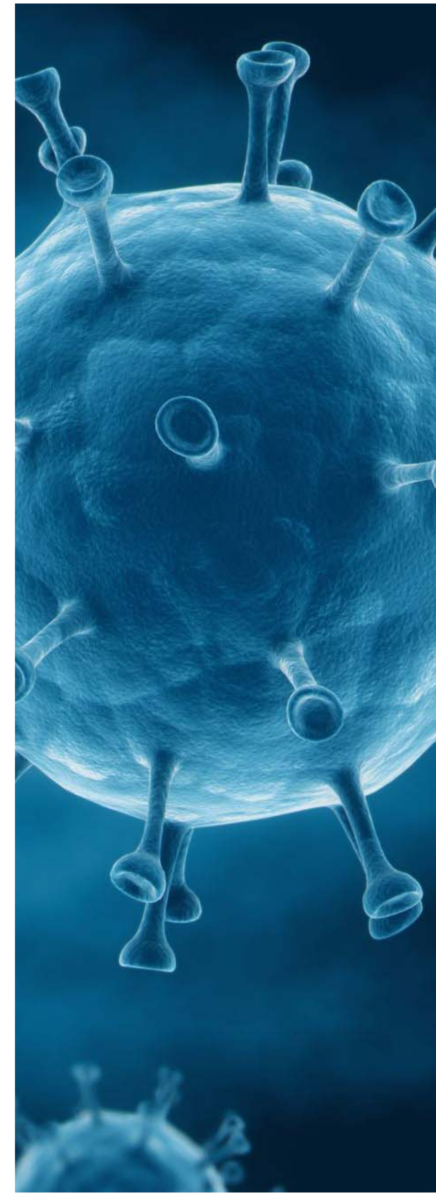
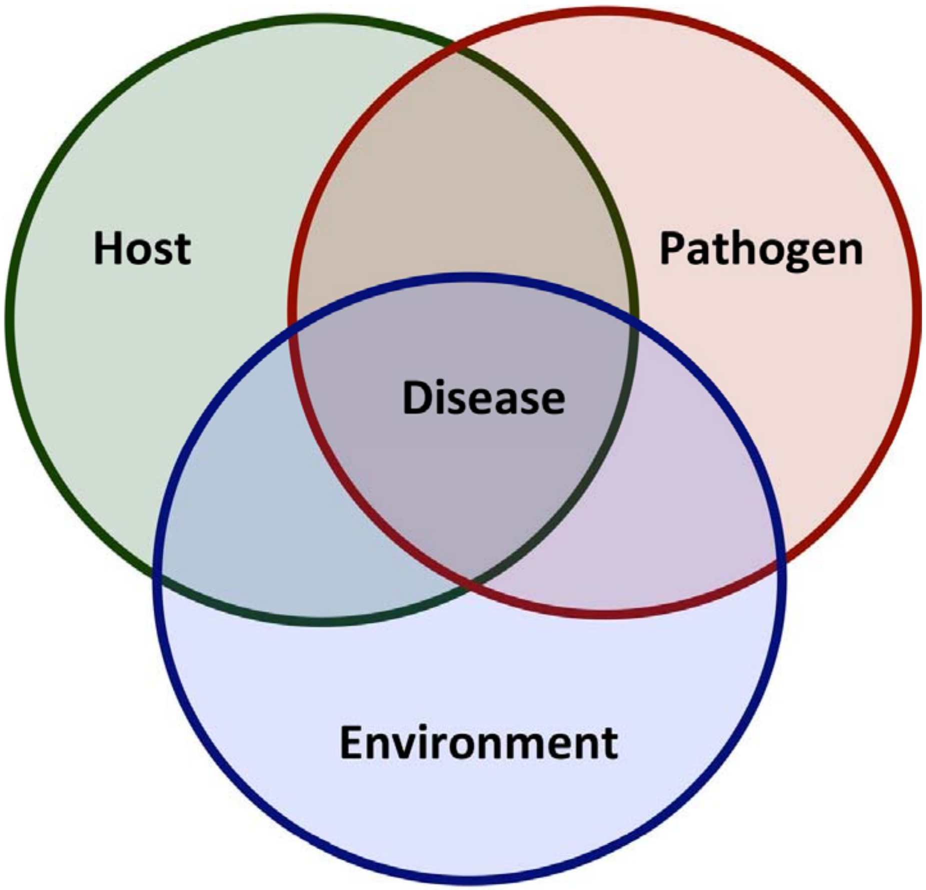
Environmental Impact on the Viruses & the diseases

Vipin M. Vashishtha, MD, FIAP
Director & Pediatric Generalist,
Mangla Hospital & Research Center,
BIJNOR-2646701 (UP)





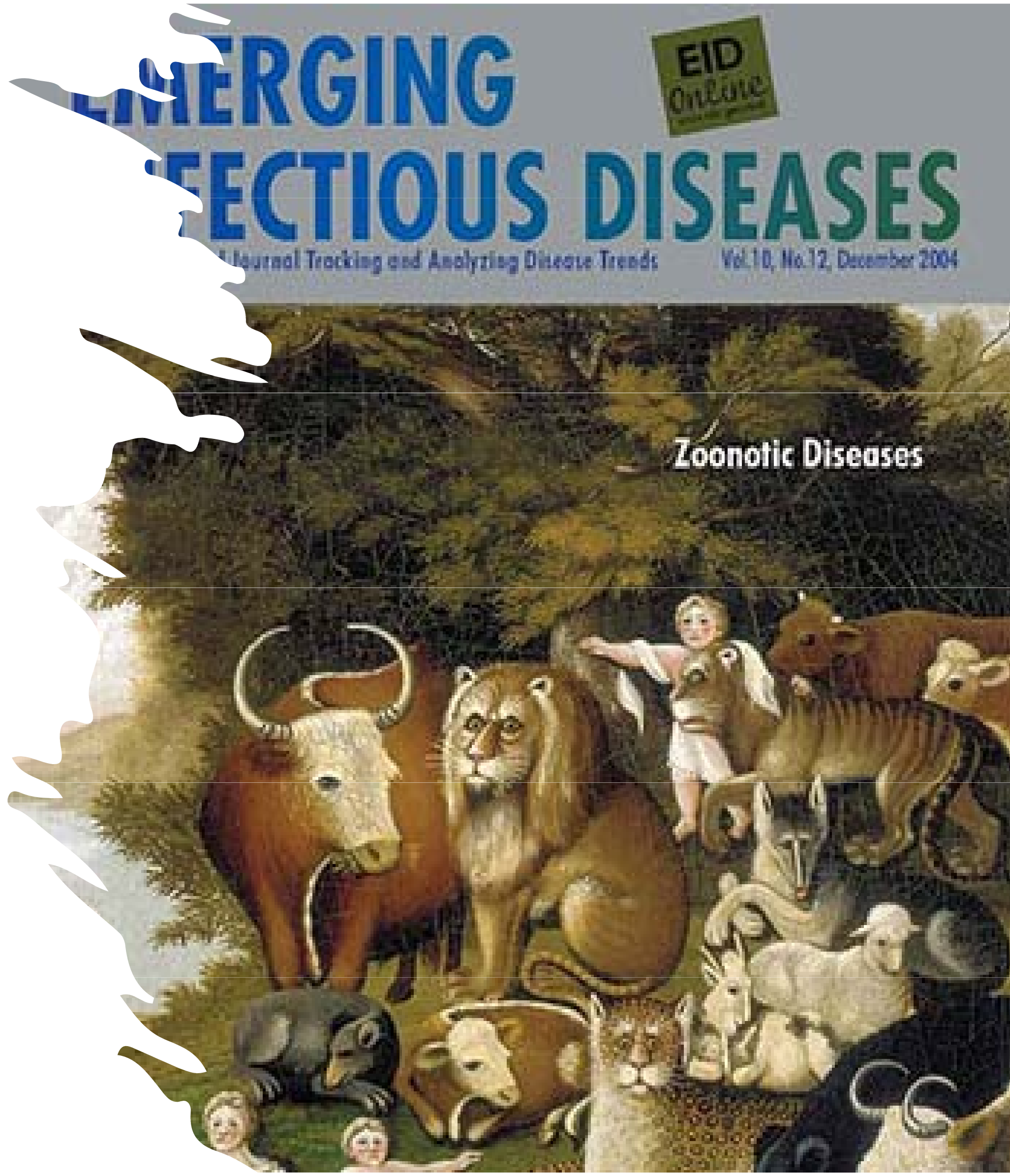
Pathogen factors
- ✓ Infectious dose
- ✓ Shedding before symptoms
- ✓ Immune evasion

Human factors
- ✓ Crowding
- ✓ Promiscuity

Environmental factors
- ✓ Poor health care

75%

of emerging diseases in human are of animal origin



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

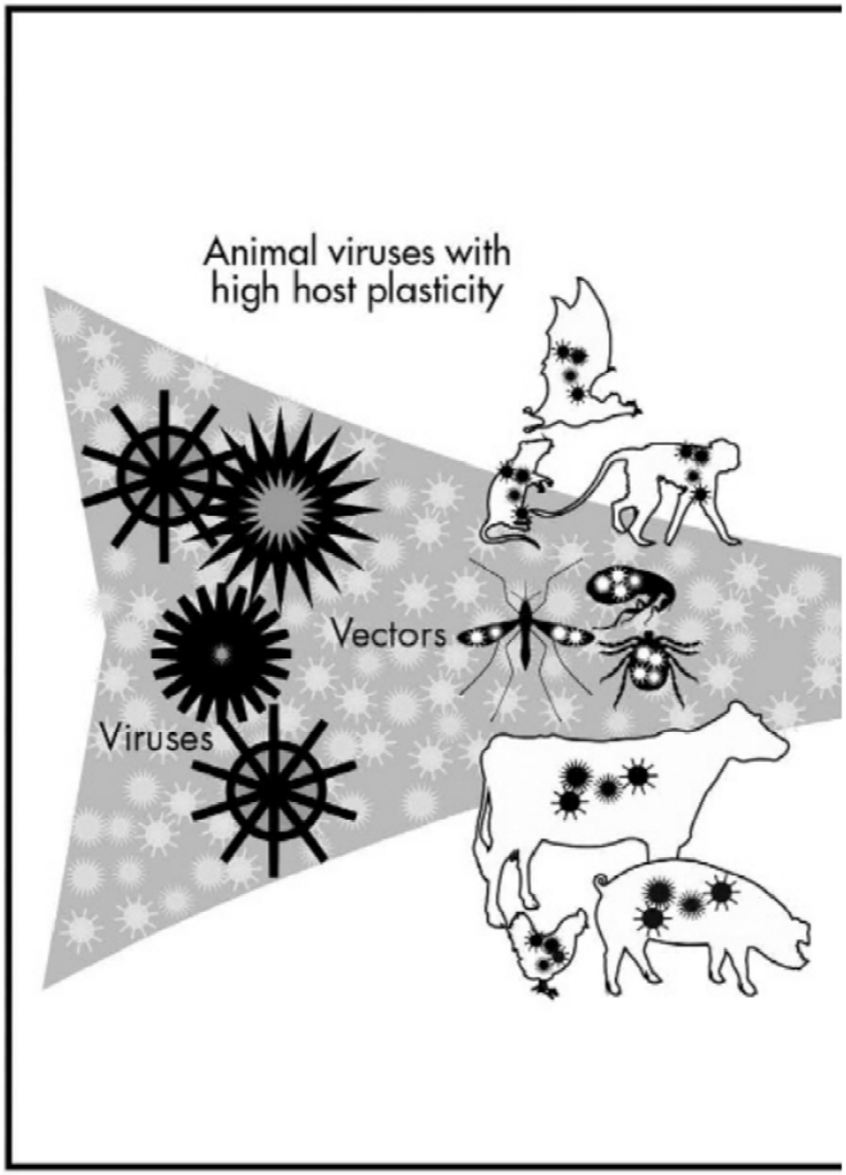
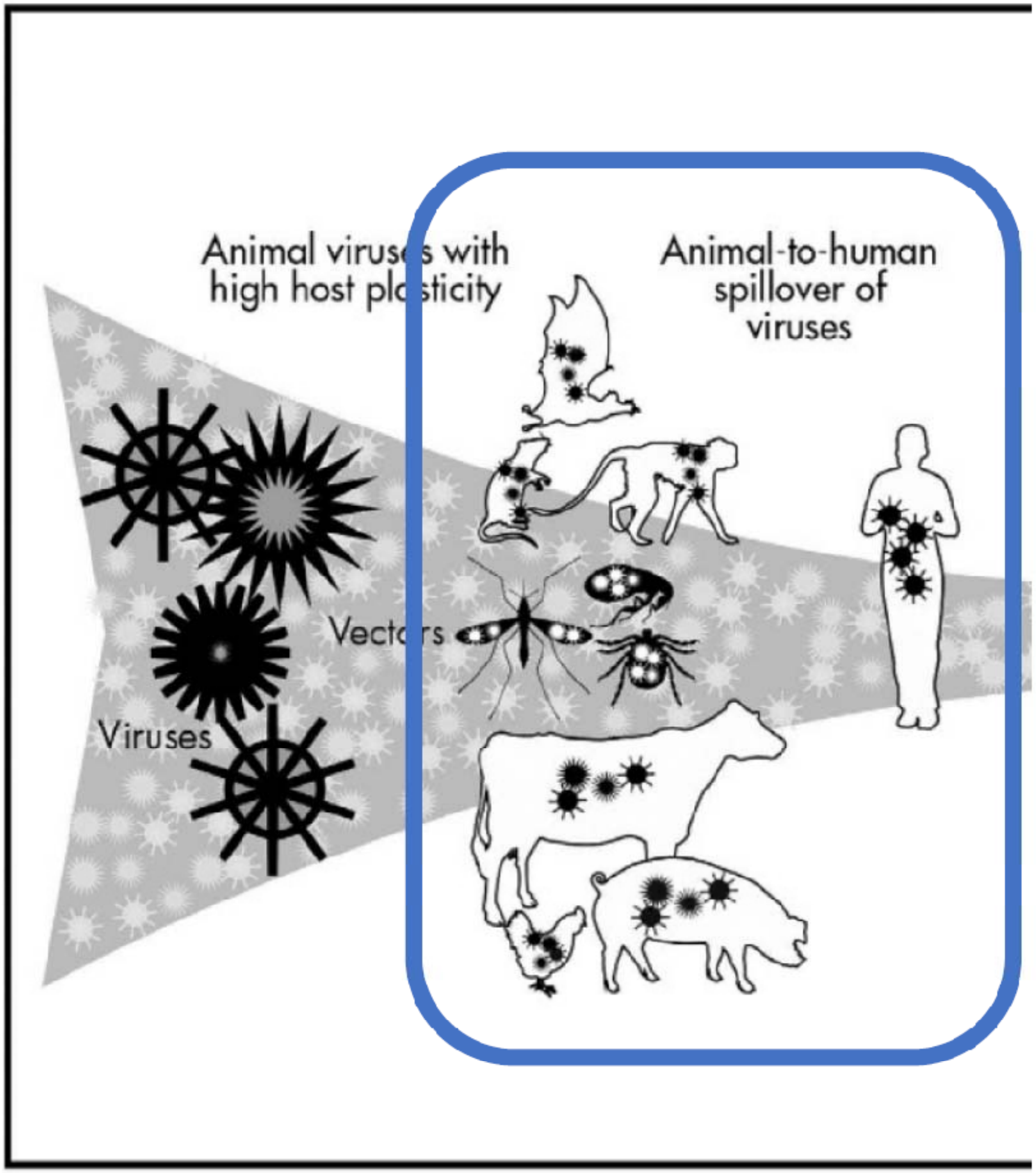
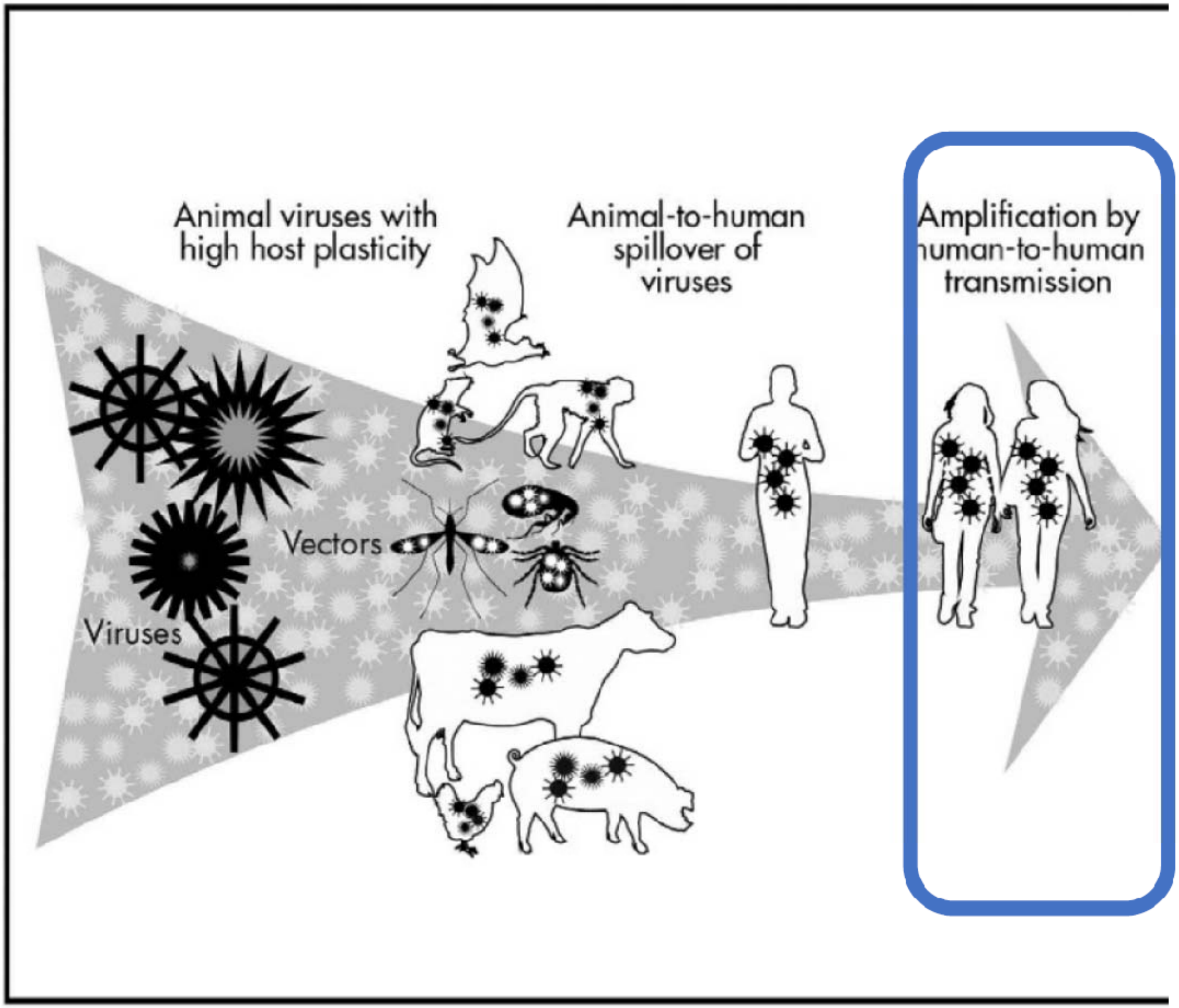


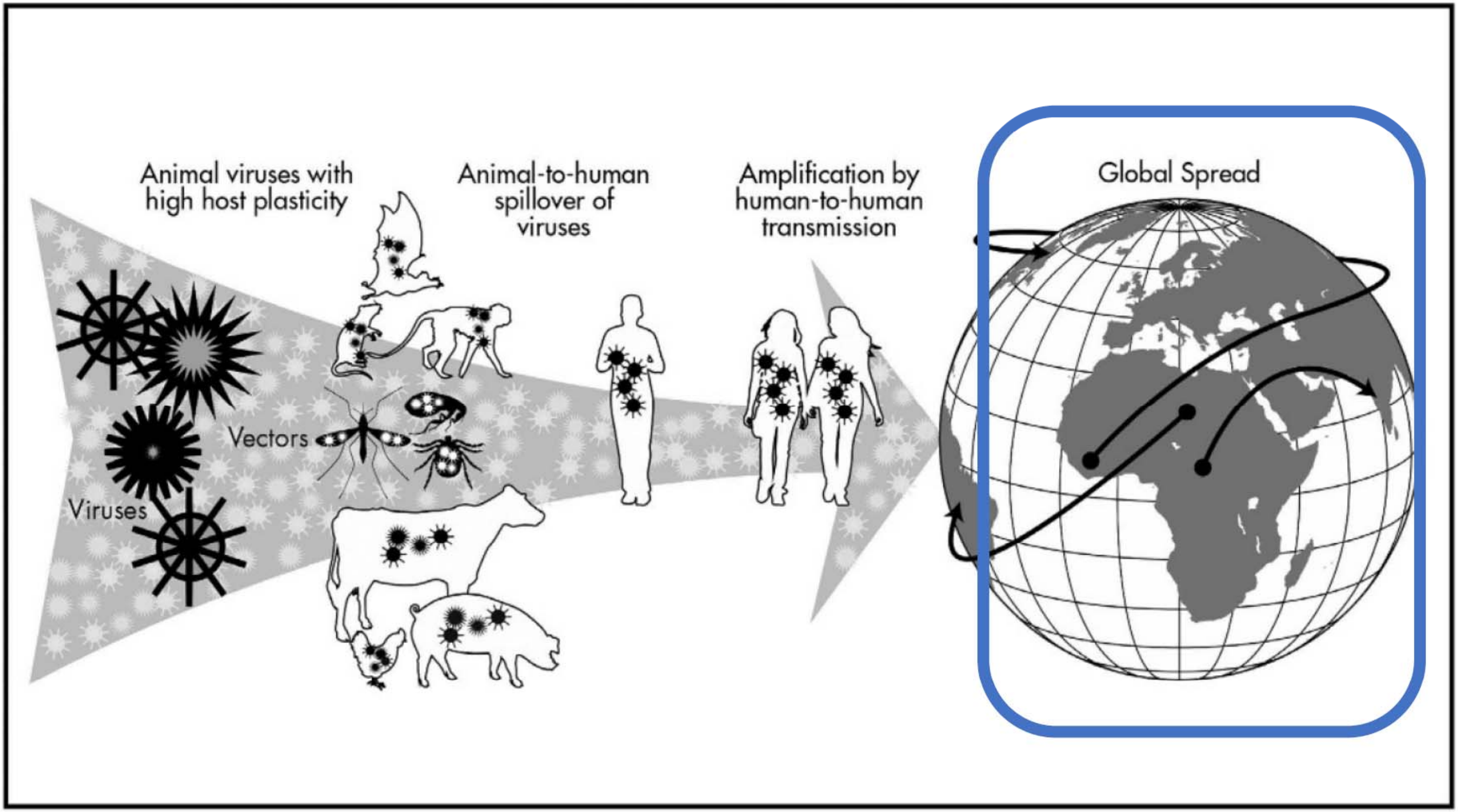
Figure 1. Pandemic properties of zoonotic viruses that spill over from animals to humans and spread by secondary transmission among humans. Key characteristics of pandemic potential that were evaluated

Kreuder et al 2015 Scientific Report

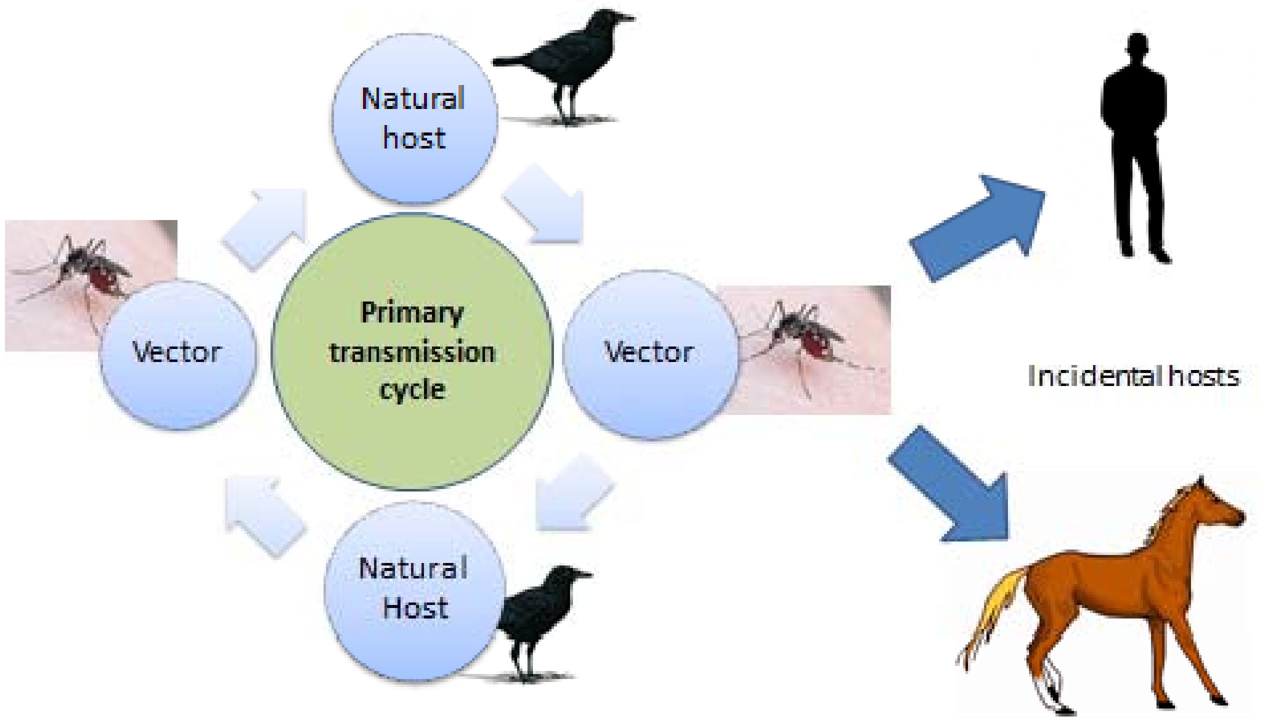


Animal viruses with high host plasticity
Animal-to-human spillover of viruses
Vectors
Viruses


Animal viruses with high host plasticity
Animal-to-human spillover of viruses
Amplification by human-to-human transmission
Vectors
Viruses


Animal viruses with high host plasticity
Animal-to-human spillover of viruses
Amplification by human-to-human transmission
Global Spread
Vectors
Viruses

Transmission Cycle of Vector borne zoonoses

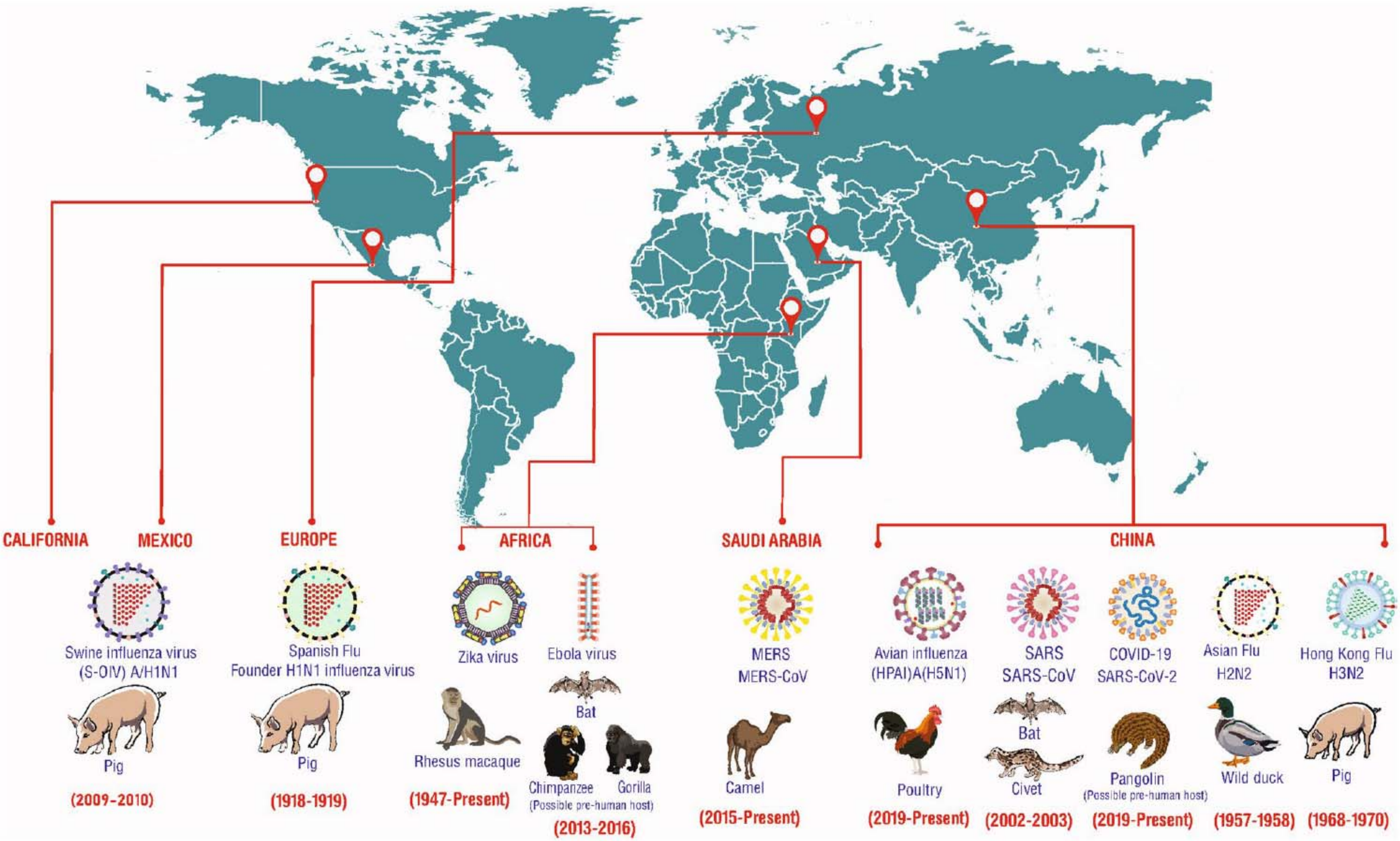


Major global & regional vector-borne diseases

Disease	Pathogen	Primary vector(s)	Primary non-human reservoir (competent) hosts
Malaria	*Plasmodium* parasite	*Anopheles* mosquito	Non-human hosts of minor concern
Dengue*	Flavivirus	*Aedes aegypti* and *Aedes albopictus* mosquitoes	Non-human hosts of minor concern
Yellow fever	Flavivirus	*A. aegypti* and *A. albopictus* mosquitoes	Non-human primates
Zika	Flavivirus	*A. aegypti* and *A. albopictus* mosquitoes	Non-human hosts of minor concern
Chikungunya*	Alphavirus	*A. aegypti* and *A. albopictus* mosquitoes	Non-human hosts of minor concern
Lymphatic filariasis*	Various filarial nematodes	A variety of mosquito genera	Non-human hosts of minor concern
Schistosomiasis*	*Schistosoma* trematode	Snail	Non-human hosts of minor concern
Onchocerciasis*	*Onchocerca volvulus* nematode	*Simulium* (black fly)	None
Chagas disease*	*Trypanosoma cruzi* parasite	Triatomine bug	Mammals
Leishmaniasis*	*Leishmania* parasite	Sand fly	Rodents, dogs, other mammals
Japanese encephalitis	Flavivirus	*Culex* mosquitoes	Pigs, birds
African trypanosomiasis*	*Trypanosoma brucei* parasite	*Glossina* (tsetse fly)	Wild and domestic animals
Lyme disease	*Borrelia* spirochete	*Ixodes* ticks	White-footed mouse and other small mammals, birds
Tick-borne encephalitis	Flavivirus	*Ixodes* ticks	Small rodents
West Nile fever	Flavivirus	*Culex* mosquitoes	Birds

https://www.nature.com/articles/s41590-020-0648-y.pdf

Major pandemic/outbreaks in the recorded history



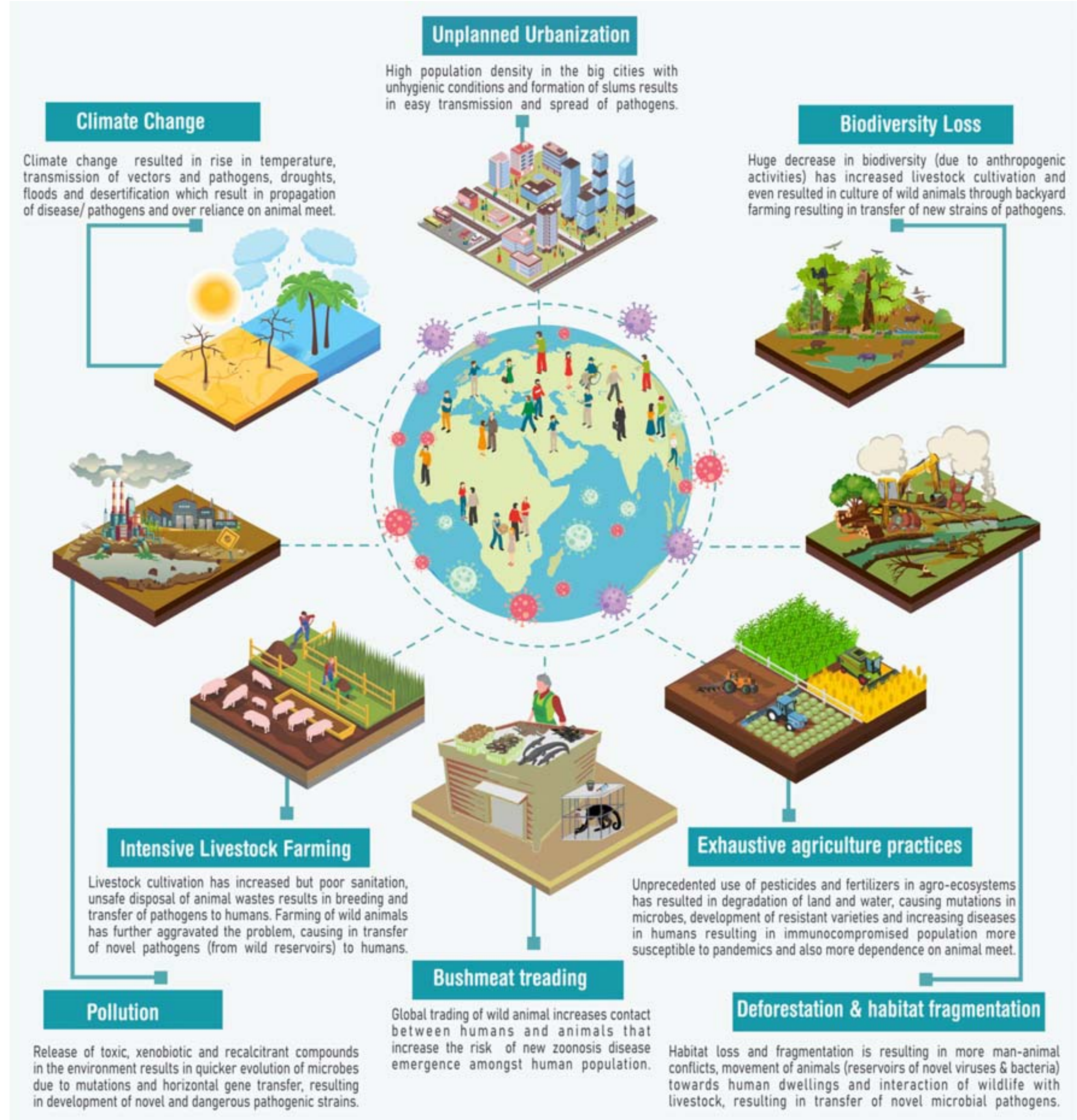
https://link.springer.com/article/10.1007/s42398-021-00165-x

Why is there frequent emergence of novel zoonotic outbreaks?

- Changing global environment
- Destruction of **natural habitats of wild animals**, possible reservoirs of novel human pathogen
- An increase in **man-animal conflicts** is being directly

In one of its report, FAO mentioned that >70% of human diseases are of animal origin, & have a direct relation with humans' reliance on animals for food

https://link.springer.com/article/10.1007/s42398-021-00165-x



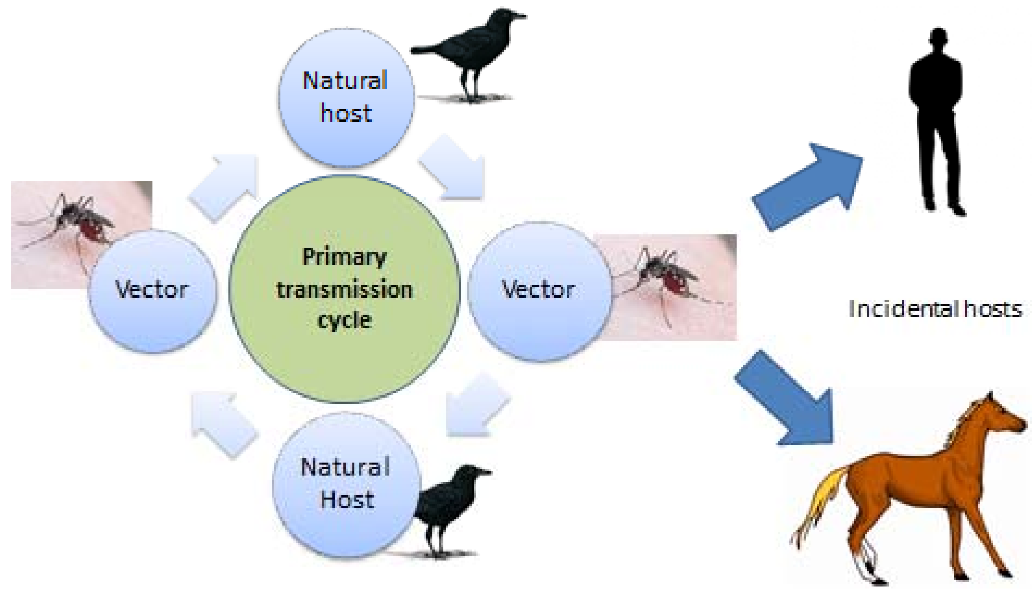
Environmental issues that lead to the pandemic

https://link.springer.com/article/10.1007/s42398-021-00165-x

How are the environmental factors becoming important in relation to the emergence & spread of novel viruses?

Climatic conditions

- In tropics change in climatic conditions have led to the **intensive spread of the carriers/vectors of zoonotic viruses** which increased the transition of viruses from their carrier to the animal host



Armon R, Cheruti U (2012) Environmental aspects of zoonotic diseases. IWA Publishing, London

Impact of climatic conditions

- **WNV:** Changes in temperature caused an adaptive mutation in the West Nile virus (WNV) in North America to efficiently propagate virus at elevated temperatures
- Brault AC (2009) Changing patterns of West Nile virus transmission: altered vector competence and host susceptibility. Vet Res 40:43

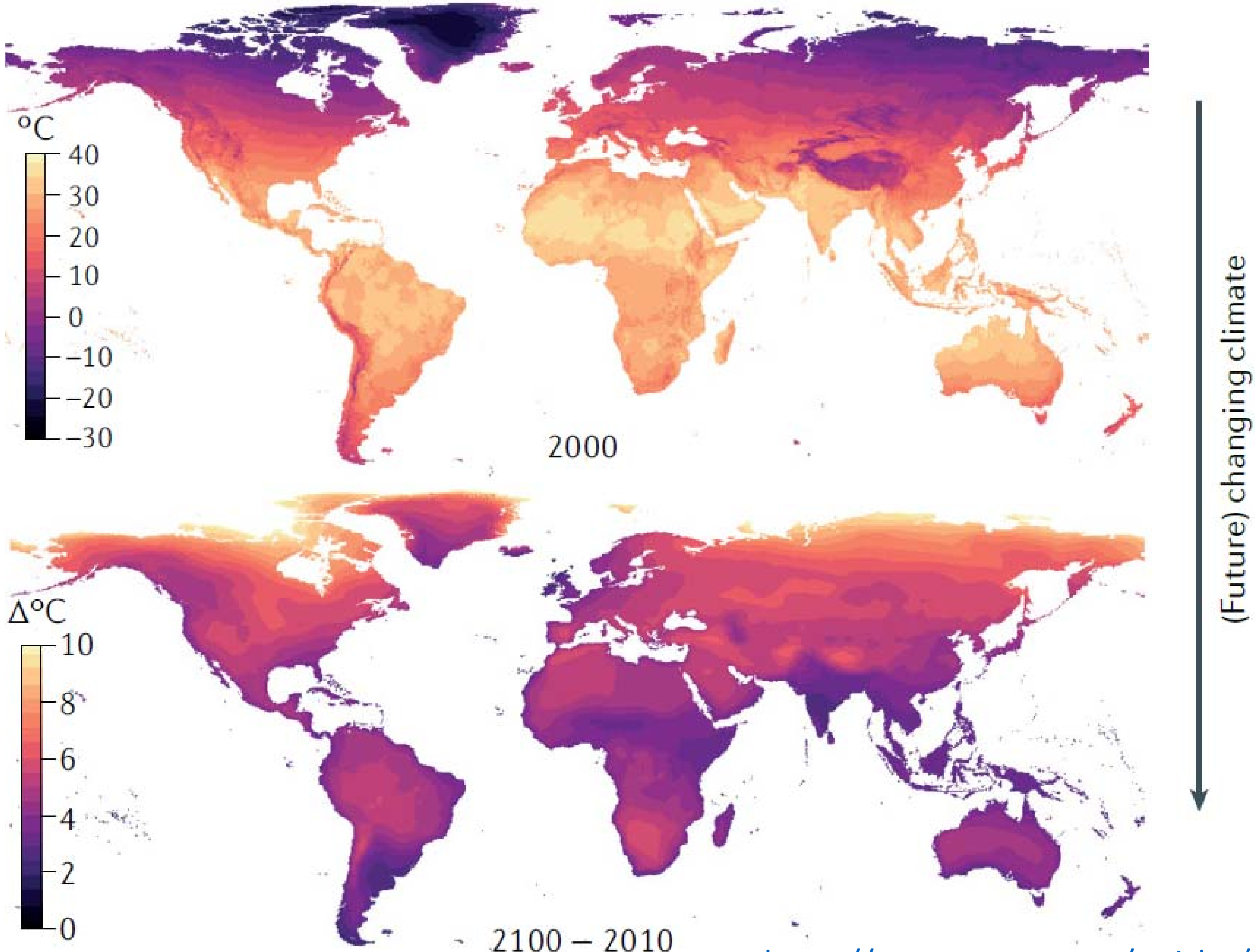
- **MERS-CoV:** 56.1% of the positive cases aroused between April to August, & the viability of the virus was favored by high temperature, high ultraviolet index, low wind speed, and low relative humidity
- Altamimi A, Ahmed AE (2019). J Infect Public Health 13:704–708

Climatic conditions: Heat & relative humidity

SARS-CoV-2:

- Most studies on the effects of temperature, and relative humidity on disease incidence and spread remain to be **contradictory or inconclusive**, with data showing positive as well as negative relation or in some researches no relationship at all

Prata et al. 2020; Sobral et al. 2020; Yao et al. 2020.

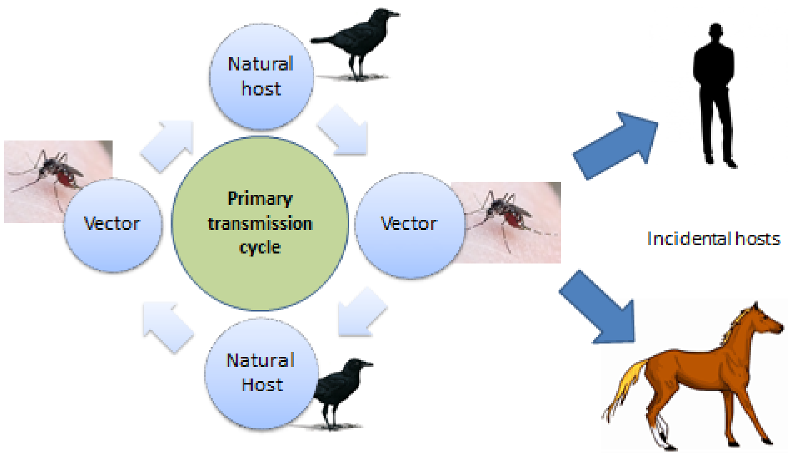


https://www.nature.com/articles/s41579-021-00639-z

Impact of global warming

- Increase in global temperature in the past few decades & future projections (of ~ 3°C rise by 2050) have & will result in the transfer of vectors of human pathogens & reservoirs (as well) in **unreported regions** of the world!

- **Spread of dengue virus in southern Europe is a classic example!**

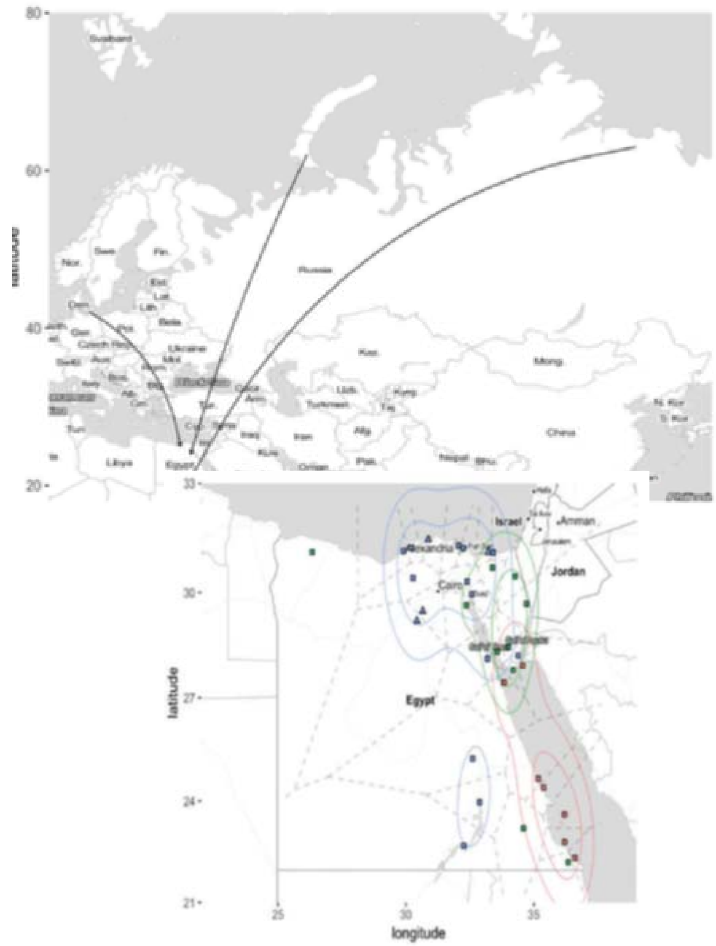


Caminade C, et al. (2019) Ann N Y Acad Sci 1436):157–173; Parkinson AJ, et al. (2014) Int J Circumpolar Health

Impact on Influenza epidemics

- Spread of Flu from one continent to another is linked with climate-driven changes.

- In case of H5N1 transmission, it was found that climatic factors (like temperature, relative humidity, & wind speed) **changed the migration patterns in migratory birds** which increased avian flu outbreaks in some regions in Egypt



Naguib MM, et al. (2019). Infect Ecol Epidemiol

Impact of Heat stress on viral genome

- Sequencing revealed that thermotolerance occurred via a **key mutation in gene** P5 (viral lysis protein), previously shown to be associated with heat shock survival in the virus.
- robust populations adapted faster to the environmental change, and more easily accessed mutations of large benefit.
- ....genetic robustness can play a role in determining the relative ability for microbes to adapt to changing environments
- **N501Y substitution of SARS2 provides higher fitness against tropical high temperature**

https://www.frontiersin.org/articles/10.3389/fmicb.2014.00035/full

Extreme weather extremes: floods and droughts

- The occurrence of floods, due to unpredictable & heavy rains has been indirectly linked with **high incidences of vector-borne disease**.
- For instance, there were more outbreaks of **Dengue, WNV, & malaria** due to heavy rainfall and flooding in Romania (1996–97), Czech Republic (1997), Italy (1998), southern Africa (2000), and some parts of Southeast Asia (2011)

https://link.springer.com/article/10.1007/s42398-021-00165-x

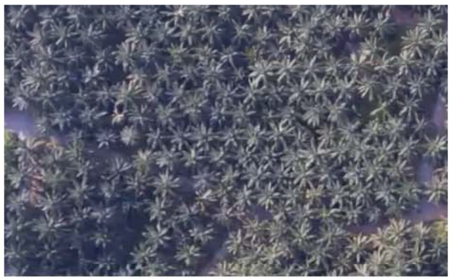
Biodiversity loss

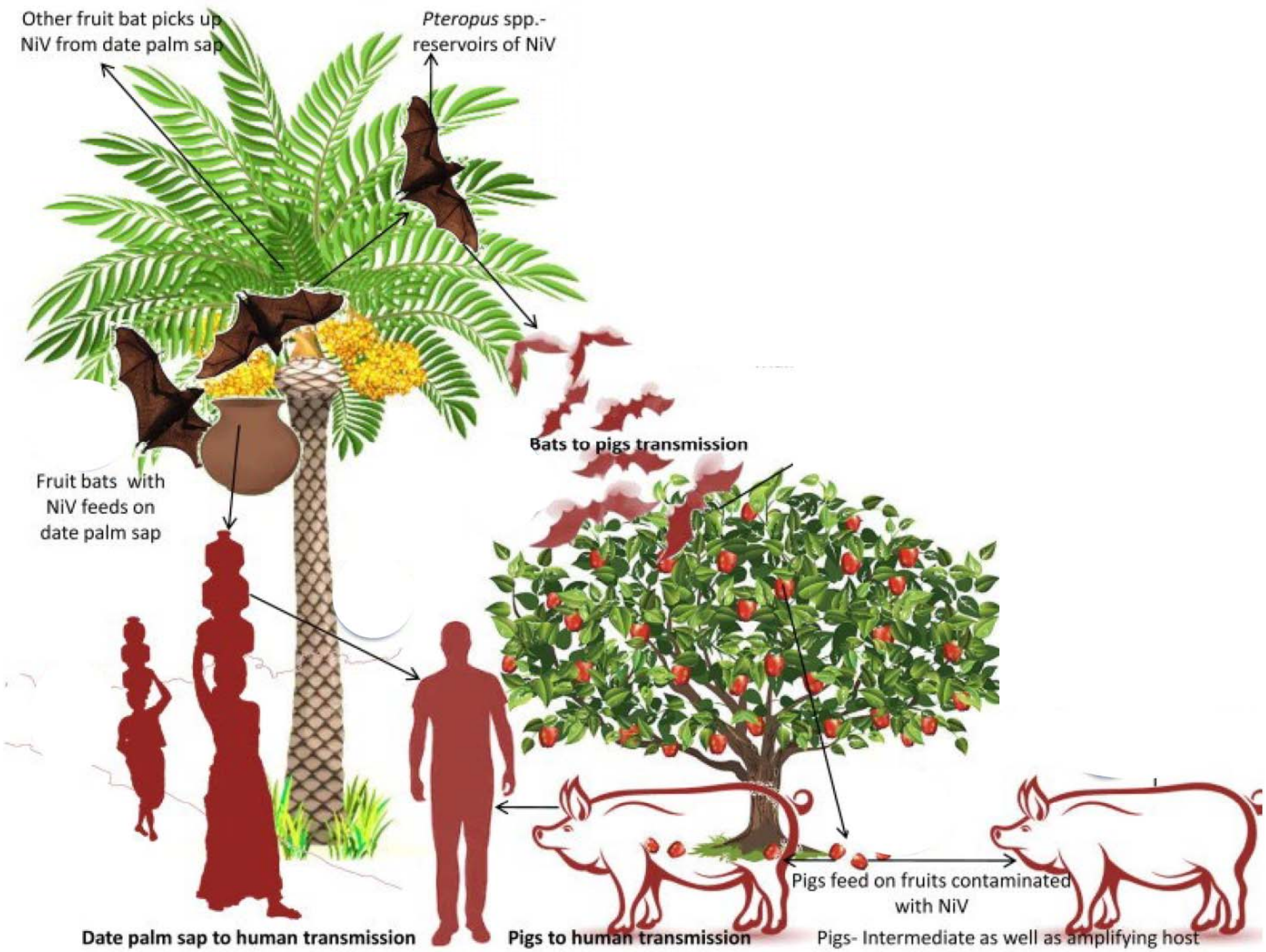
- Biodiversity loss makes an ecosystem more fragile and possible breach by the pathogens to humans becomes much easier.
- Biodiversity loss is correlated with a decrease in forest cover, increased human-animal conflicts, upsurge in livestock farming, and cultivation of wild animals.
- Sudden changes in species diversity can also result in an upsurge of novel pathogens.
  - **Nipah virus outbreak** in Malaysia in the late 1990s is an ideal example
  - **Hantavirus outbreaks** followed after a decline in the diversity of small mammals' reservoir (rodent) increased the prevalence of viruses

Suzán G, et al. (2009). PLoS ONE 4(5):e5461

Virus Nipah, Malaysie 1998

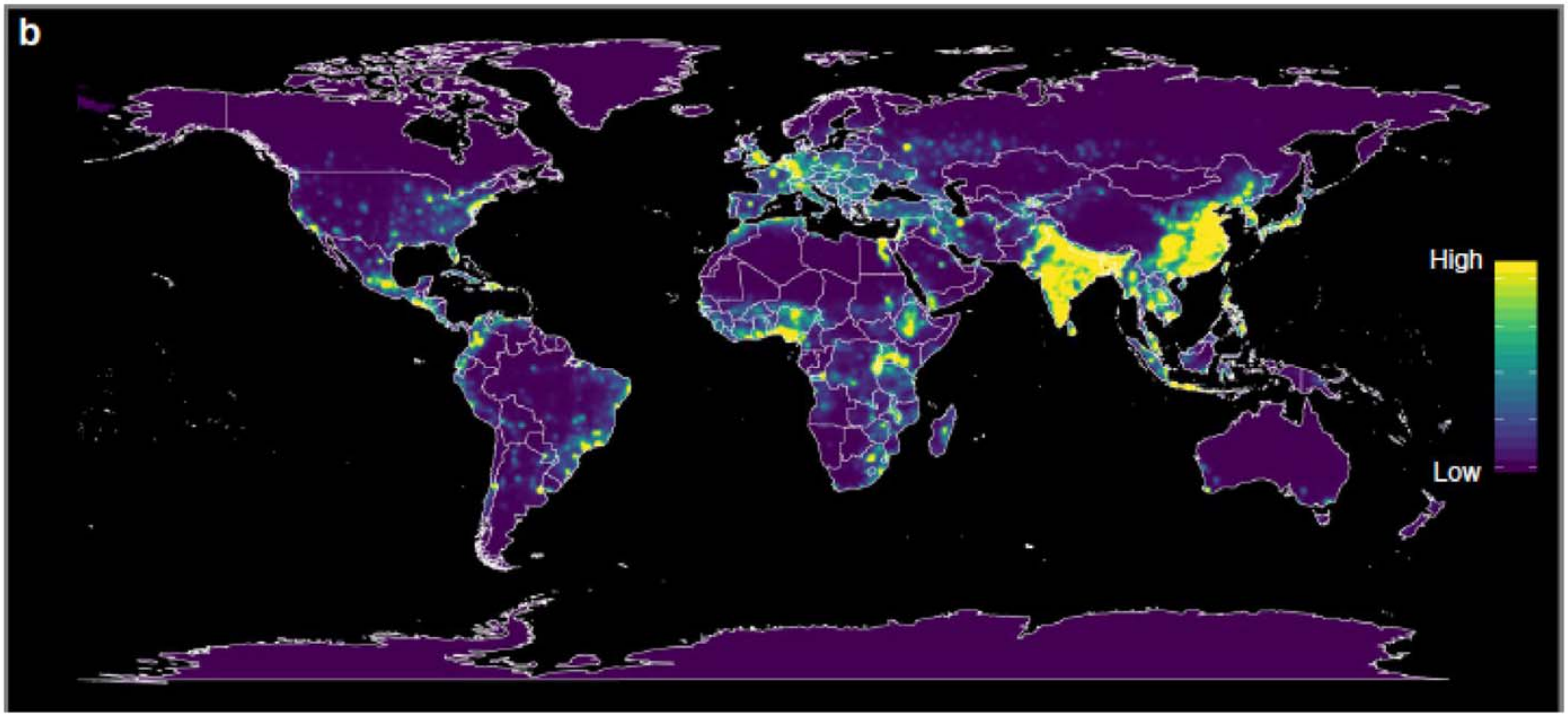
Deforestation for palm tree plantation →





Singh et al 2019 VetQuater

Risk of emerging zoonosis in humans



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

Allen et al 2017 Nature communication

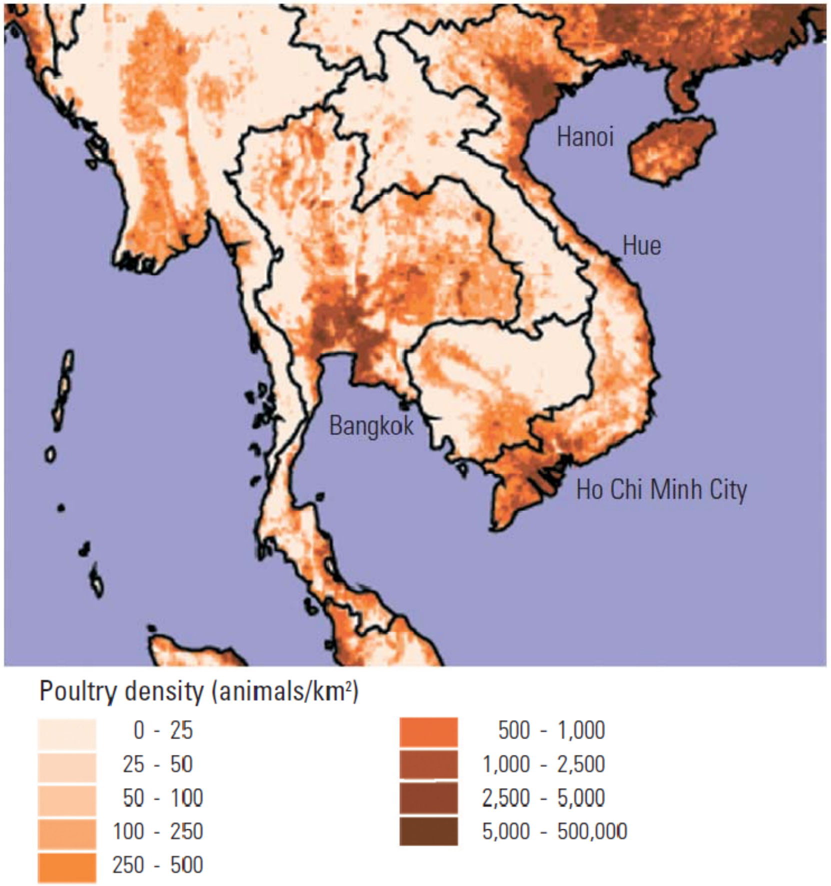
Anthropogenic factors

- Intensive livestock production
- Exhaustive agricultural practices
- Urbanization
- Globalization
- Pollution

Intensive poultry production in Southeast Asia

- Intensive poultry production in Southeast Asia led to the highly pathogenic **Avian Influenza** upsurge early in 2004

Estimated poultry density in Thailand, Laos and Vietnam (animals per km2)



Slingenbergh J, et al. Ecological sources of zoonotic diseases. Rev Sci Tech 23:467–484

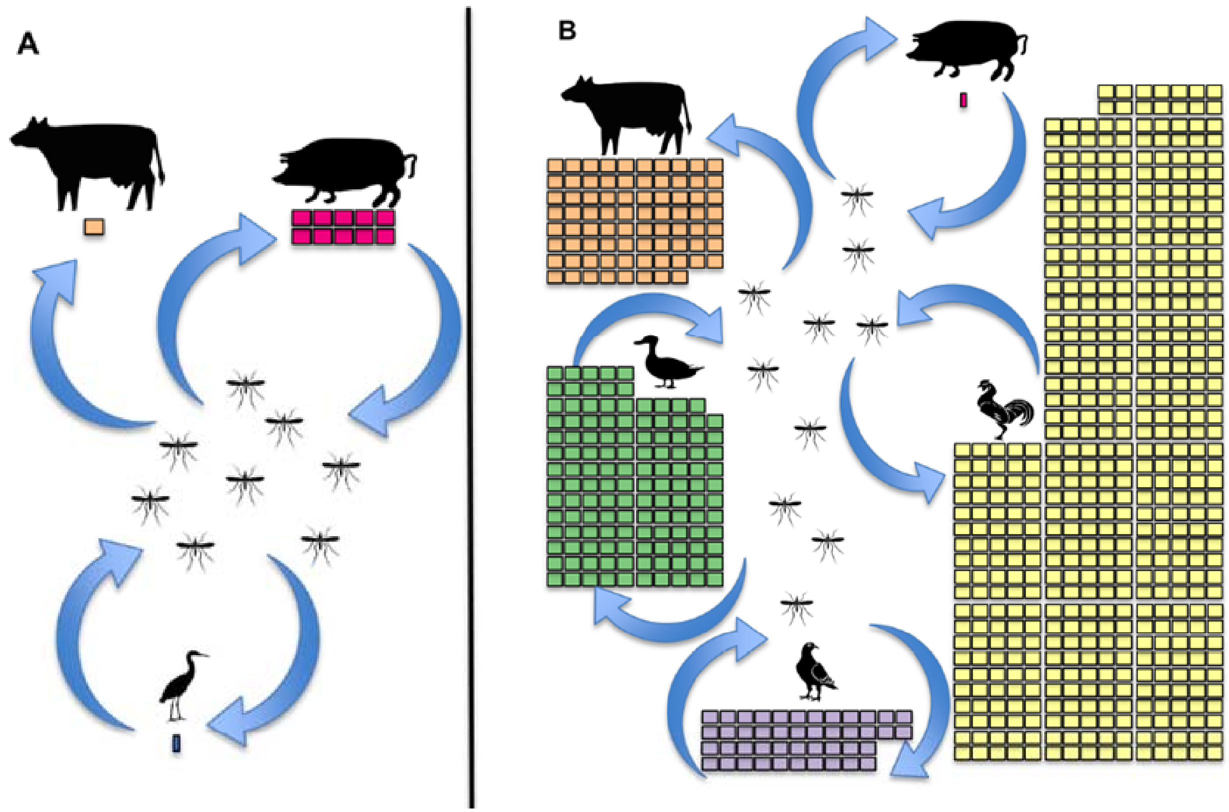
Japanese encephalitis virus (JEV) outbreaks in Southeast Asia

- In the case of JE virus outbreaks in Southeast Asia, **increased production of irrigated rice and pig farming** were reported as major anthropogenic factors to induce disease prevalence

van den Hurk AF, et al. Annu Rev Entomol. 2009;54:17-35

JE Virus Transmission: Changing trends

Outbreaks of JE in the 1950s in Saitama Prefecture, Japan



JE-endemic regions of India & B'Desh

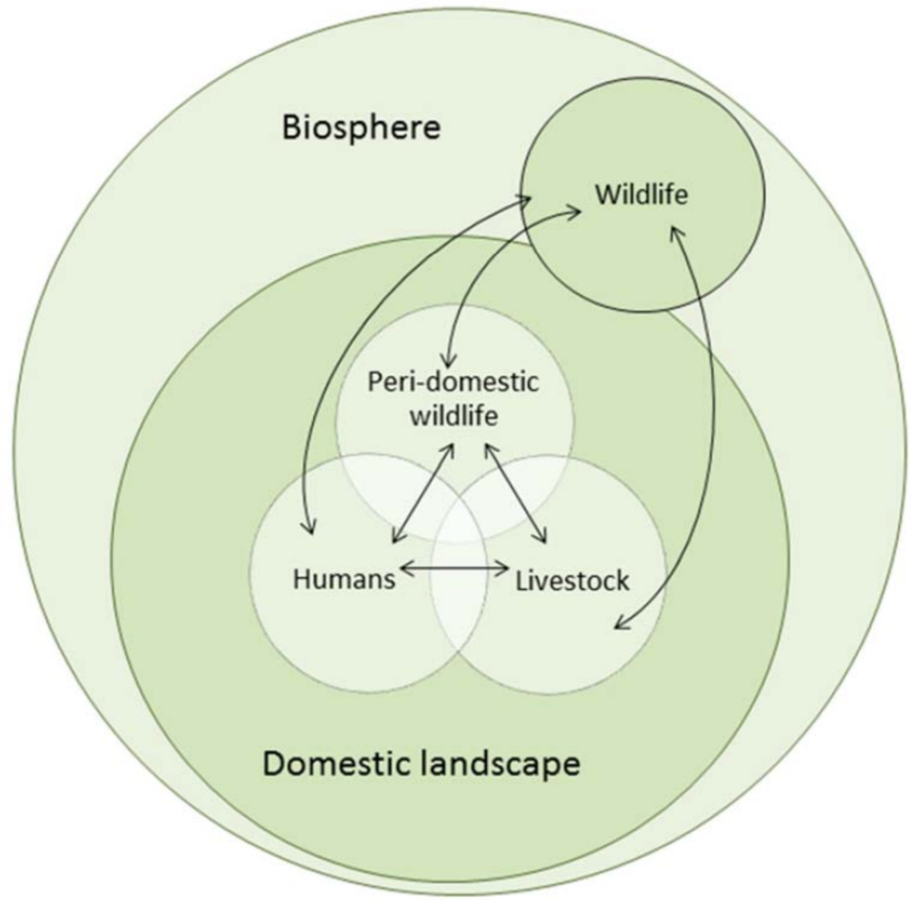
Lord JS, Gurley ES, Pulliam JR. PLoS Negl Trop Dis. 2015 ;9(12):e0004074; Viruses. 2021 Feb 24;13(3):357

Role of agricultural intensification &/or environmental changes

- *"In the near future rate of zoonotic disease emergence or re-emergence will be closely linked to the evolution of the agriculture–environment nexus"*

Proc Natl Acad Sci USA 110:8399–8404

Pathogen flow at the wildlife–livestock–human interface



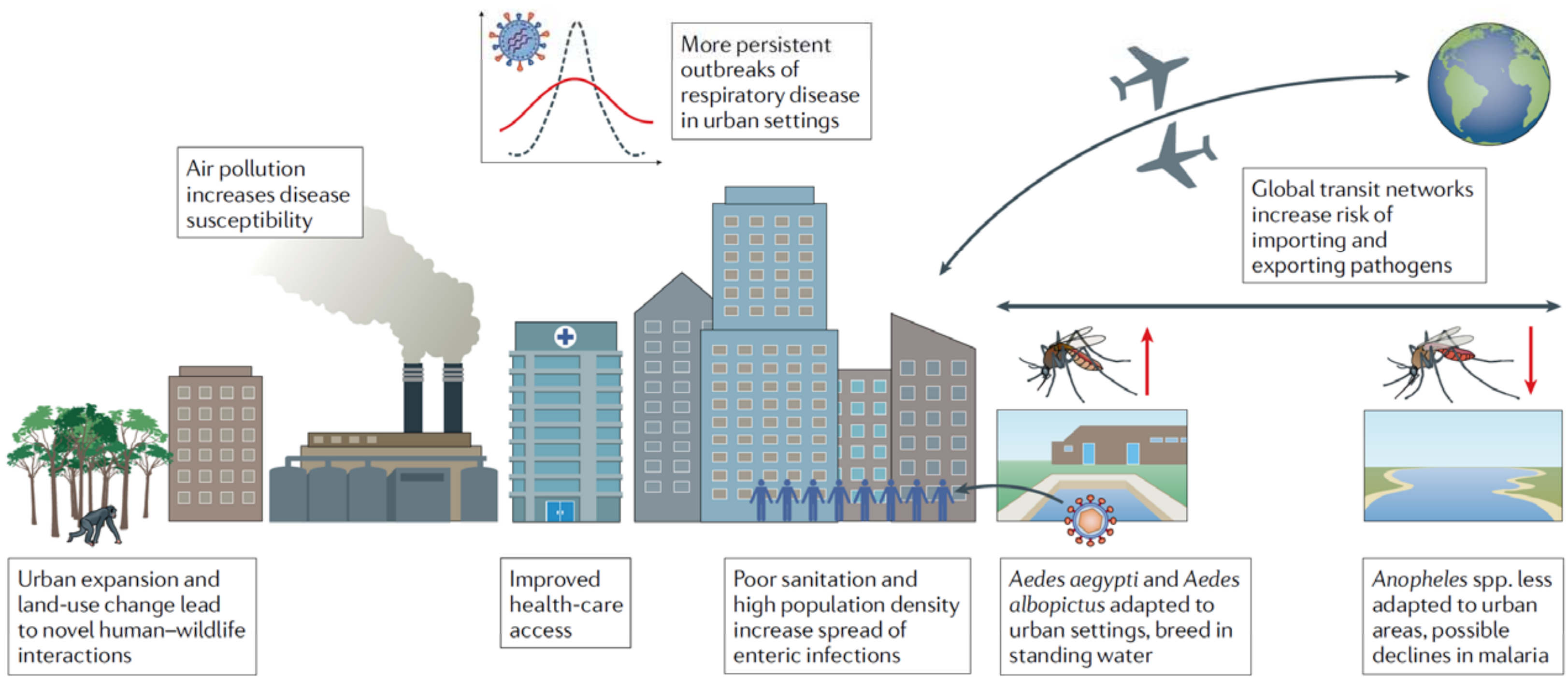
https://www.pnas.org/content/110/21/8399.long

Extensive use of **agrochemicals**

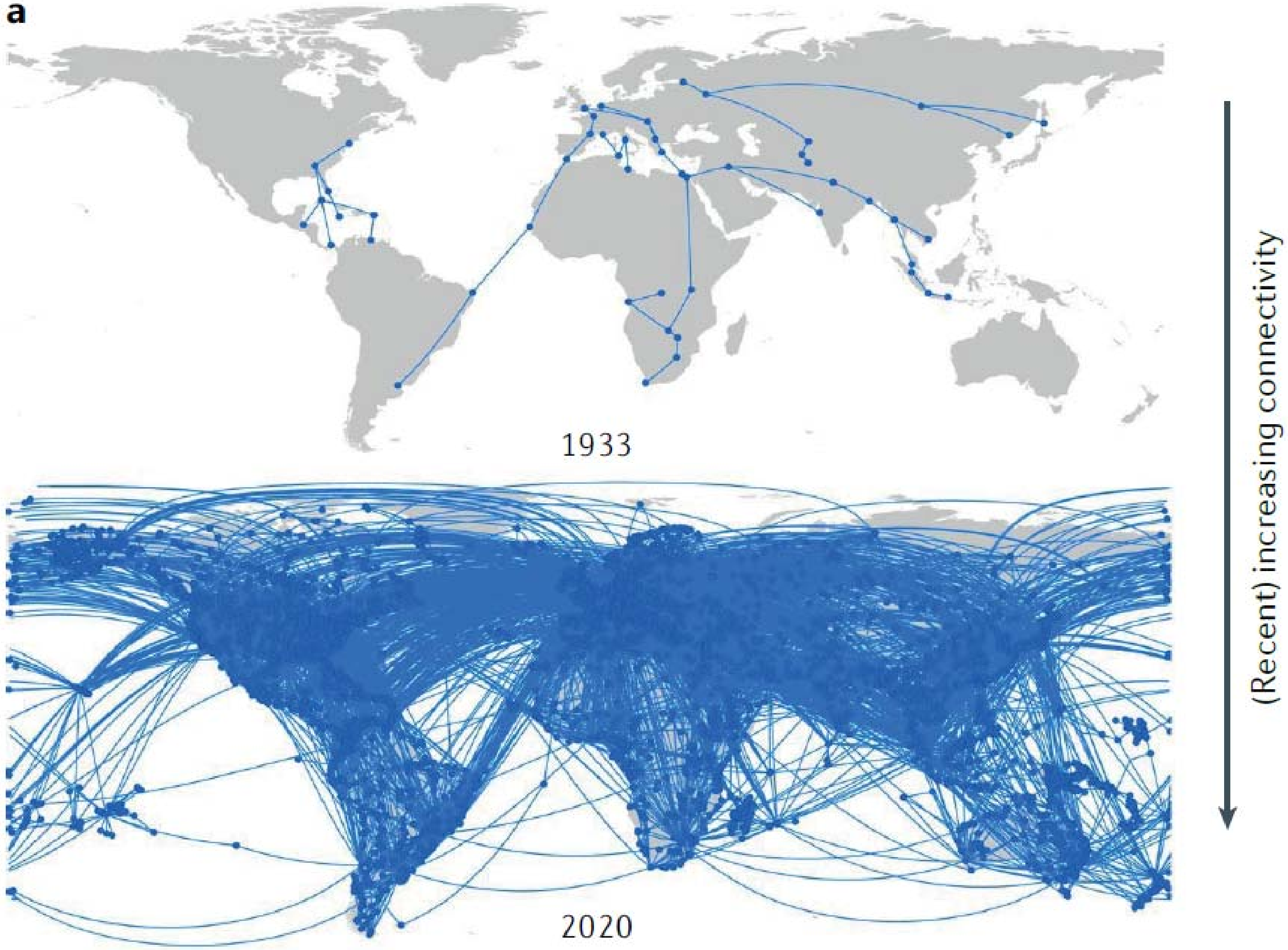
- The extensive use of **agrochemicals** in agriculture has resulted in the **loss of biodiversity**, an increase of **desertification & marginal lands**, and **mutation** among microbial populations in soil and water bodies (Arora 2018).
- It has been realized that pollution due to dangerous recalcitrant and xenobiotic pollutants including **pesticides** can be significant for the evolution of bacterial & viral pathogens & their transfer to humans.

Arora NK (2018) Agricultural sustainability and food security. Environ Sustain 1:217–219

Impacts of urbanization on infectious disease



a



Impacts of urbanization on viral diseases

- Rapid urbanization affects peak timing, prevalence, & bimodality of **influenza pandemics** in Australia.

- Slums in the cities/peri-urban areas have become **COVID hotspots** in many countries and have become major areas for the spread of SARS2in big cities

SCIENCE ADVANCES | RESEARCH ARTICLE

SOCIAL SCIENCES

Urbanization affects peak timing, prevalence, and bimodality of influenza pandemics in Australia: Results of a census-calibrated model

Cameron Zachreson[1]*, Kristopher M. Fair[1], Oliver M. Cliff[1], Nathan Harding[1], Mahendra Piraveenan[1], Mikhail Prokopenko[1,2]

We examine salient trends of influenza pandemics in Australia, a rapidly urbanizing nation. To do so, we implement state-of-the-art influenza transmission and progression models within a large-scale stochastic computer simulation, generated using comprehensive Australian census datasets from 2006, 2011, and 2016. Our results offer a simulation-based investigation of a population's sensitivity to pandemics across multiple historical time points and highlight three notable trends in pandemic patterns over the years: increased peak prevalence, faster spreading rates, and decreasing spatiotemporal bimodality. We attribute these pandemic trends to increases in two key quantities indicative of urbanization: the population fraction residing in major cities and international air traffic. In addition, we identify features of the pandemic's geographic spread that we attribute to changes in the commuter mobility network. The generic nature of our model and the ubiquity of urbanization trends around the world make it likely for our results to be applicable in other rapidly urbanizing nations.

World Medical and Health Policy

Preventing COVID-19 Amid Public Health and Urban Planning Failures in Slums of Indian Cities

Amit Patel

The COVID-19 pandemic has brought renewed attention to the lack of urban planning and its public health implications in developing countries. Slum communities face the dual challenges of chronically poor residential environments and the acute effects of a pandemic and the preventive measures that follow. In this paper, I assess the effectiveness and implications of social distancing, frequent hand-washing, and lockdown in the context of slums in Indian cities, where overcrowding, lack of access to water and sanitation, and dependence on daily wages for sustenance and livelihood are common. Using data from multiple sources, I demonstrate that not only will these measures be hard to achieve in slums in the short term due to specific characteristics of these habitats, but they will bring new challenges in the long term due to disproportionate impacts on the urban poor. Lessons learned from this pandemic will require us to rethink public health responses and urban planning practices that could better prepare our cities for future pandemics.

KEY WORDS: COVID-19, slums, India, urban health, urban planning

Air pollution impact on Covid19

- Cities with high air pollution levels are more affected with COVID19 cases and deaths
- **Indoor air pollution** aggravates the severity of COVID-19.
- **A slight increase of 1 µg/m3 in PM$^{2.5}$ can result in 8% increment in COVID19 death rate!!**


medRχiv
THE PREPRINT SERVER FOR HEALTH SCIENCES
CSH Cold Spring Harbor Laboratory BMJ Yale
HOME | ABOU
Search

Comments (23)

Exposure to air pollution and COVID-19 mortality in the United States:A nationwide cross-sectional study

Xiao Wu, Rachel C Nethery, M Benjamin Sabath, Danielle Braun, Francesca Dominici

doi: https://doi.org/10.1101/2020.04.05.20054502

Now published in *Science Advances* doi: 10.1126/sciadv.abd4049

Abstract | Full Text | Info/History | Metrics | Preview PDF

Abstract

Objectives United States government scientists estimate that COVID-19 may kill tens of thousands of Americans. Many of the pre-existing conditions that increase the risk of death in those with COVID-19 are the same diseases that are affected by long-term exposure to air pollution. We investigated whether long-term average exposure to fine particulate matter (PM$^{2.5}$) is associated with an increased risk of COVID-19 death in the United States.

Wu X, et al. medRxiv 20202004200520054502. https:// doi. org/ 10. 1101/ 20200 40520054502

Bushmeat (Wildlife) consumption and trade

Wet markets

Bush meat consumption

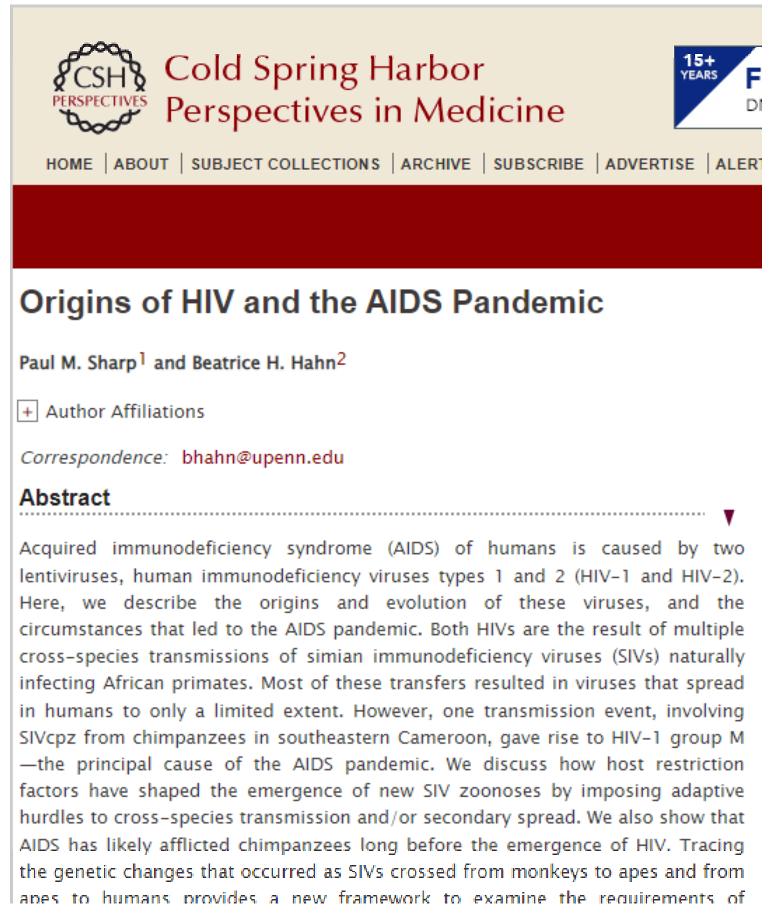
Kurpierset al 2016 *In* Problematic Wildlife, Springer

Bushmeat consumption & emergence of novel zoonotic disease

- Every four months one new infectious disease emerges in humans & is likely to be linked to the consumption of NHP and other exotic animals *(UNEP frontiers 2016 report)*

- **HIV 1 & 2** reached in humans by multiple cross-species transmission of simian immunodeficiency viruses (SIVs) through bushmeat hunting & trade

- **SARS-CoV** is reported to be originated from bats then transmitted to humans, while **MERS-CoV** passed on from bats to camels to humans



Cold Spring Harbor Perspectives in Medicine

HOME | ABOUT | SUBJECT COLLECTIONS | ARCHIVE | SUBSCRIBE | ADVERTISE | ALER

Origins of HIV and the AIDS Pandemic

Paul M. Sharp[1] and Beatrice H. Hahn[2]

+ Author Affiliations

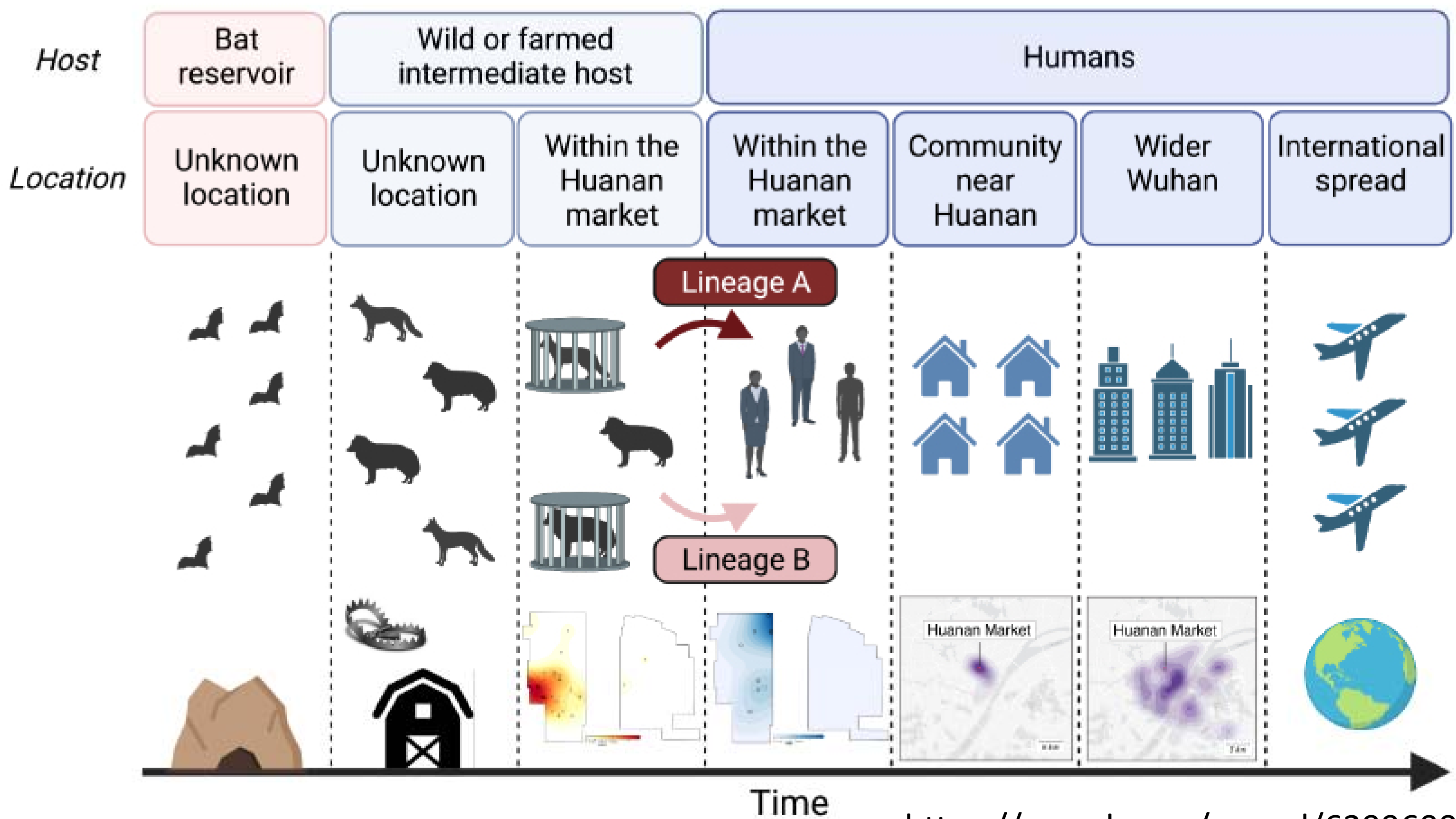
Correspondence: bhahn@upenn.edu

Abstract

Acquired immunodeficiency syndrome (AIDS) of humans is caused by two lentiviruses, human immunodeficiency viruses types 1 and 2 (HIV-1 and HIV-2). Here, we describe the origins and evolution of these viruses, and the circumstances that led to the AIDS pandemic. Both HIVs are the result of multiple cross-species transmissions of simian immunodeficiency viruses (SIVs) naturally infecting African primates. Most of these transfers resulted in viruses that spread in humans to only a limited extent. However, one transmission event, involving SIVcpz from chimpanzees in southeastern Cameroon, gave rise to HIV-1 group M—the principal cause of the AIDS pandemic. We discuss how host restriction factors have shaped the emergence of new SIV zoonoses by imposing adaptive hurdles to cross-species transmission and/or secondary spread. We also show that AIDS has likely afflicted chimpanzees long before the emergence of HIV. Tracing the genetic changes that occurred as SIVs crossed from monkeys to apes and from apes to humans provides a new framework to examine the requirements of

Sharp & Hahn BH. Cold Spring Harb Perspect Med. 2011(1):a00

Schematic diagram of key milestones in the emergence of SARS-CoV-2



https://zenodo.org/record/6299600#.YhxLmDhBzIW

Conclusions

- 75% of emerging viral 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/urbanization
- **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 to conserve the ecosystem! Conservation of natural resources and control of environmental pollution
- Need biotechnological tools & study of the microbiome of possible reservoirs--identifying the possible novel pathogens or their genes in advance
- A paradigm shift is required in the thinking and working to let the nature breathe and sustain itself.

Thank You for your attention!