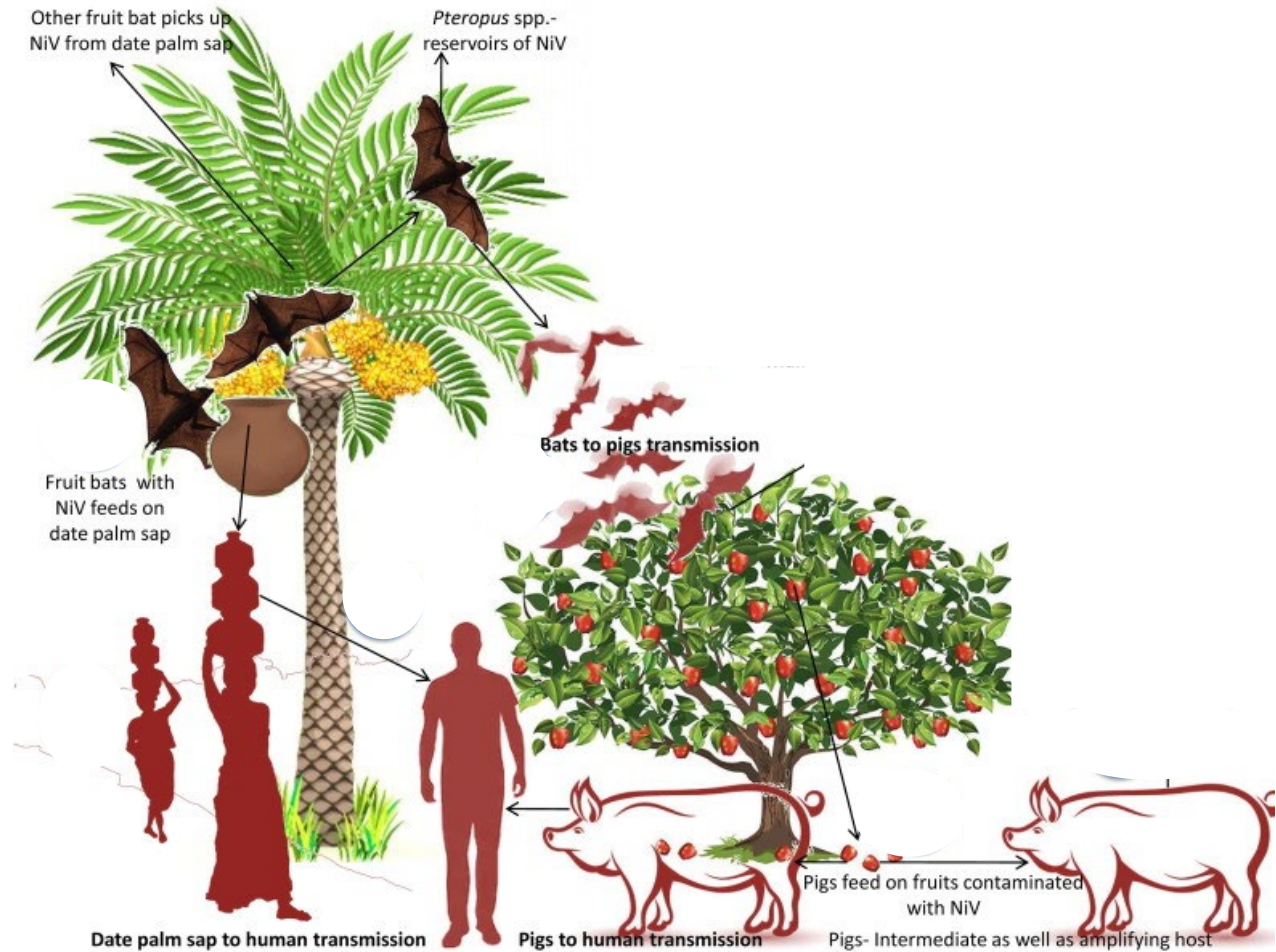
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➤ Landuse change

Virus Nipah, Malysie 1998

Deforestation for palm tree plantation →



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Singh et al 2019 Vet Quater

➤ Wildlife consumption and trade

Wet markets



Bush meat consumption

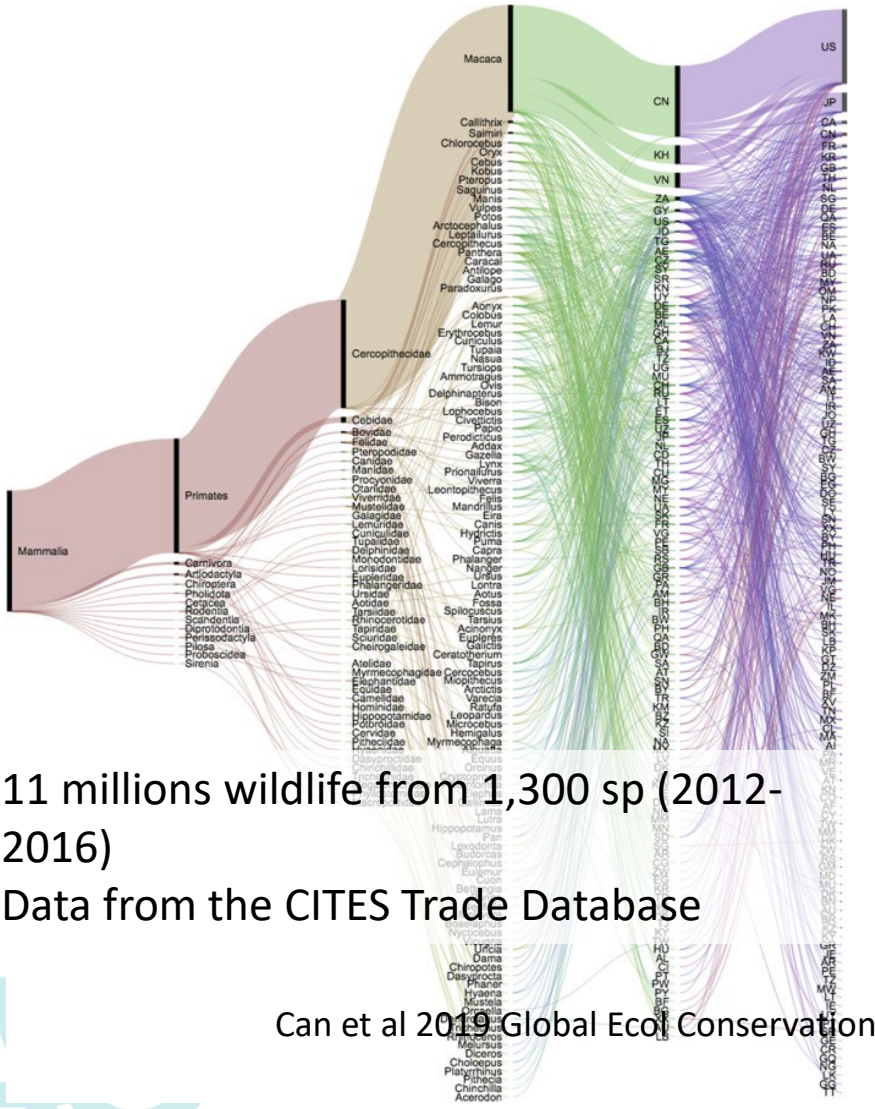


Kurpiers et al 2016 *In Problematic Wildlife*, Springer

Wildlife consumption and trade

Legal trade

Illegal trade

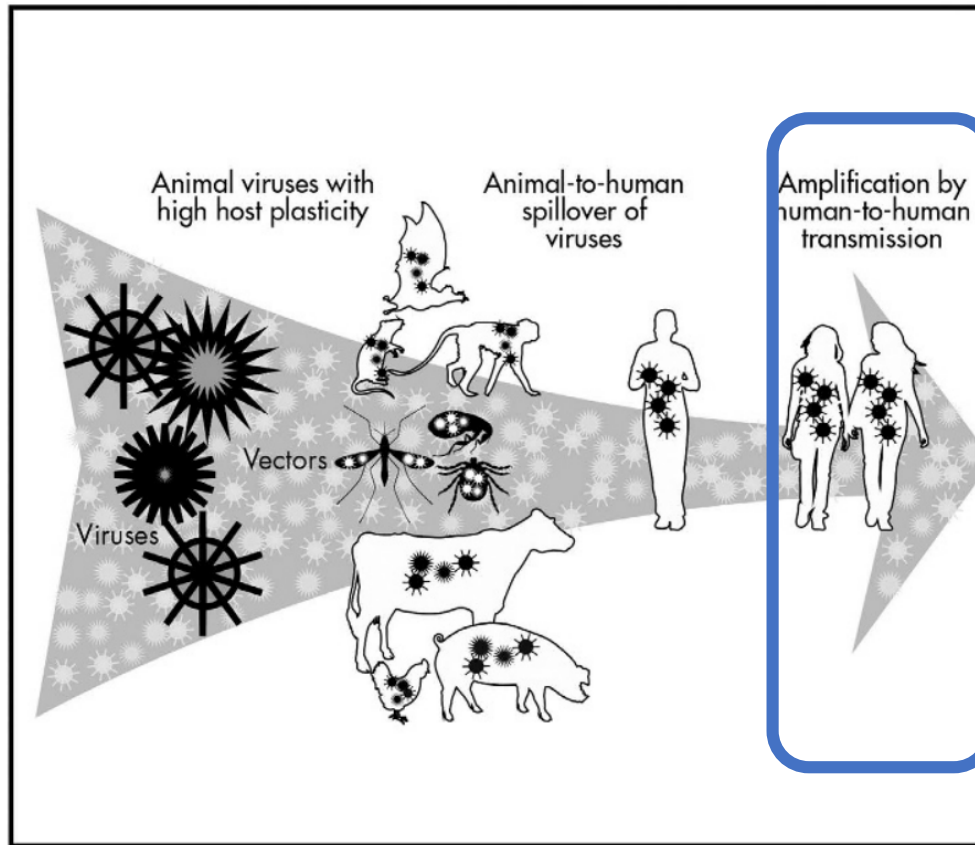


<https://www.traffic.org/site/assets/files/12648/sea-traps-february-2020.pdf>

11 millions wildlife from 1,300 sp (2012-2016)
Data from the CITES Trade Database

Can et al 2019 Global Ecol Conservation

➤ Emergence of zoonoses



Pathogen factors

- ✓ Infectious dose
- ✓ Shedding before symptoms
- ✓ Immune evasion

Human factors

- ✓ Crowding
- ✓ Promiscuity

Environmental factors

- ✓ Poor health care

Figure 1. Pandemic properties of zoonotic viruses that spill over from animals to humans and spread by secondary transmission among humans.

➤ Emergence of zoonoses

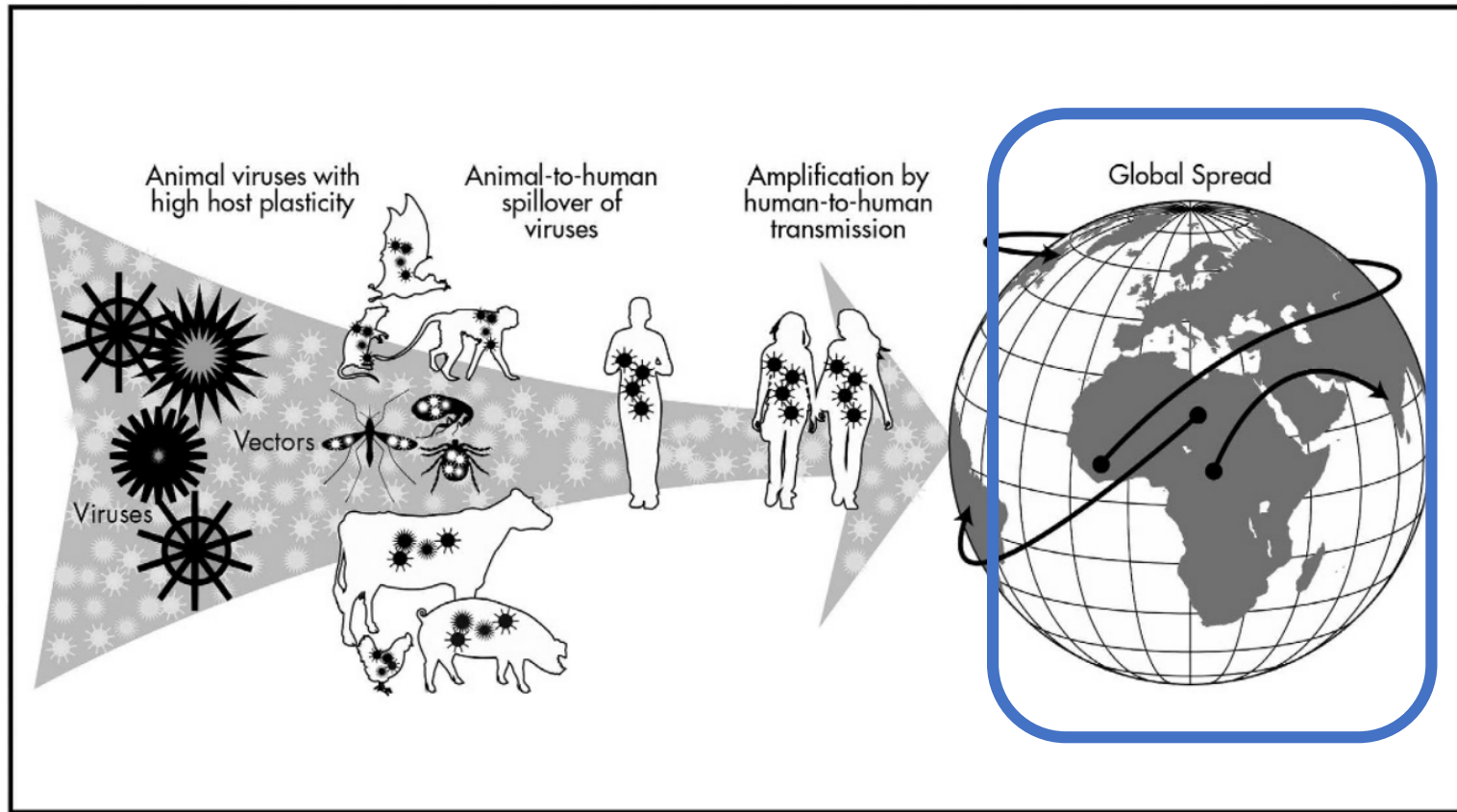
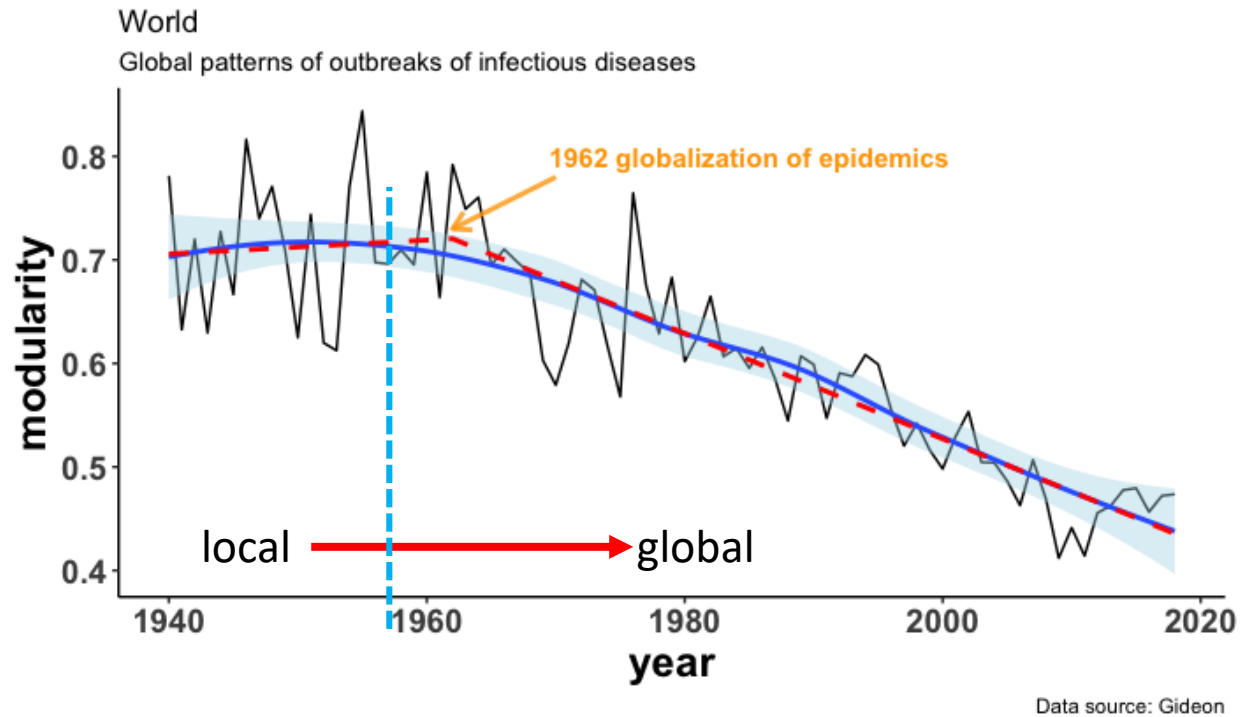


Figure 1. Pandemic properties of zoonotic viruses that spill over from animals to humans and spread by secondary transmission among humans.

➤ Global patterns of outbreaks



Morand 2015. Basics in human evolution; Morand & Walther soumis

➤ Concluding remarks

- ✓ 75% of emerging infectious diseases in humans are from animal origin
- ✓ Human pressure on the environment intensifies exposure of wildlife to human
- ✓ Spread of diseases is accelerated through globalization

What can we do ?

- Early warning and action → preparedness, cooperation
- Limit wildlife – human interface
 - market / trade / bushmeat → balance between prohibition, regulation and support
 - human disturbance of habitats → reduce human footprint, relocalisation
- Need of integrated approach of health and ecological crises
- Foster resilient socio-ecosystems regarding sanitary and ecological risk



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➤ Thank you for your attention

Thanks to, Jean-François Guégan (INRAE, IRD) and Serge Morand (CNRS, CIRAD) for their inputs