One Health and Global Biosecurity: Concept, Complexity and Commitment

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Nathan C. Nieto Memorial Lecture

Annual Southwest One Health Symposium

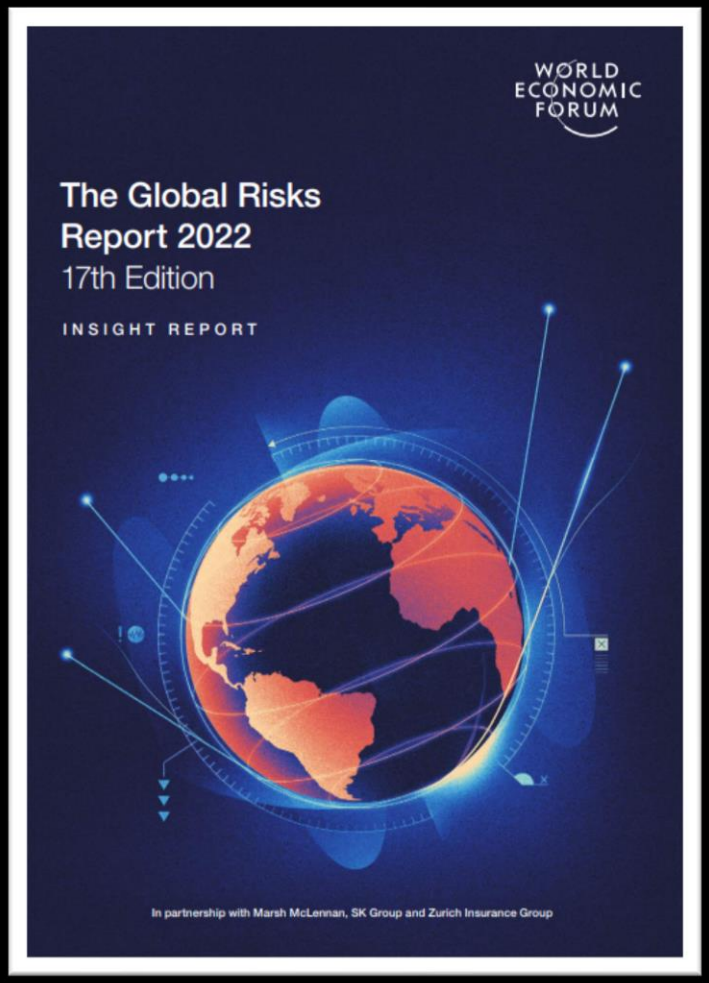
Coconino Center for the Arts, Flagstaff, Arizona

16 November 2022

Dr. Nathan (Nate) Nieto and the One Health Concept

An eclectic intellect and outstanding research on the pathogen-host-environmental nexus in disease dynamics

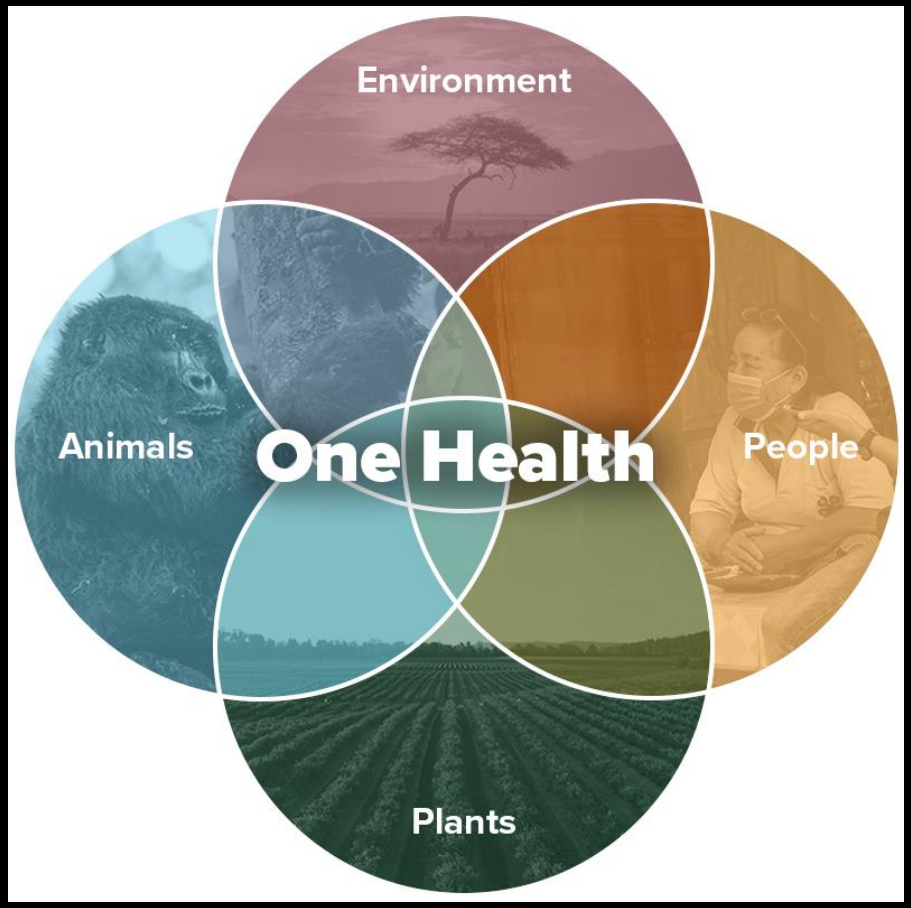
Biosecurity



- multi-dimensional challenges of escalating complexity and urgency
- more than detection and control of infectious diseases
- diverse constellation of threats to biological systems with the potential to generate profound societal and geopolitical instabilities and conflict
  - local, national, international
- risk assessment and mitigation require understanding myriad connectivities and inter-dependencies between diverse complex adaptive systems

One Health

- an integrated, systems-based approach to optimize the health of people and animals, availability of crucial food resources and sustainable environmental ecosystems

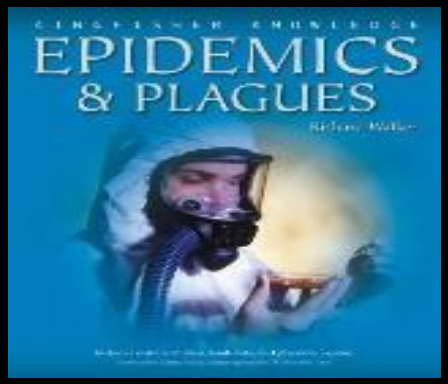


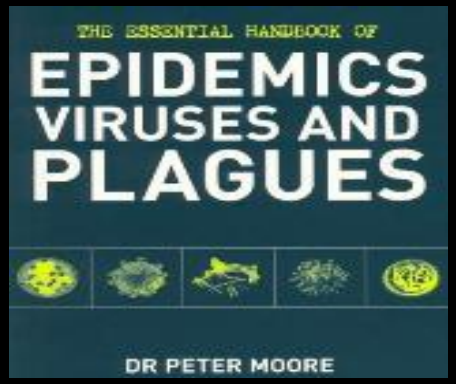
Complexity

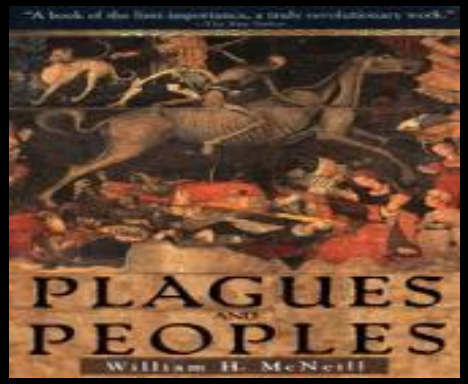
The Anthropocene: Understanding the Complex Inter-Dependencies Shaping the Earth-Human System

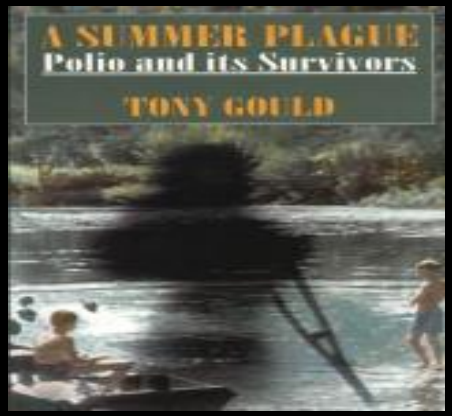
- trajectory of human activities over last 10,000 years
- transformational technologies
  - farming, forestry, mining
  - industrialization, urbanization and financial systems
  - global transportation and trade
  - communication systems
  - computing and digital connectivities
  - healthcare and population growth
  - weapons systems
- impact on global ecosystems
  - terrestrial and oceanic biosphere, biomass composition, atmosphere and biogeochemical cycles
- complex macro-system of complex subsystems many of which are ill-defined or unknown

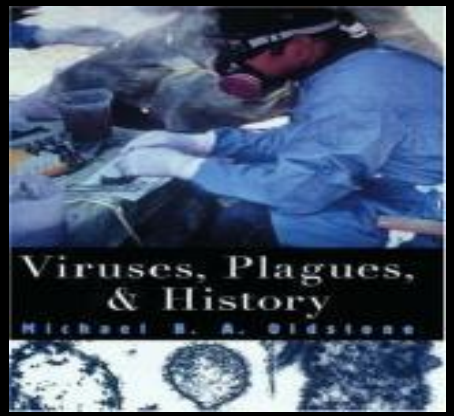
Infectious Diseases:
A Powerful Force in Human Evolution

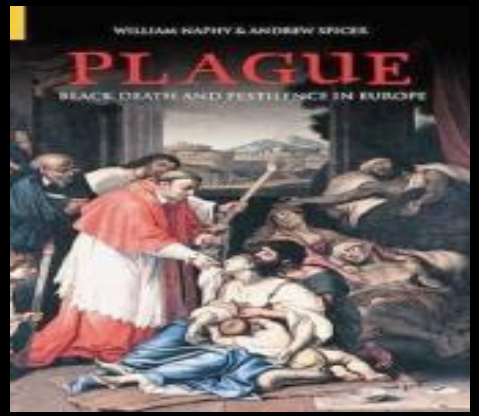


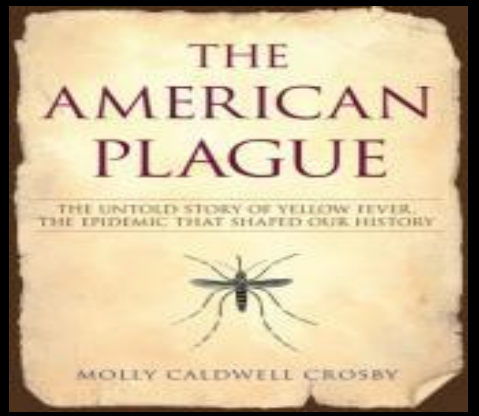


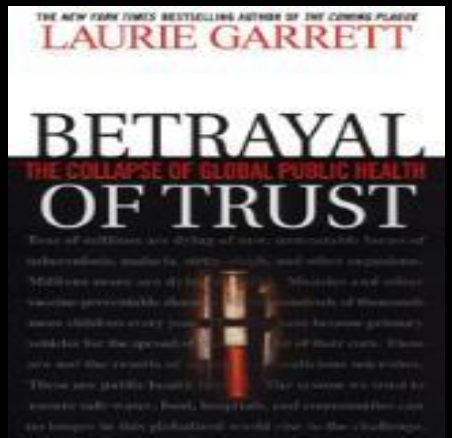


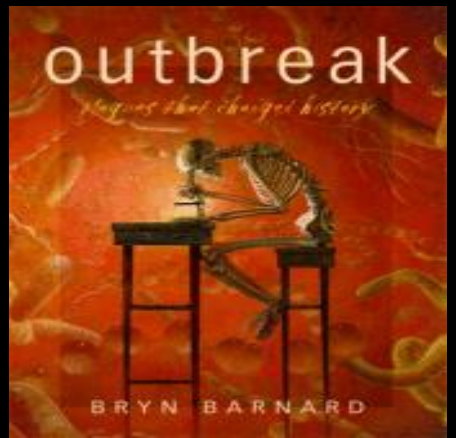


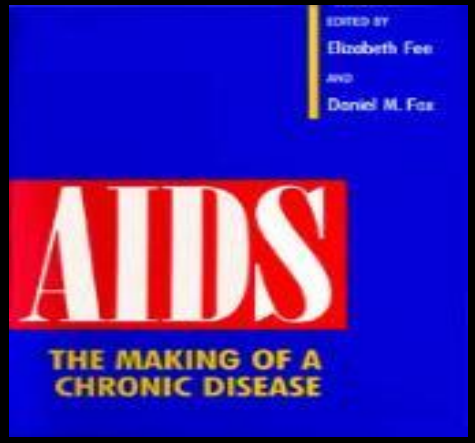


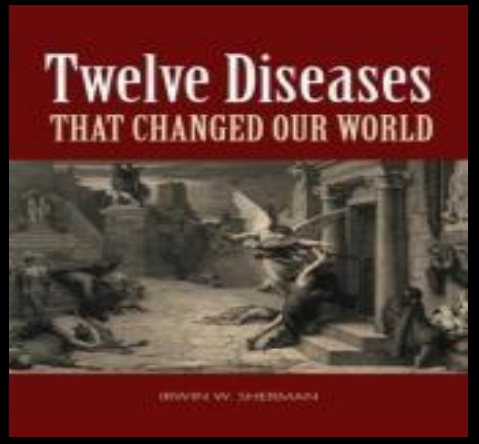










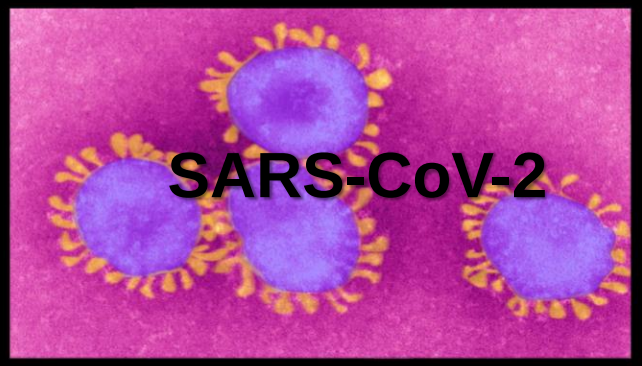


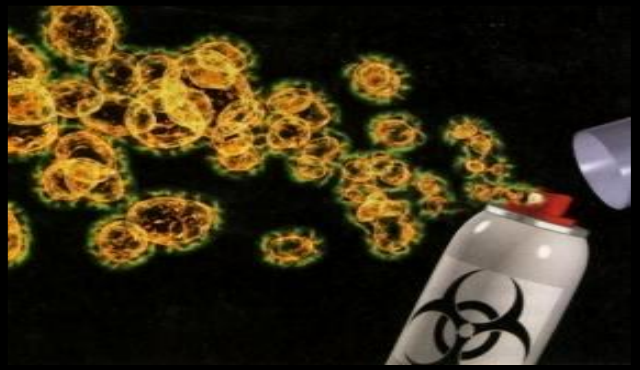
The Relentless Ever-Changing Dynamics of Infectious Diseases

old foes resurgent: Rx – resistance

omnipresent pandemic threats

new foes: emerging infectious diseases



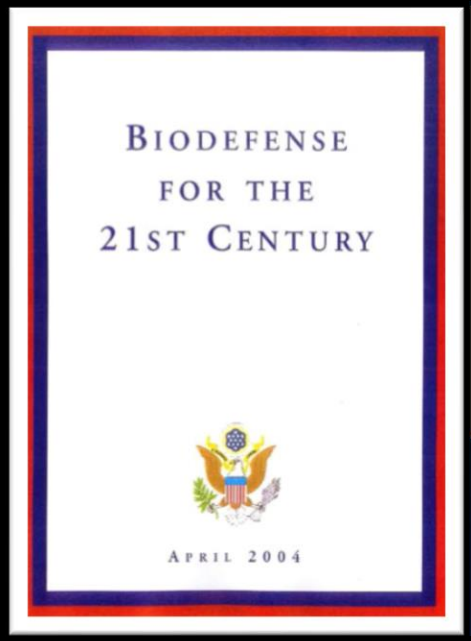


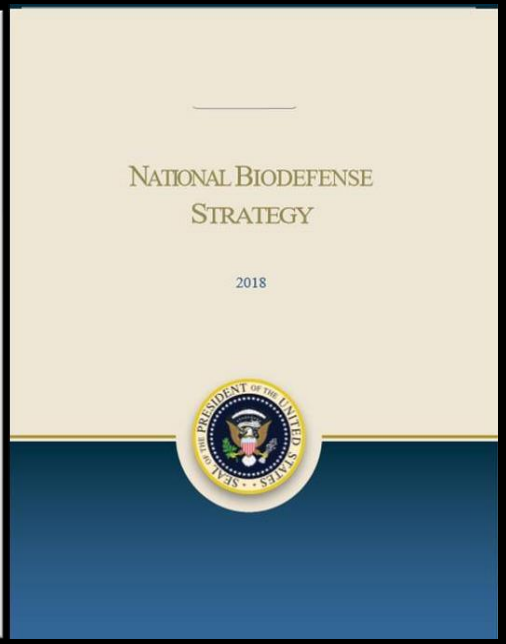
climate change and new vector ranges

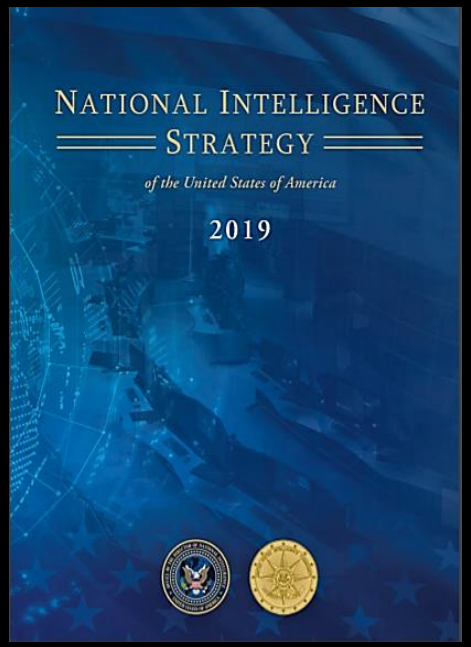
bioterrorism and bioweapons

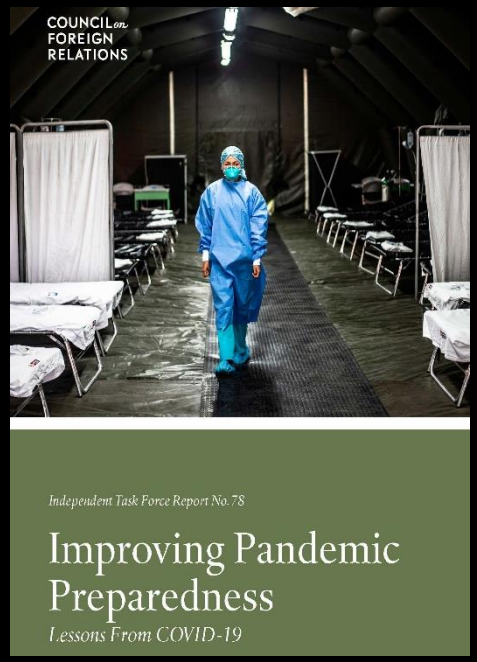
dual-use research of concern

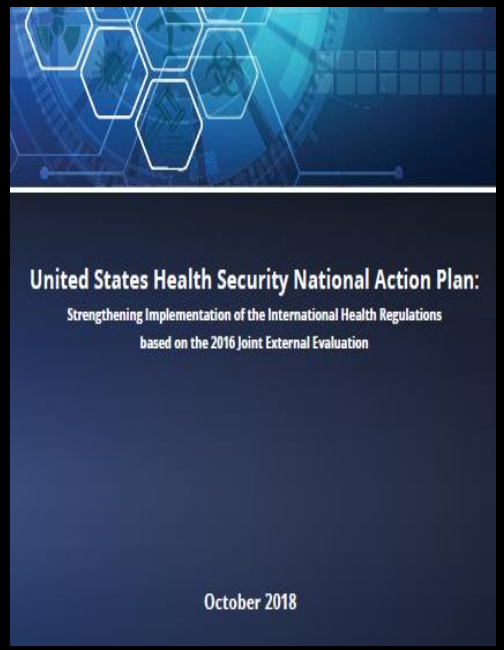
U.S. National Security Policy and Biodefense

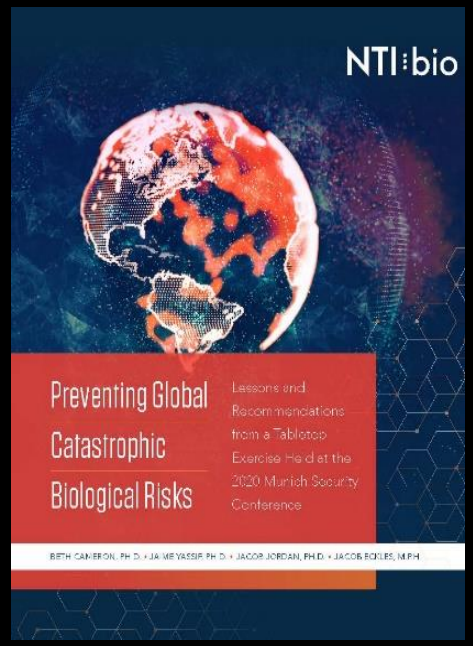


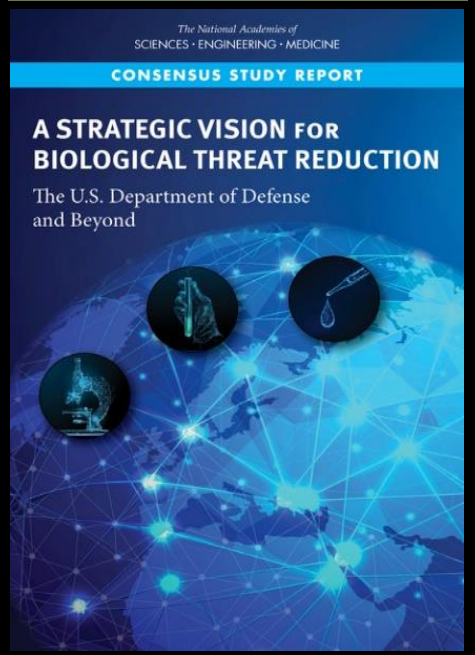




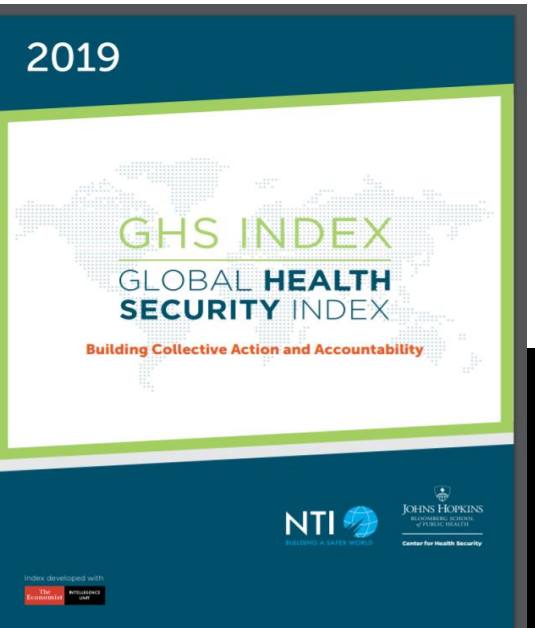








Sars-CoV-2 Revealed Major Shortcomings in the US Public Health Capabilities



PREPARED ?

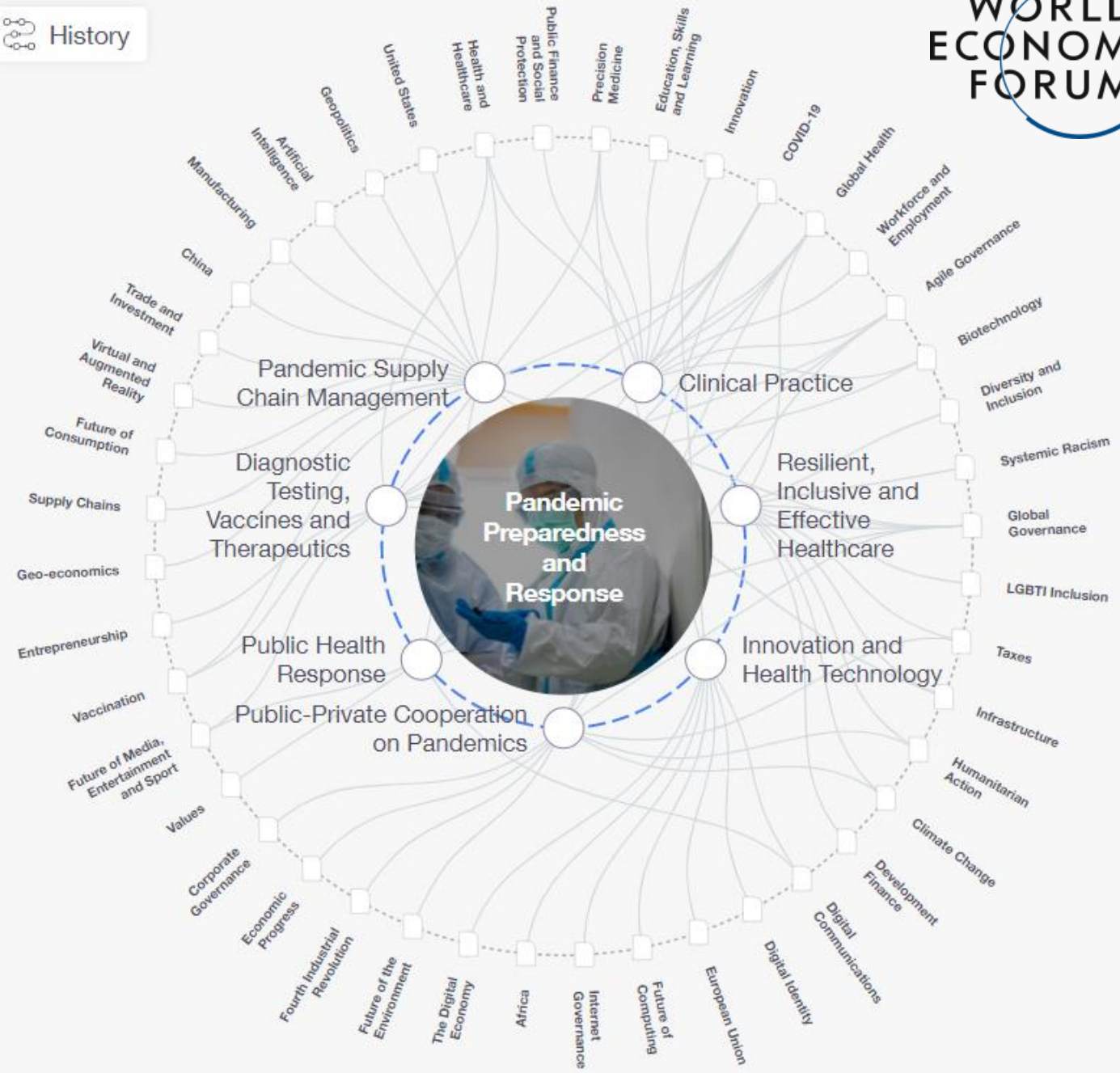
NO !

Key

- Most Prepared
- More Prepared
- Least Prepared

History

WORLD ECONOMIC FORUM



Global Biosecurity:
Interaction of Multiple Nested Hierarchies of Dynamic Complexity Embedded in Heterogeneous Spatio-Temporal Landscapes

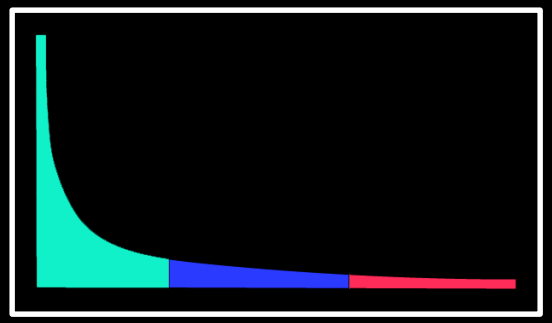
One Health Dynamics

- humans
- animals
- plants
- ecosystems

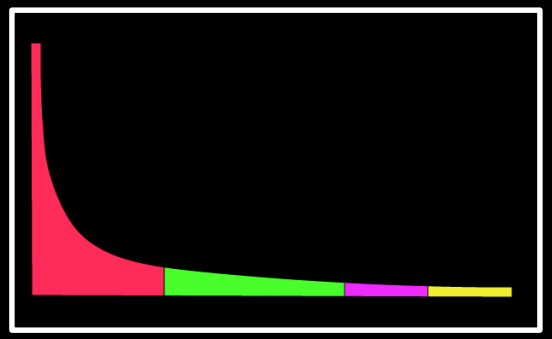
Anthropogenic Dynamics

- socio-economic
- cultural
- financial
- technical
- geopolitical

The Properties (Behavior) of Multi-Scale Complex Dynamic Systems

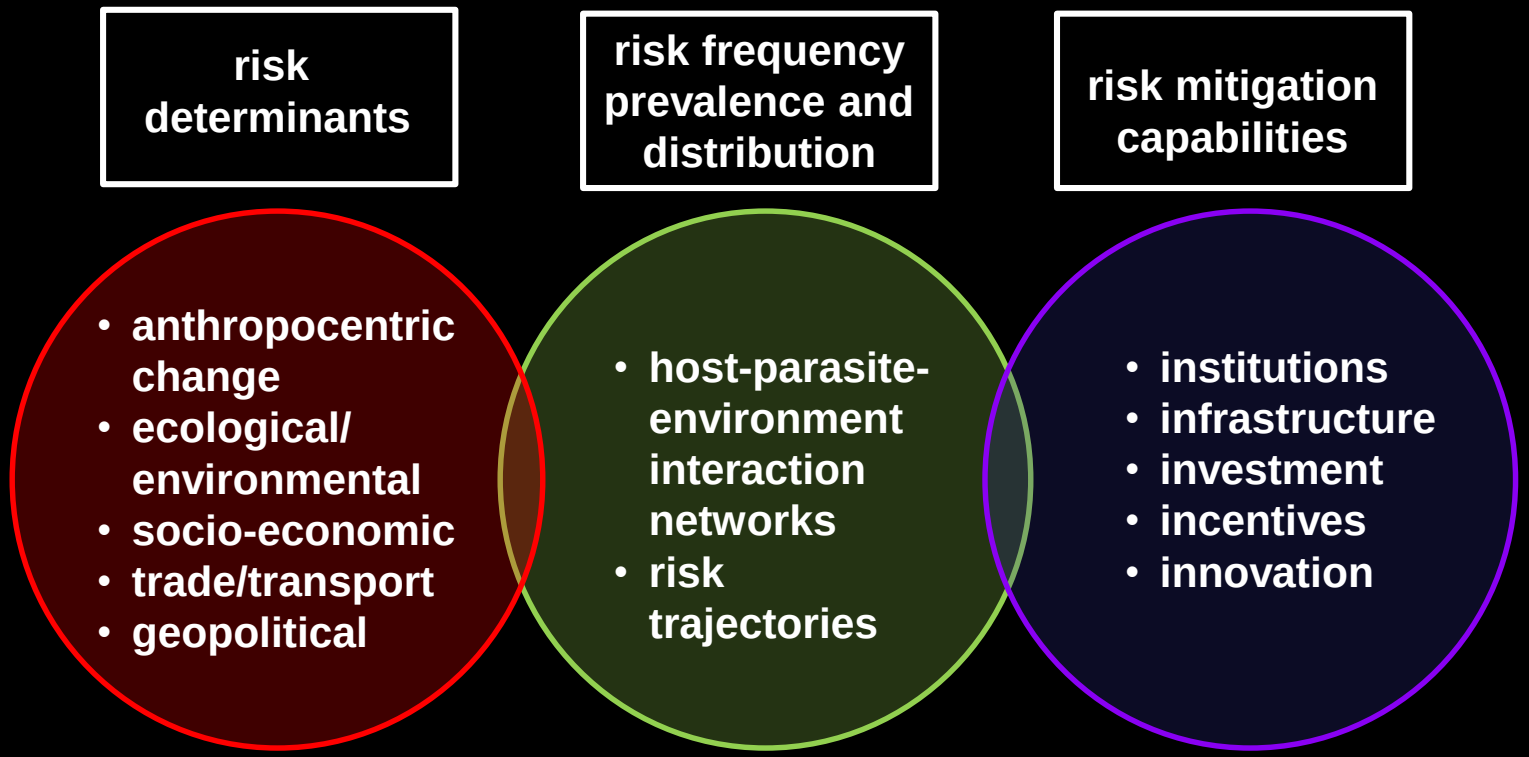


- complex (adaptive) biological systems comprise multiple ‘state spaces’ with ‘long tails’ of low frequency states
- biological systems exhibit highly optimized tolerance and exist at ‘far from’ equilibrium states
- evolved robustness (resiliency) to frequently encountered selection pressures



- highly vulnerable to low probability events not previously encountered which can trigger sudden amplification of low frequency tail states and a major shift in total state space (emergence, phase shifts, black swans)

The Communicable Disease Landscape



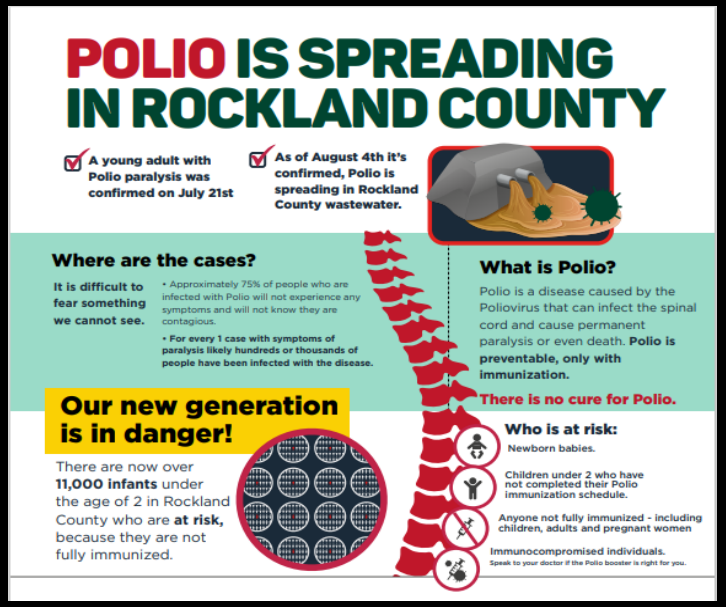
Core Elements in Proficient Management of Communicable Disease Threats

- detection of atypical event (speed of alert)
- containment (stamp out at the source)
- prevent spillover (sparks to ignite a fire)
- mitigation (flatten the curve and reduce demand on finite resources)
  - large scale testing and contact tracing
  - slow the spread and assess herd immunity
- maintenance of essential services and public order
- surge capacity, supply chain logistics and triage priorities for allocations of finite resource
- reliable information and public trust in actions by authorities (managing the worried well)

The Need for Continued Vigilance Against Known Pathogens

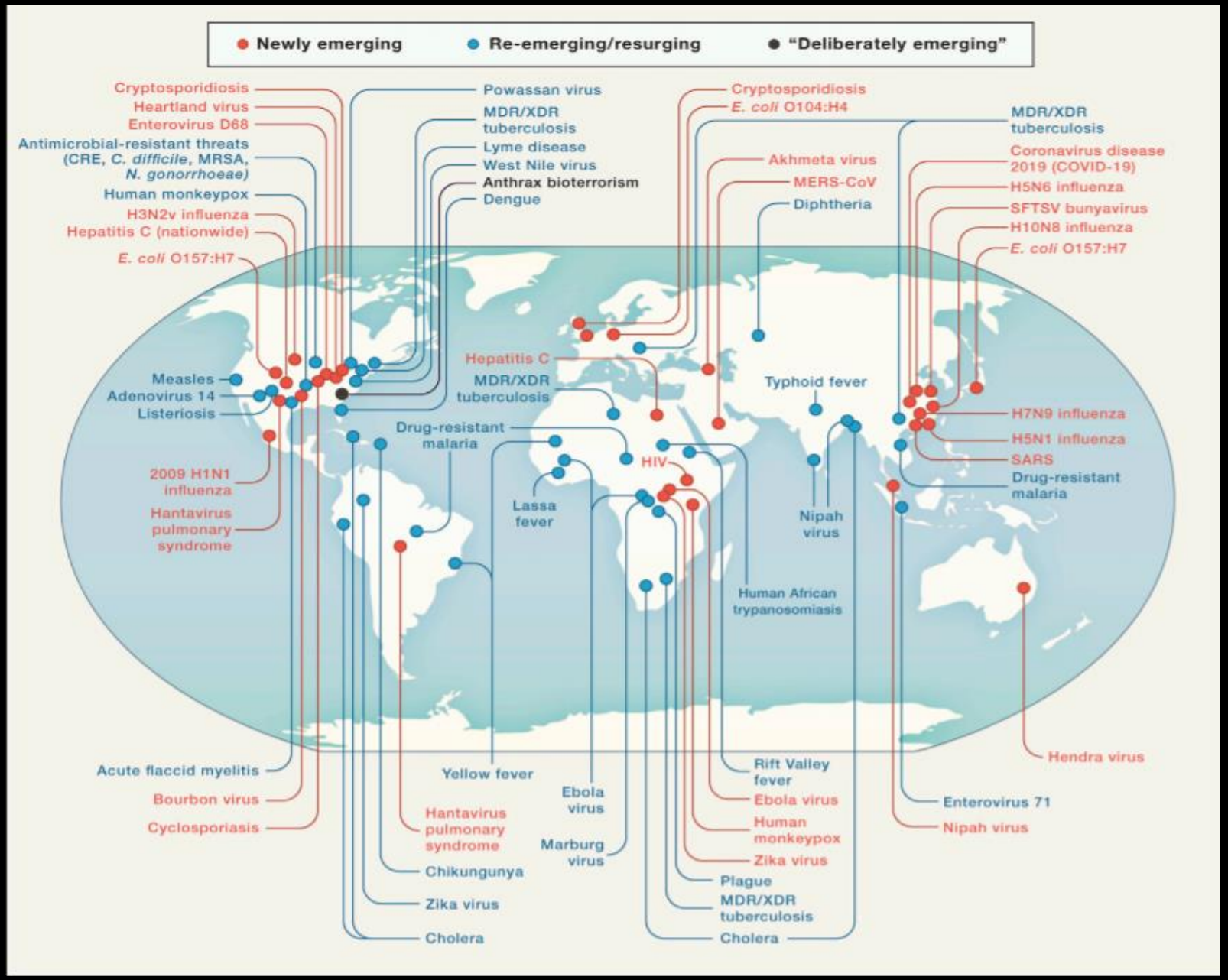
Global Emergence of Monkey Pox Virus (2022)

Poliovirus New York 2022



Poliovirus Afghanistan

Emerging Infection Diseases (1990-2020)

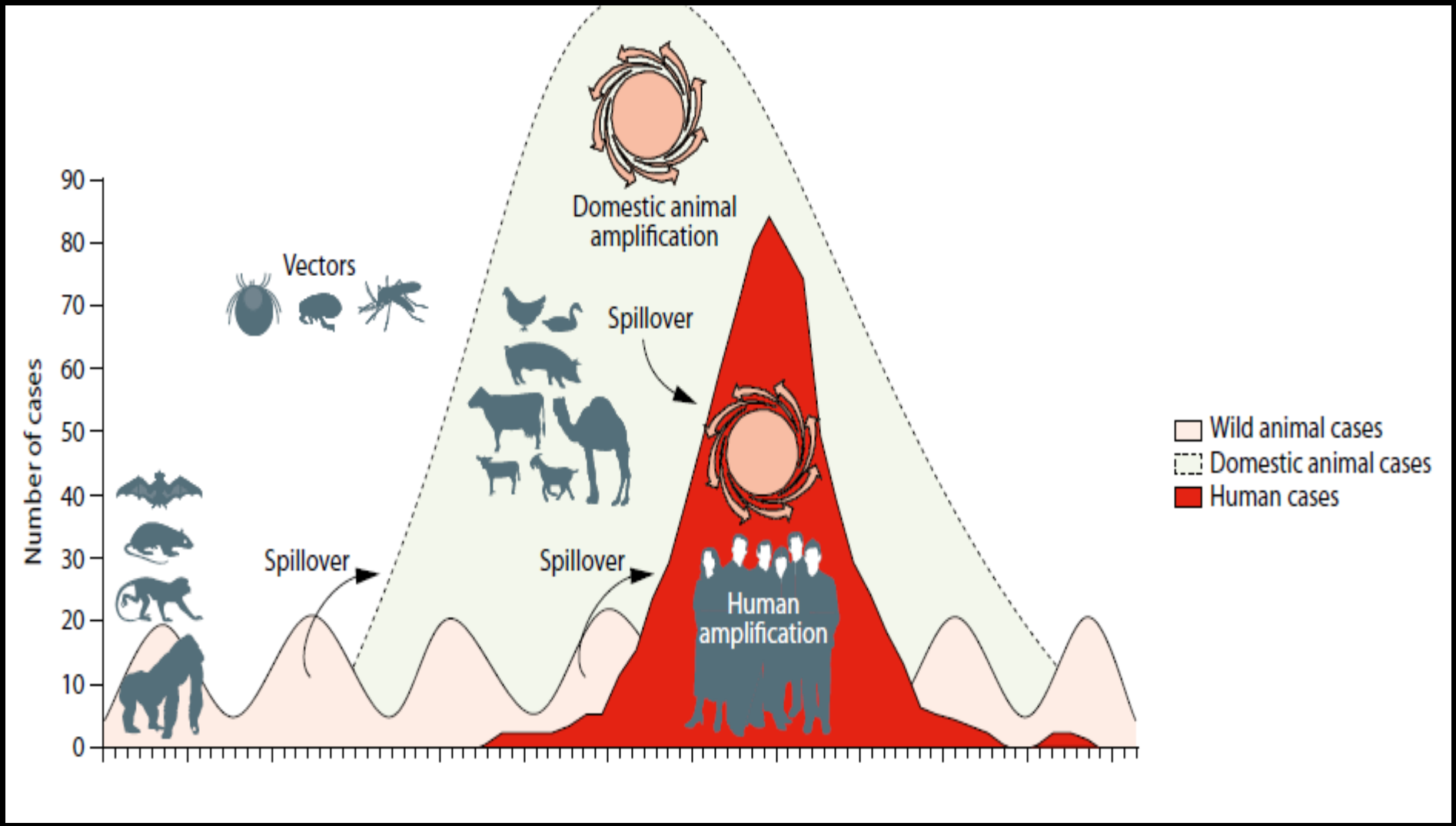


Cell 182, D. Morens, A. Fauci (2020), 1082

Emerging Infectious Diseases (EIDs)

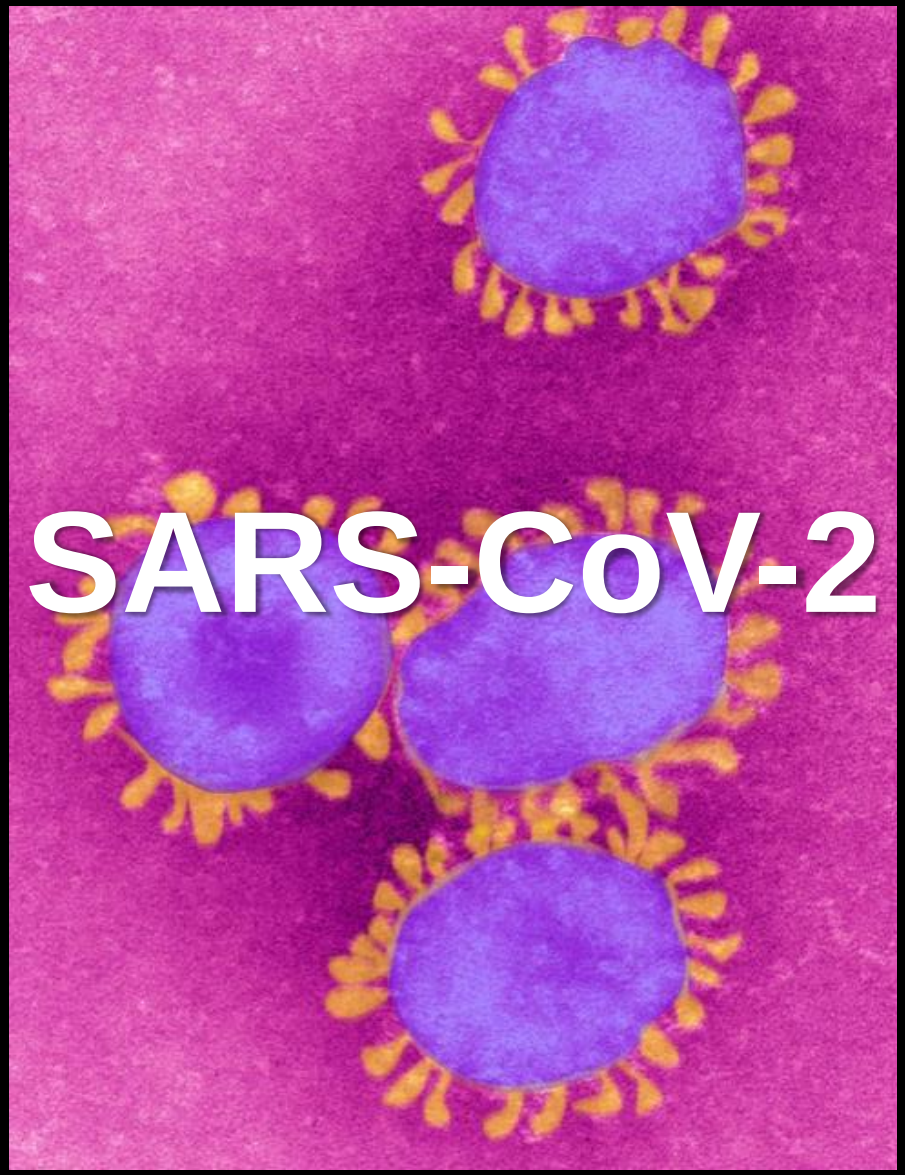
- number of emerging infectious diseases of humans increased during last 3 decades
- 70-80% of zoonotic origin due to changes in human-animal-environment nexus
- higher frequency of zoonotic emergence in warm, humid climates with higher host diversity
  - rodents, bats and non-human primates as high concern wildlife zoonotic reservoirs
- emergence in regions with higher rates of land use change
  - agroecosystems and urbanization
  - spillover from wildlife to domesticated livestock
- spatial information on emergent hot spots and environmental correlates but limited generalizability for risk forecast modeling in different host-pathogen systems

Dynamics of Cross-Species Zoonotic Pathogen Risk Spillover



W. Karesh et. al. (2012) Lancet 380, 1942

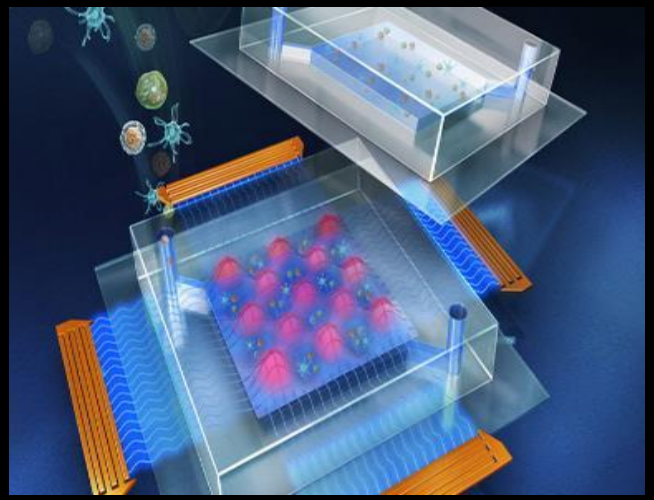
What's Out There?
Comprehensive Global Biosurveillance and Preparedness for Epidemic/Pandemic Threats



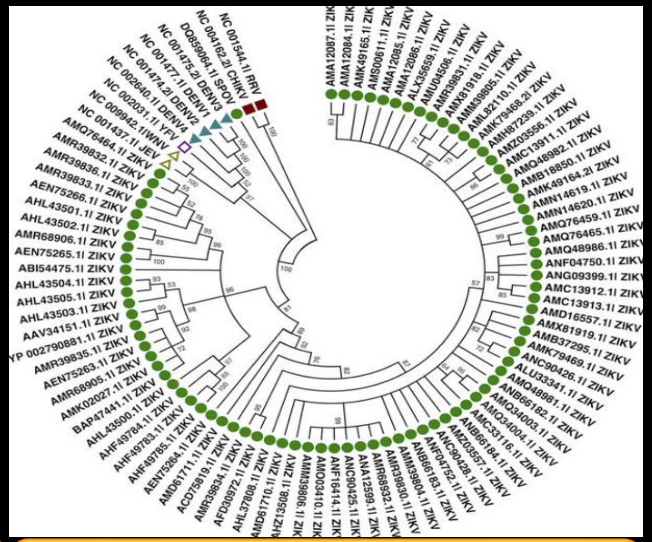
The Primacy of Diagnostics in Biosurveillance and Preparedness Mobilization

Profile:
signatures of infectious agents

Detect:
rapid automated PON/POC diagnostics



Act:
real-time situation awareness, decisions



surveillance
sans frontières

genomics of
pathogen evolution

dual-use research and
engineered biothreats

Flying Blind!
The Dangerous Void Created by Lack of Comprehensive Diagnostic Infrastructure for Pathogen Detection

- massive gaps in real-time spatio-temporal epidemiological data in early stages of COVID-19 pandemic evolution
  - inadequate availability of diagnostic tests for mapping infection prevalence and distribution
  - underappreciation of major fraction of asymptomatic infections
- impact on computational forecast modeling of pandemic trajectory
  - influential in national policy decisions
  - ‘lock down’, school/work closures, travel bans

‘One Health’ Global Biosurveillance: The Front Line in Preparedness

- range and physical contact
- environmental factors

- demographics
- cultural, political and economic factors
- health system capacity to detect/respond

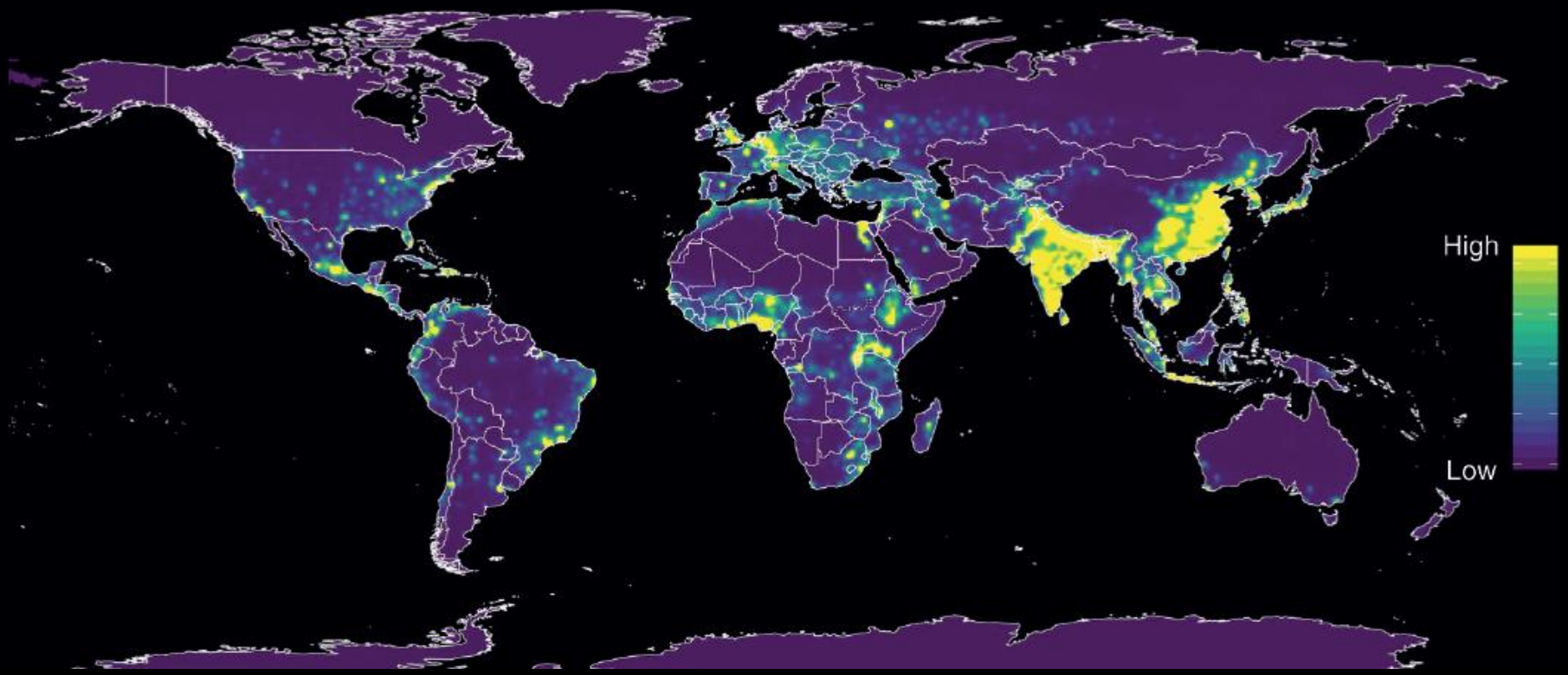
Adapted from: R. A. Medina (2018) Nature Rev. Microbiol. 16, 61

Ecological Shifts and Cross-Species Viral Transmission Risk

- estimated 10,000 virus species have the ability to infect humans
  - only 1% of documented global mammalian virome
- vast majority circulate silently in wild mammals and birds
- changes in land use and climate change and increased opportunities for viral sharing among previously geographically isolated species
- most cross-species transmission events are dead ends
- virus-phylogenetics and host phylogeny as predictors of pathogen sharing and spillover invasion of new pathogens

Global Hotspot Map of Projected Wildlife Zoonotic Risk Emergence

T. Allen et. al. (2017) Nature Comm. 8, 017-00923-8



- tropical forested regions
- mammal species richness
- human population density
- altered land use and increased wildlife and domesticated livestock-human interactions

Zoonotic Pathogen Spillover

- attribution of spillover to a single species as primary zoonotic source is not straightforward
  - many zoonotic pathogens infect multiple animal species
- growing evidence that multiple spillover events are needed before pathogen evolves significant replication efficiency in new species, including humans, to achieve high transmissibility
- reciprocal transmission from humans to animals (reverse zoonoses) may accelerate evolution of pathogen traits compatible with increased spillback to humans

Five Virus Families as Prioritized Pathogens for Biosurveillance and Pathogen-Agnostic Diagnostics and Therapeutics

- Coronaviridae
- Flaviviridae
  - dengue, Zika, West Nile, Japanese encephalitis
- Orthomyxoviridae
  - influenza and genetic reassortment combinations
- Paramyxoviridae
  - measles, mumps
  - henipaviruses
    - Hendra, Nipah, Langya
- Togaviridae (alphaviruses)
  - Chikungunya, Ross River fever, Eastern-, Western-, and Venezuelan equine encephalitides
- Arenaviridae – VHFs
  - Rift Valley fever, Crimean-Congo hemorrhagic fever, Hantaviruses, Lassa
- Filoviridae
  - Ebola, Marburg, Mengla

RNA Viruses as Major EID Threats

- 45-50% of EIDs
- error-prone replication cycles
- faster evolutionary rates and emergence of variants
  - higher risk of ‘species-jump’
  - immune evasion
  - altered tissue tropism
- genetic reassortment between avian, mammalian and human viruses

Proactive Large Scale Biosurveillance (BSV) for Pathogen Prevalence and Spillover Risk

- obvious logic but financial, technical, logistical and political barriers to implementation at scale
- many predicted zoonotic spillover ‘hot spots’ are located in LICs
  - limited technical infrastructure/workforce
  - access to remote locations and conflict zones
  - political fragility and varied levels of government cooperation from governments/local populations
  - concern over potential adverse economic input if viewed as ‘hot spot’ (trade, tourism)

Urbanization and Mega-Cities in Developing Countries and the Increased Threat of Zoonotic EIDs

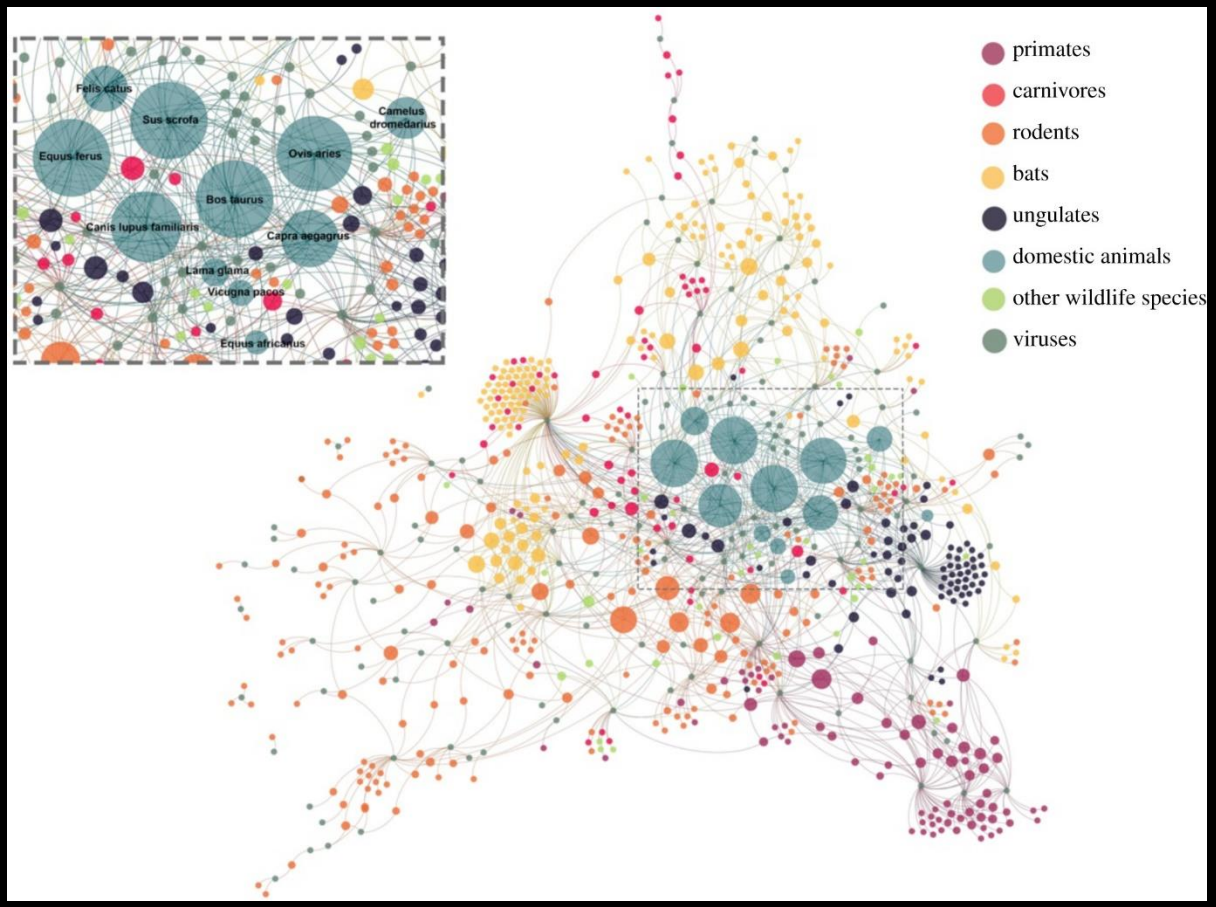
High Population Density With Inadequate Biosurveillance

Expanded Eco-niches and New Zoonotic Exposures/Risks

Major Gaps in Health Infrastructure and Rapid Disease Reporting

Concentrated Animal Feeding Operations (CAFO)

Bipartite Network Of Zoonotic Virus Associations in Wild and Domesticated Mammals



adapted from: C.K. Johnson et. al. (2020) Proc. Roy. Soc. B287.20192736

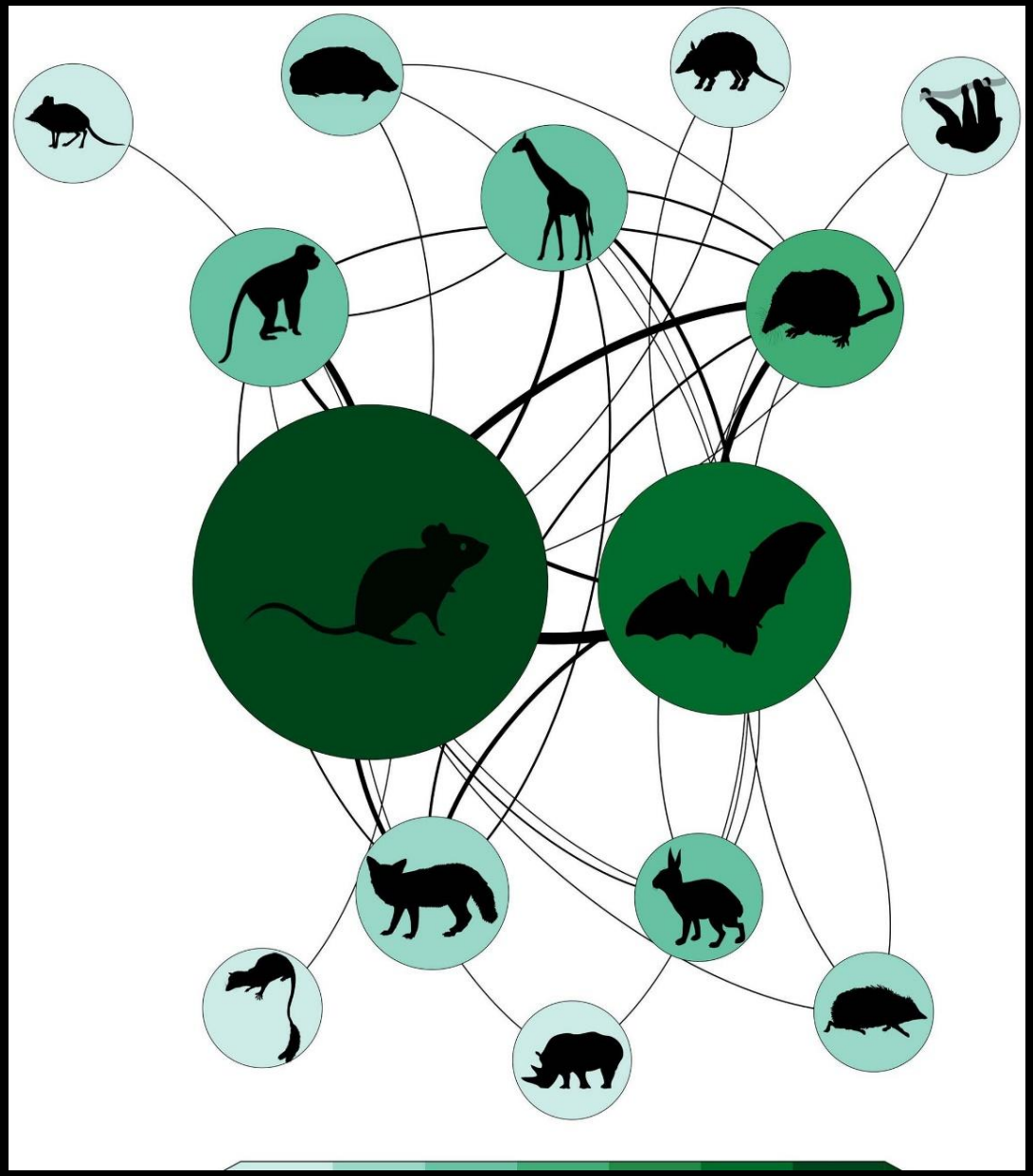
- domesticated animals are the most central species in shared viral networks and share many viruses between domestic species and wildlife
- domesticated livestock host 50% of zoonotic viral richness
  - 12 species with vulnerability of average 19 viruses/host

Synanthropic Wildlife and Zoonotic Transmission to Agricultural Livestock and Humans

- urban-adapted mammals comprise only 6% of mammalian taxa (157/2792) but 39% of known host-parasite combinations for human spillover*
  - acknowledged potential bias and lack of comparable sampling intensity in non-rural/remote regions and tropical vs temperate regions
- comparable host-parasite datasets for avian and other vertebrate species not available

*G.F. Albery et al. (2022) Nat. Ecol. Evol. 6, 794

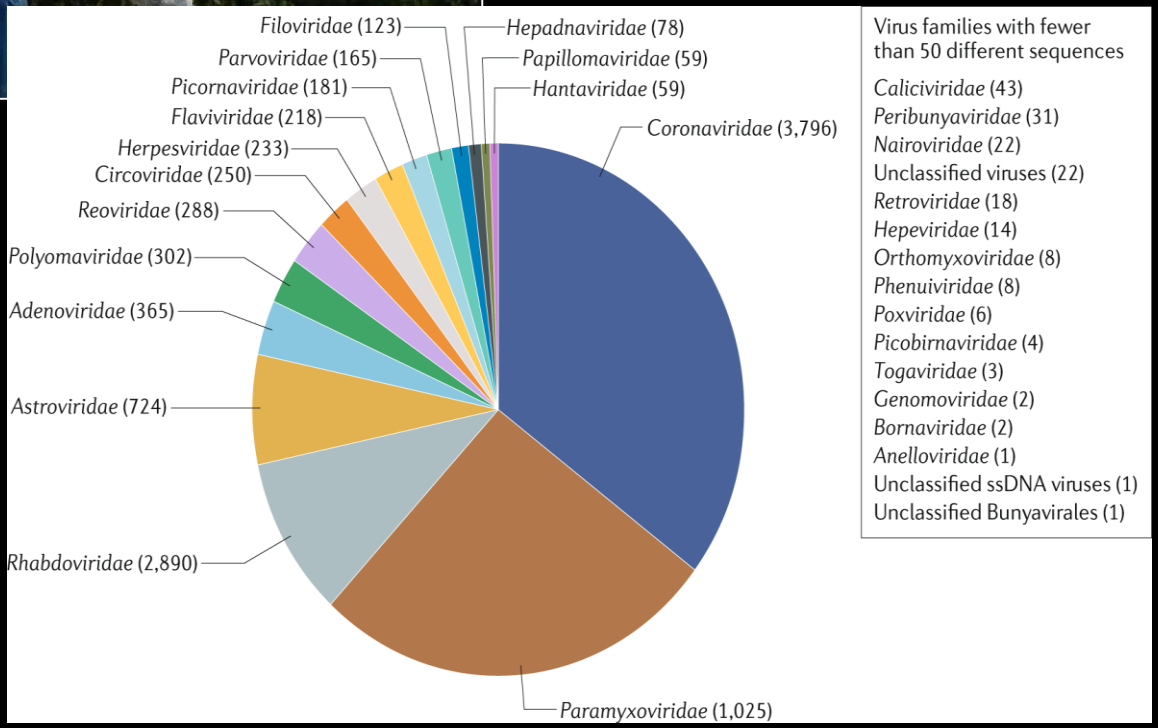
Deforestation and Inter-species Virus Transmission Patterns



J. Carlson et. al. (2022)
Nature 607, 555

Node Size = total # species; edge width = pairwise prediction of viral sharing probabilities

Bat Virus Diversity



Recognition of the Importance of Bats as Potential Zoonotic Reservoirs and Inter-Species Virus Transfer

- are bats unique in their higher viral richness, higher proportion of zoonotic viruses and immune adaptations versus other mammals?
- rapid range expansion in bat species around the world including circulation on continental scale (panmixia)
- even non-migratory bats regularly travel hundreds of kilometers in a lifetime ≡ 50 years for dispersal of small mammals

Wildlife Markets and Transmission of Zoonotic EIDs

Wildlife Trade Supply Chains

- industrial scale wildlife farms and markets
  - estimated employment of 14 million people in PRC in 2016 (Chinese Academy of Engineering Report 2017)
- CCP decision to close wildlife breeding farms for food animals (Feb. 2020) but exclusion of animals farmed for fur
  - mink, racoon dogs, foxes: all susceptible to SARS-CoV-2
- continued expansion of international trade in live animals (IPBES secretariate, Bonn, 2020)
- mixing of captive-bred and wild-caught animals and transport of live animals, carcasses or derivative products
- US largest market for wildlife pets (millions/year) from hotspot countries with minimum BSV/regulatory oversight
- need for increased BSV/biosafety inspection mechanisms and enforcement

Bushmeat Food Chains

Wildlife (Bushmeat) Consumption

- long-established source of food in rural LIC communities
  - dependency exacerbated by socio-economic deterioration, political instabilities and conflict
- deeply routed cultural practices
- risk education and communication and more effective than prohibitions (China, Vietnam) behavior change interventions
- prohibitions
  - push harvesting and consumption practices underground
  - government intervention/penalties heighten food insecurity in rural and indigenous communities

Fast Track Action Committee Report: Recommendations on the Select Agent Regulations Based on Broad Stakeholder Engagement

October 2015

National Science and Technology Council
Committee on Homeland and National Security
Subcommittee on Biological Defense Research and Development
Fast Track Action Committee on the Select Agents Regulations

Addressing Antibiotic Resistance

A REPORT FROM THE JOINT APLU | AAVMC TASK FORCE ON ANTIBIOTIC RESISTANCE IN PRODUCTION AGRICULTURE

Association of Public and Land-grant Universities
AAVMC Association of American Veterinary Medical Colleges

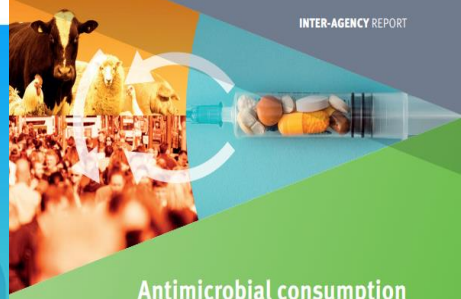
NATIONAL QUALITY FORUM

National Quality Partners Playbook™:

ANTIBIOTIC STEWARDSHIP IN POST-ACUTE AND LONG-TERM CARE

ecdc · efsa · European Medicines Agency

INTER-AGENCY REPORT



Antimicrobial consumption and resistance in bacteria from humans and animals

Third joint inter-agency report on integrated analysis of antimicrobial agent consumption and occurrence of antimicrobial resistance in bacteria from humans and food-producing animals in the EU/EEA

JIACRA III
2016–2018

ANTIBACTERIAL AGENTS IN CLINICAL DEVELOPMENT

An analysis of the antibacterial clinical development pipeline, including tuberculosis

World Health Organization

ReAct

Dag Hammarskjöld Foundation

development dialogue paper
no.26 | december 2018

Antimicrobial resistance and sustainable development:

A planetary threat but a financing orphan

Planet Earth faces the very real threat of having to survive and thrive in a 'post-antibiotic' era in which there are few, if any, antibiotics which effectively and affordably cure infections. A world without antibiotics would necessitate radical changes in health care and farming. Despite the severity of this threat, many low- and middle-income countries struggle to identify resources for even basic activities related to antimicrobial resistance (AMR).

In this context, the Dag Hammarskjöld Foundation and ReAct - Action on Antibiotic Resistance hosted a meeting to discuss how AMR could become more visible and how more funds to tackle AMR could be mobilised.

WHO GUIDELINES ON USE OF MEDICALLY IMPORTANT ANTIMICROBIALS IN FOOD-PRODUCING ANIMALS

World Health Organization

Review on Antimicrobial Resistance

Tackling drug-resistant infections globally

TACKLING DRUG-RESISTANT INFECTIONS GLOBALLY:

FINAL REPORT AND RECOMMENDATIONS

THE REVIEW ON ANTIMICROBIAL RESISTANCE

CHAIRED BY JIM O'NEILL

MAY 2016

Expansion of Intensive Livestock Farming Processes and Inter-species Transmission of Antibiotic Resistant Plasmids

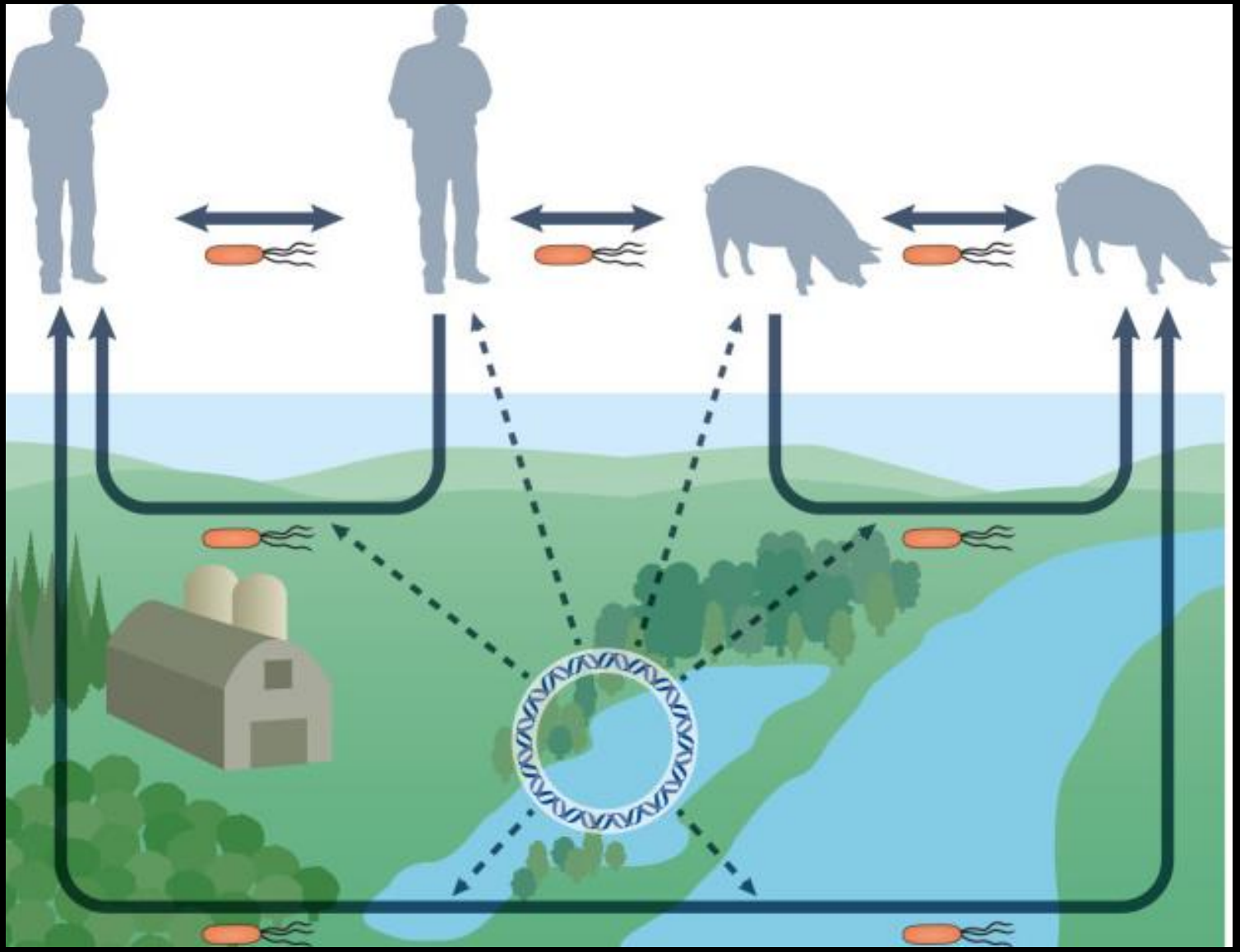


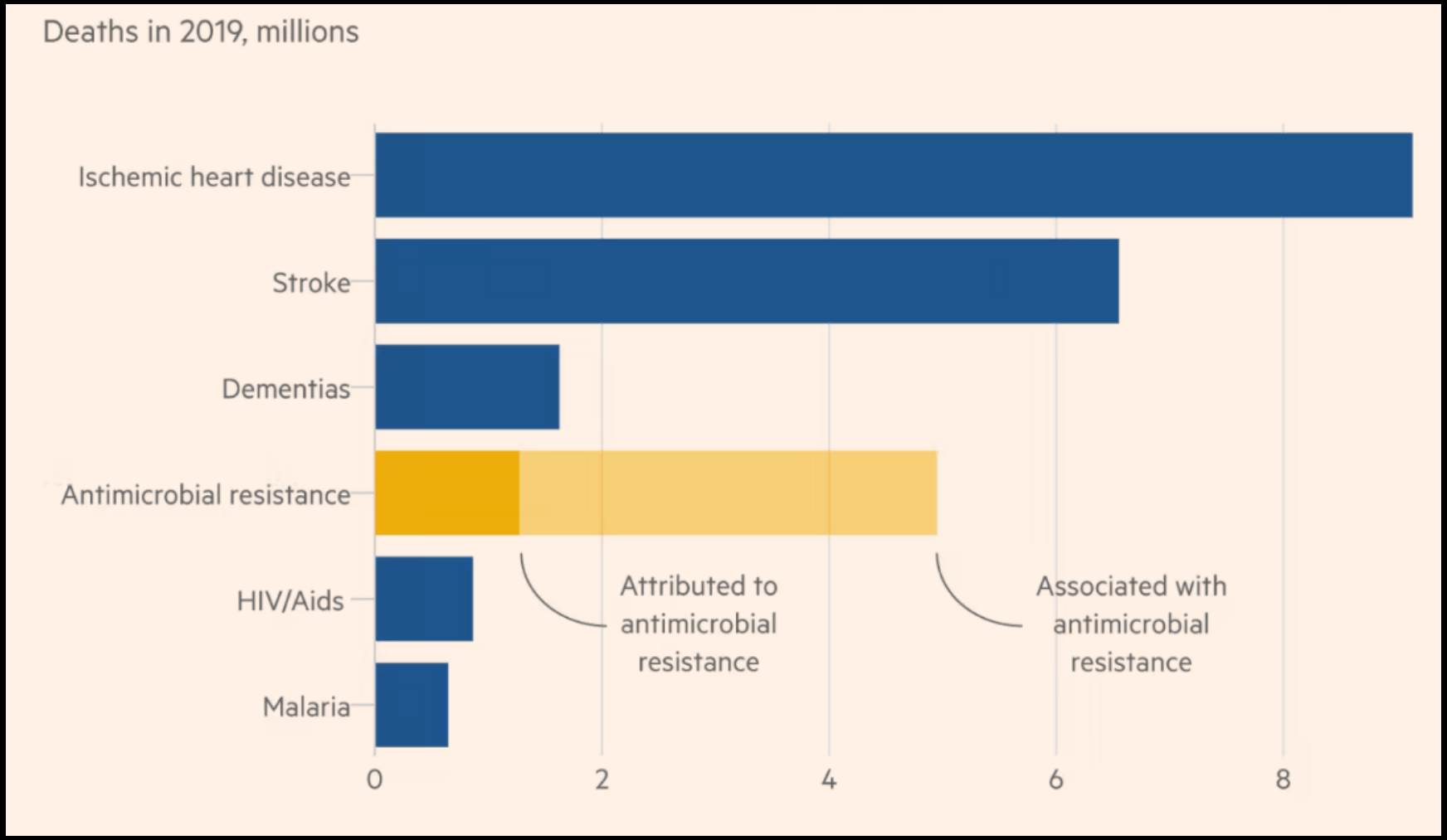
Fig. 3. From D.G.J. Larsson and C.F. Flach (2022) Nature Rev. Microbiol. 20, 261

No ESKAPE!: Resistant Bugs and Few New Drugs

- increasing resistance in G^+ and G^- pathogens in hospital and community settings

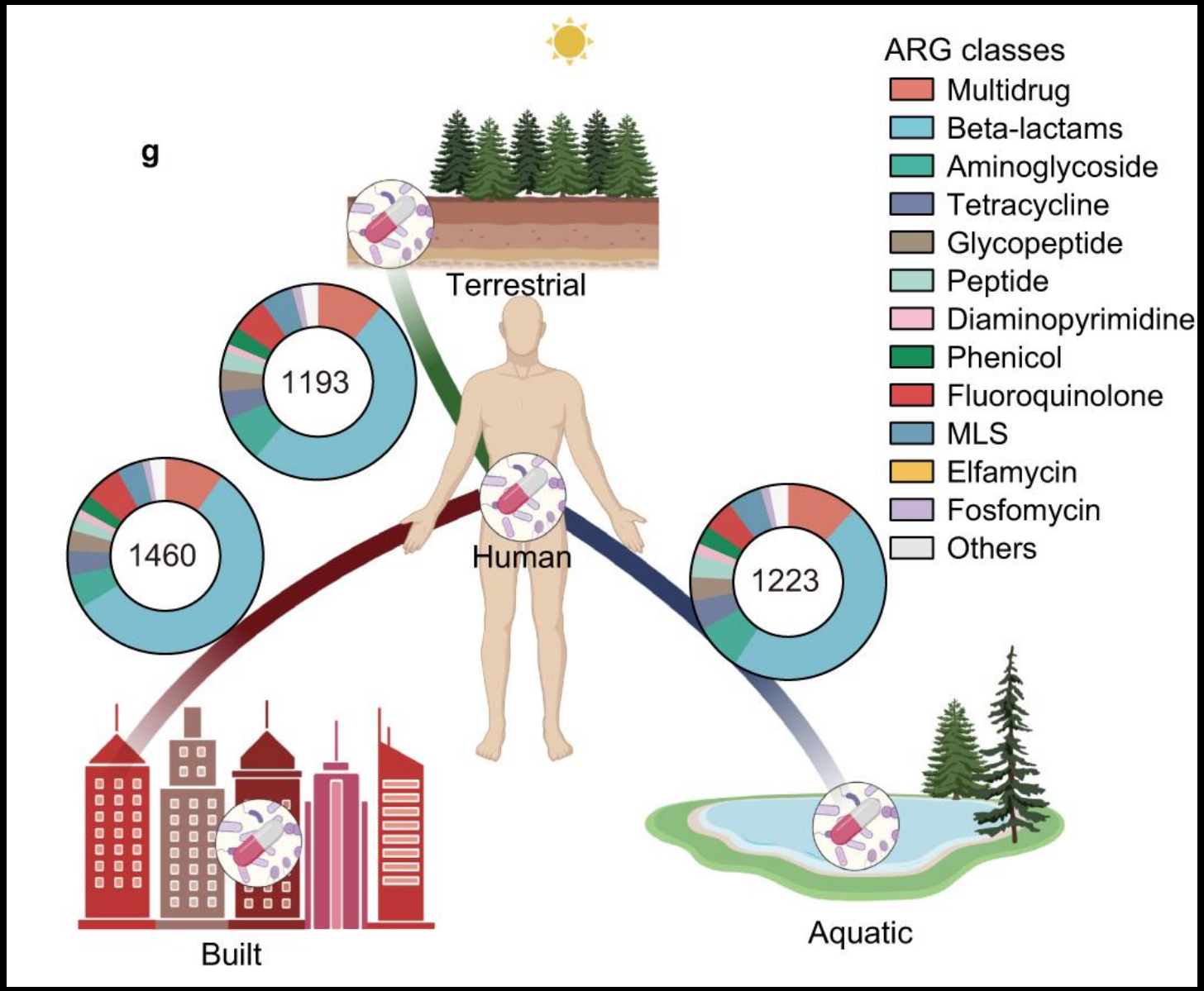
- the **ESKAPE** pathogens
  - ***E**nterococcus faecium*
  - ***S**taphylococcus aureus*
  - ***K**lebsiella pneumoniae*
  - ***A**cinetobacter baumanii*
  - ***P**seudomonas aeruginosa*
  - ***E**nterobacter species*

Antimicrobial Resistance is Linked to More Deaths than HIV and Malaria



Source: Global Burden of Disease Collaborative Network
https://www.ft.com/content/accf1951-48db-40f8-910f-16f66ff5531d

Antibiotic- Resistance Gene (ARG) Classes Shared Between Human-Associated and Three Habitat Domains



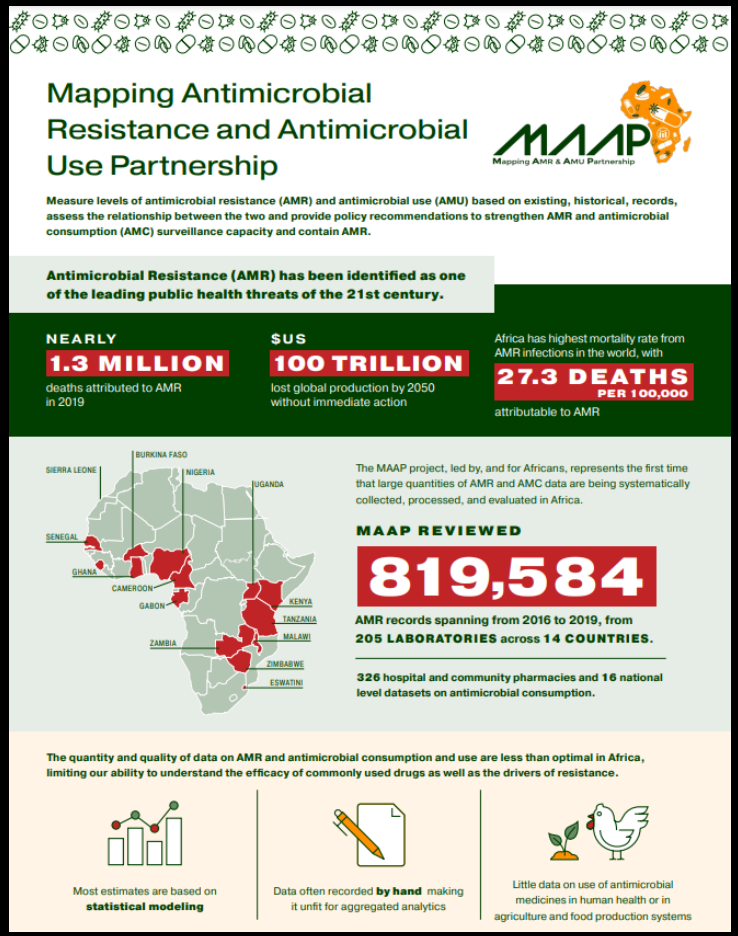
Z. Zhang et. al. (2022) Nature Comm. 13, 1553

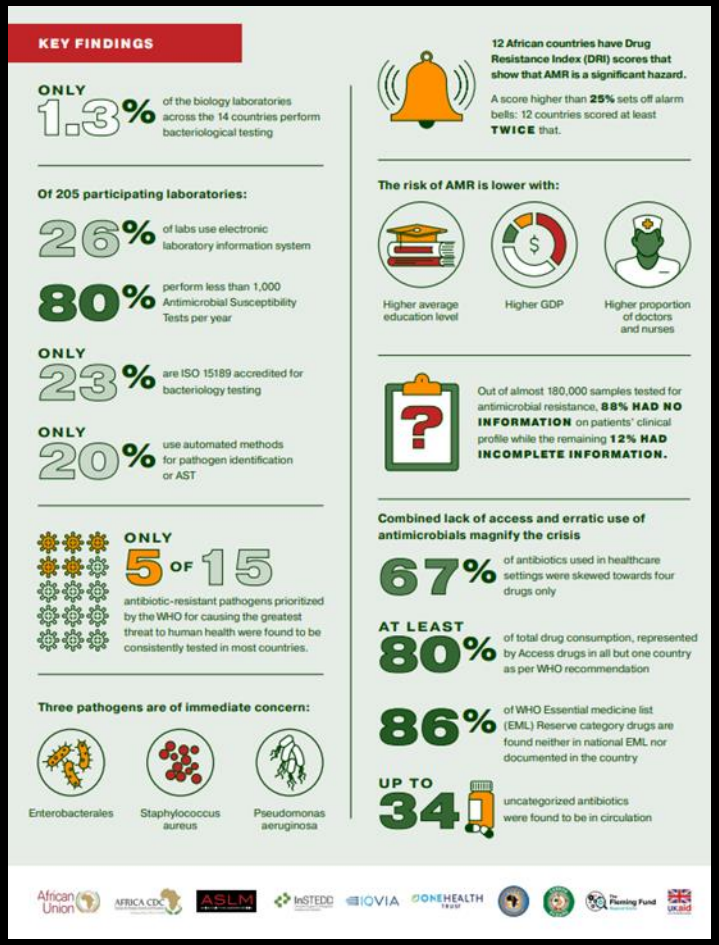
4572 metagenomic samples, 2651 ARGs countering and resistance to 24 classes of antibiotics

One Health Trust

The Crisis Within the AMR Crisis*

- survey of 50,000 clinical laboratories across 14 African countries
- only 1.3% perform AMR profiling

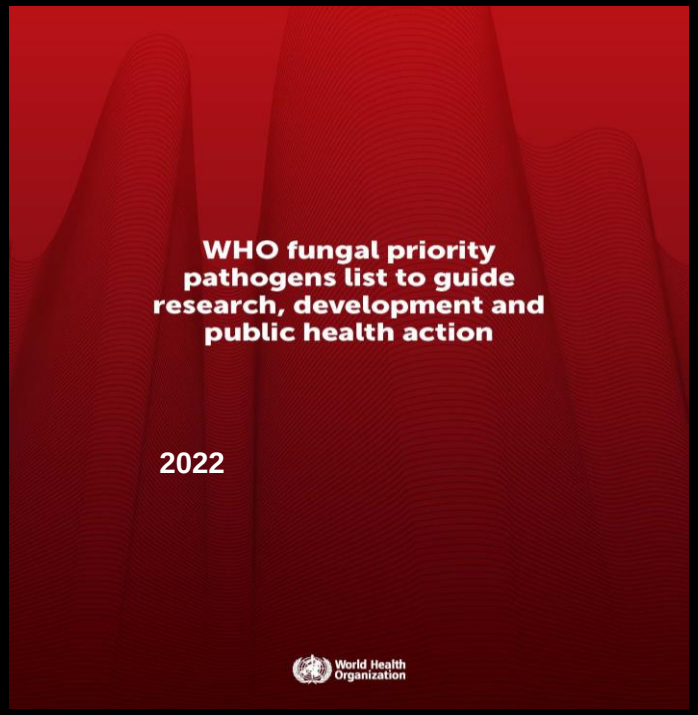


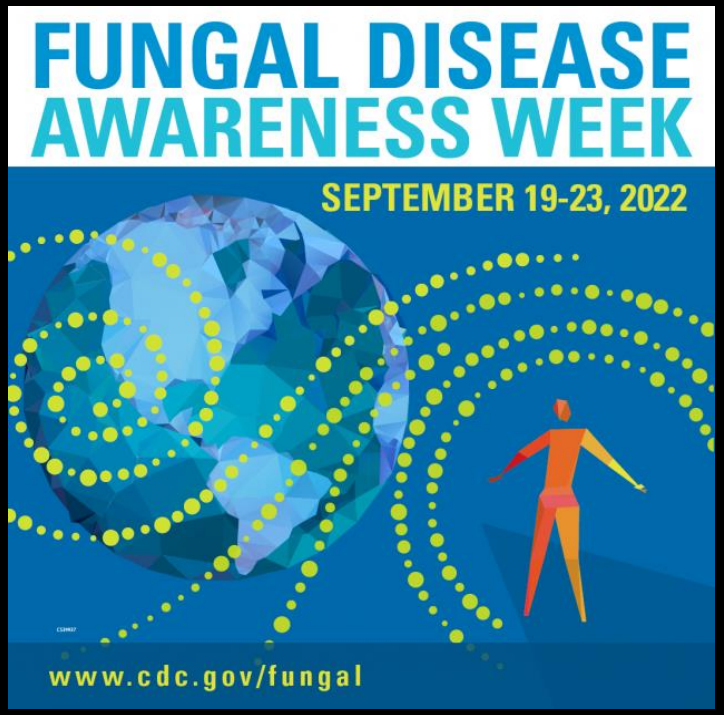


E. Kalanxhi et. al. posted 26 Sept. 2022

Conflicting Priorities Between Veterinary and Public Health

- animal infections with serious human impact but no direct animal health benefits for testing
  - *E.Coli* 0175





Critical group	High group	Medium group
Cryptococcus neoformans	*Nakaseomyces glabrata (Candida glabrata)*	*Scedosporium* spp.
Candida auris	*Histoplasma* spp.	*Lomentospora prolificans*
Aspergillus fumigatus	Eumycetoma causative agents	*Coccidioides* spp.
Candida albicans	Mucorales	*Pichia kudriavzeveii (Candida krusei)*
	Fusarium spp.	*Cryptococcus gattii*
	Candida tropicalis	*Talaromyces marneffei*
	Candida parapsilosis	*Pneumocystis jirovecii*
		Paracoccidioides spp.

Emerging Fungal Infections

- historical paucity of mycotic disease of mammals
  - poor survival and replication at mammalian temperatures
- *C. auris* as first example of fungal species with pathogenic potential to overcome mammalian endothermy barrier
  - proposed emergence due to climate warming
- natural habitat in soil ecosystems with some salinity: tidal salt marshes
- nearly simultaneous emergence of different clades in different continents (2011-12)
  - first US case 2016 and subsequent spread to over 30 countries

One Health Implications of Widespread Use of Broad-Spectrum Agricultural Fungicides*

- azole fungicide use in USA increased by > 400% to C.3,000 metric tons per year (2006 to 2016)
- PRC and Europe X 10 use (300,000 metric tons/year)
- degradation T½ of 47-120 days and widespread environmental persistence
- increased detection of azole-resistant *A.fumigatus* isolates in clinical and environmental samples
  - frequency elevated in high-temperature environments (composts, greenhouses, tropics)
- thermal adaptation to warmer climate invoked to explain rapid worldwide emergence of multidrug resistance *Candida auris* following discovery in 2009

*M.C. Fisher et al. (2022) Nat. Rev. Microbiol. 20, 557

Climate Change and Health Risks

Human Direct Dependency on Nature for Basic Needs*

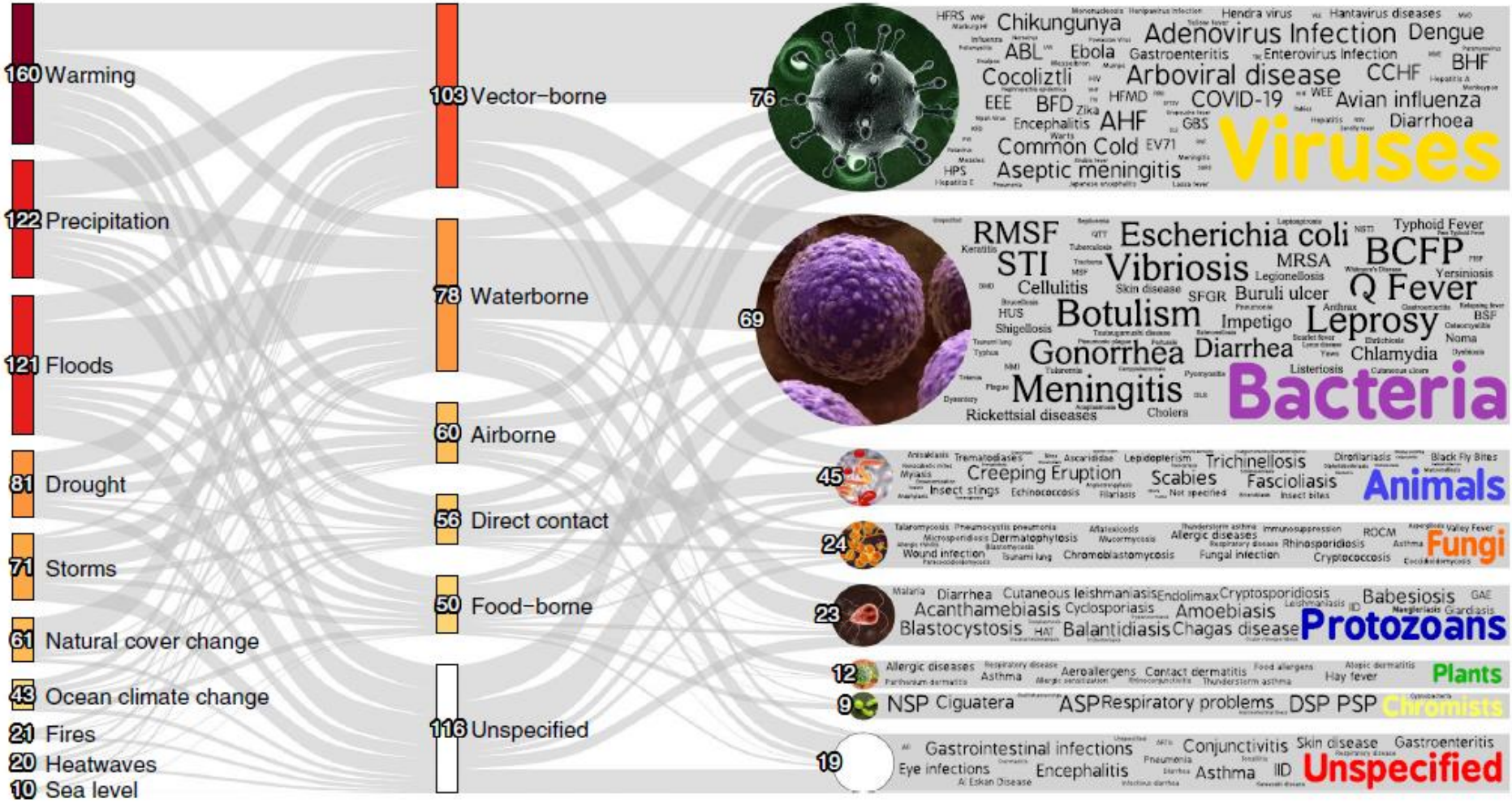
- energy, food, water, housing
- 3 billion (40% global population) depend solely on biomass (wood/leaves) for cooking/heating
- 500 million derive income from smallholder farming
- smallholder farming, forestry and fishing represent 70% of household income in tropical rural areas
- 800 million live without improved sources of drinking water (pipes/pumps)
  - rely on rivers, streams, groundwater
- 1.3 billion build houses from natural products (wood, dung)

*G. Fedele et al. (2021) Global Environ. Change 102368

Climate Shifts and New Pathogen-Host Interactions

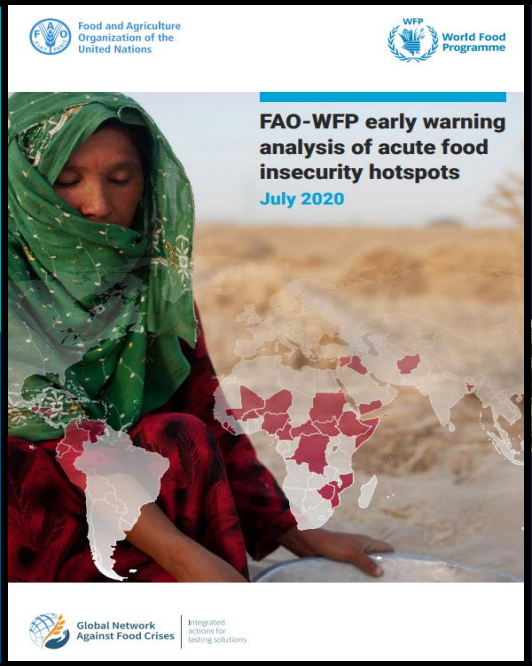
- warming, precipitation changes and expanded vector ranges
  - mosquitoes, ticks, fleas, birds, mammals
- warming at higher latitudes and increased pathogen and vector survival
  - zika, dengue
- land cover changes and habitat destruction
  - human encroachment
  - wildlife migrations over larger areas for food foraging and zoonotic spillover risks
- floods and storms
  - wastewater overflow and food-borne illness
  - human displacement and refugee migrations

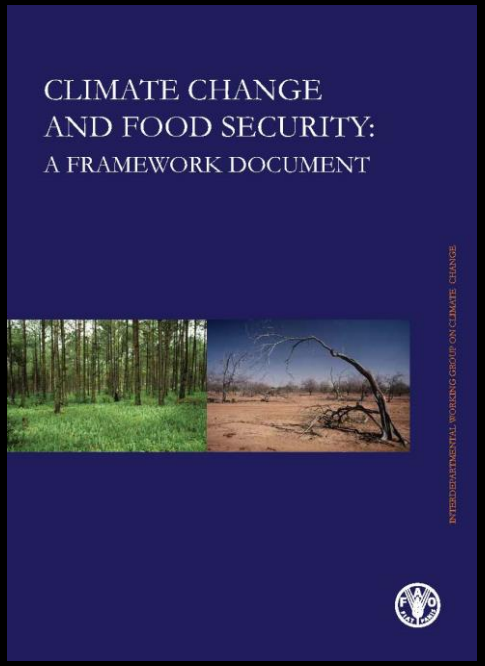
Over Half of Known Human Pathogenic Diseases Can Be Aggravated By Climate Change

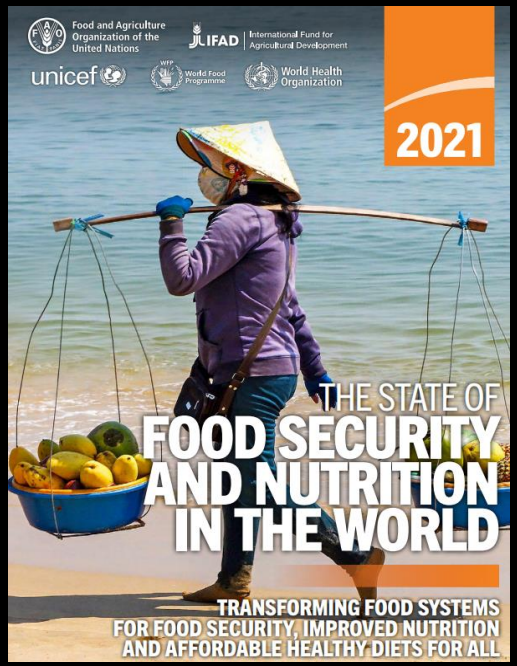


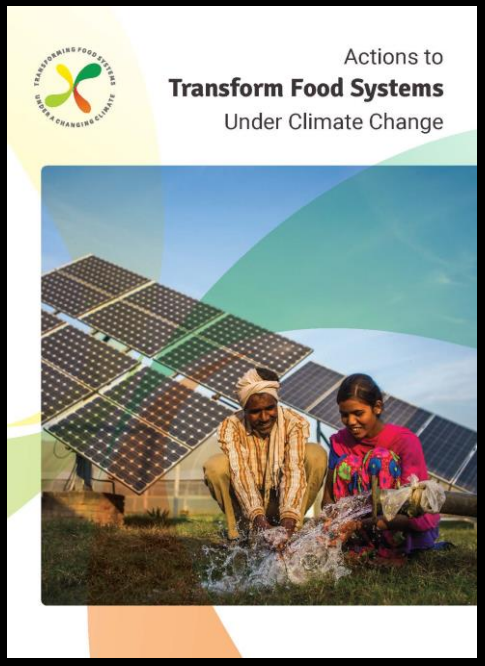
C. Mora et. Al. (2022) Nature Clim. Chan. 12, 869

Climate Change and Growing Challenges of Global Food Security

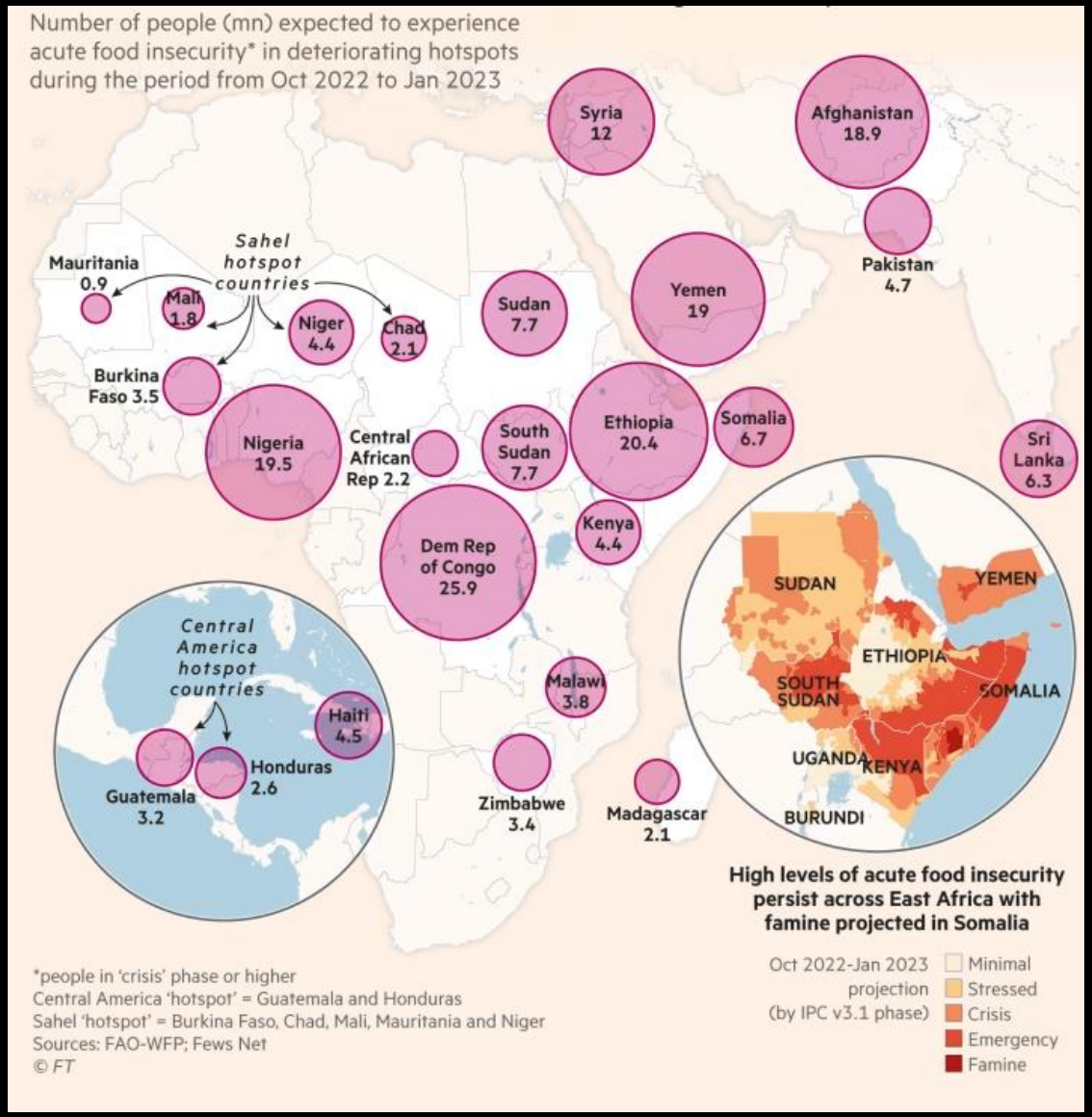








Conflict and Weather Extremes Drive Acute Hunger in ‘Hotspot’ Countries



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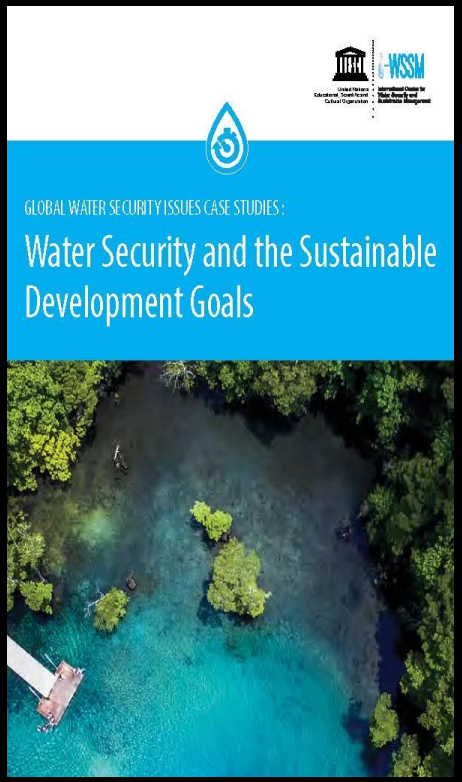
Water Security



Climate Change Induced Ecological Shifts In Host and Pathogen Ranges and New Cross-Species Viral Transmission Risks

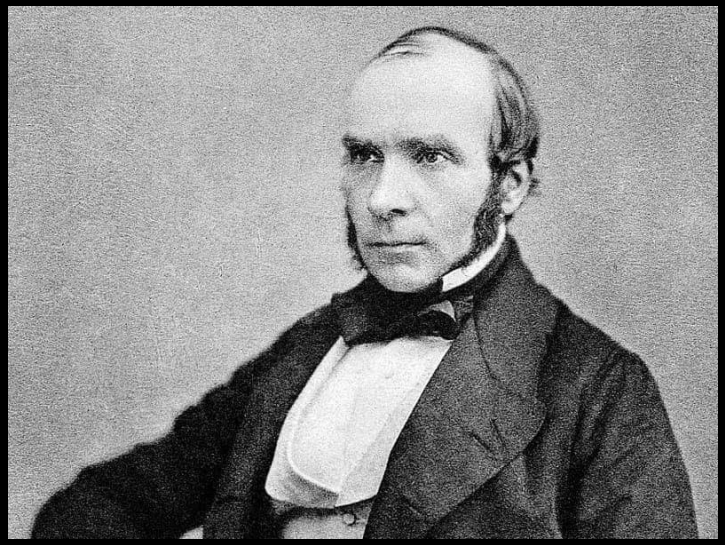
- estimated 6,500 placental mammalian hosts*
- only 7% share common geographical range
- only 6% currently known to host one or more of the same virus species (virus sharing)
- modeling of climate change effects on global range distribution**
  - projected increase in novel first-encounters between species notably in tropical Africa and SE Asia
  - dispersal patterns of bats in continental panmixia and new zoonotic reservoirs

*G.F. Albery et al. (2020) Nat. Commun. 11, 2260
**C.J. Carlson et al. (2020) Nature 607, 555

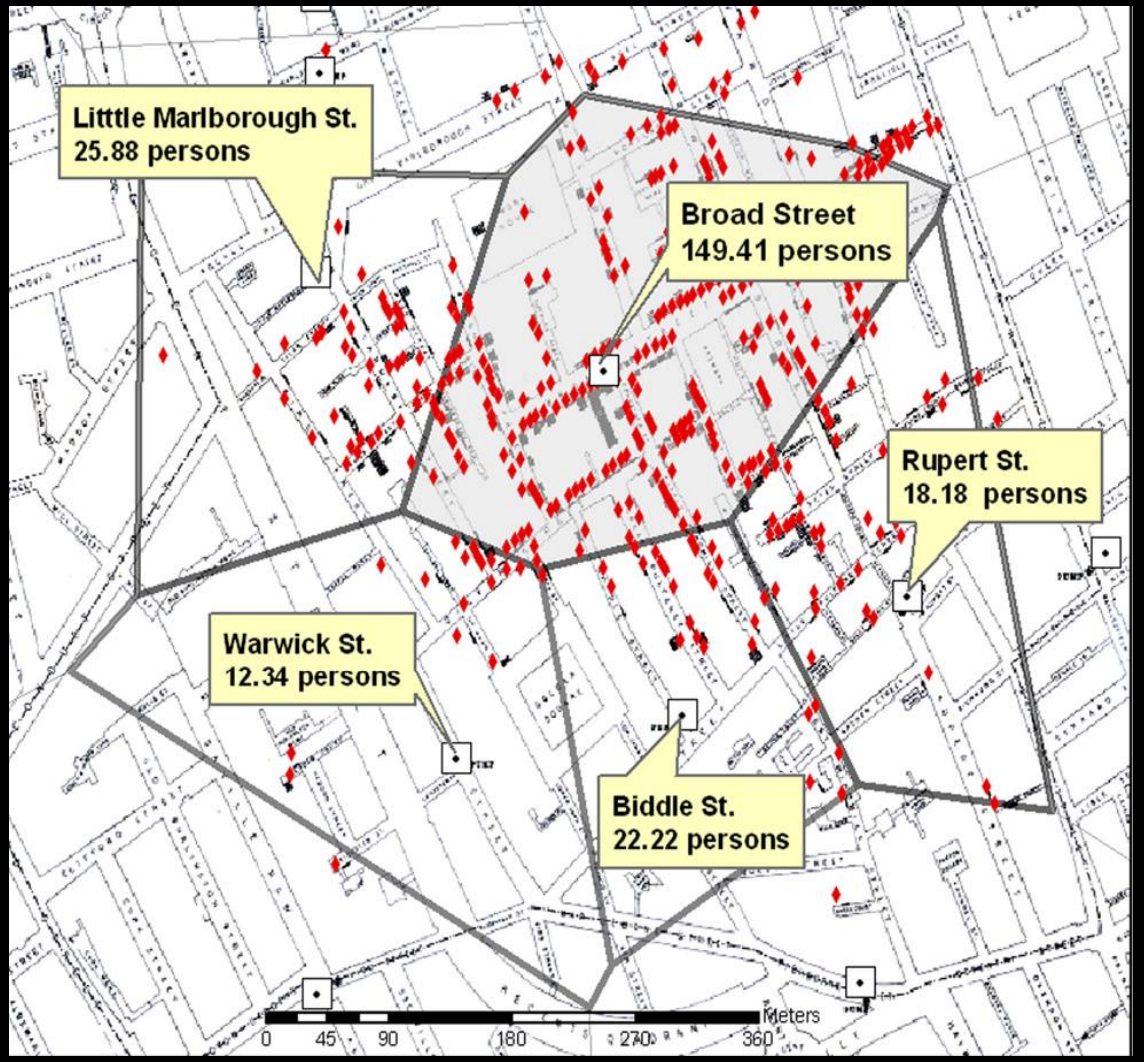
https://www.nature.com/nature/volumes/611/issues/7934

Data: The Foundation of Epidemiology and Informed Decisions

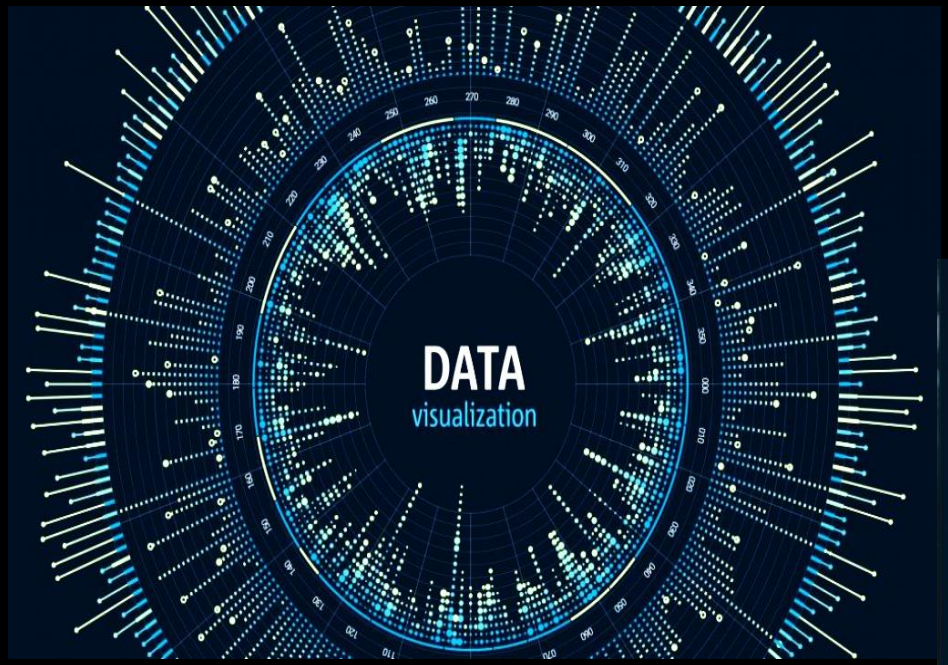
Dr. John Snow, 1855

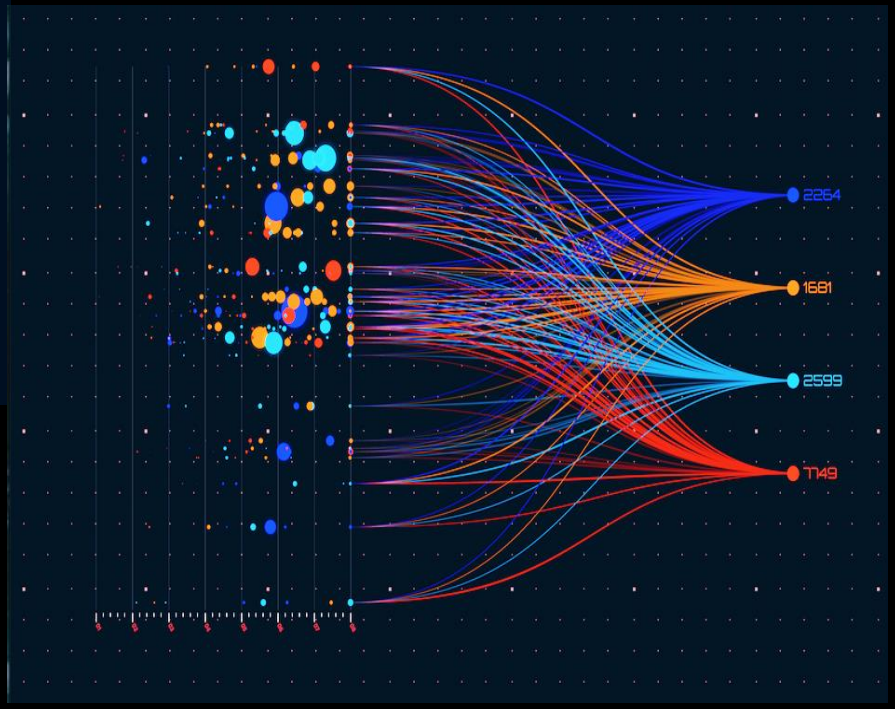


- cholera deaths per 1,000 population



Data Dashboards for Realtime Situational Awareness: The Foundation of Informed Decisions



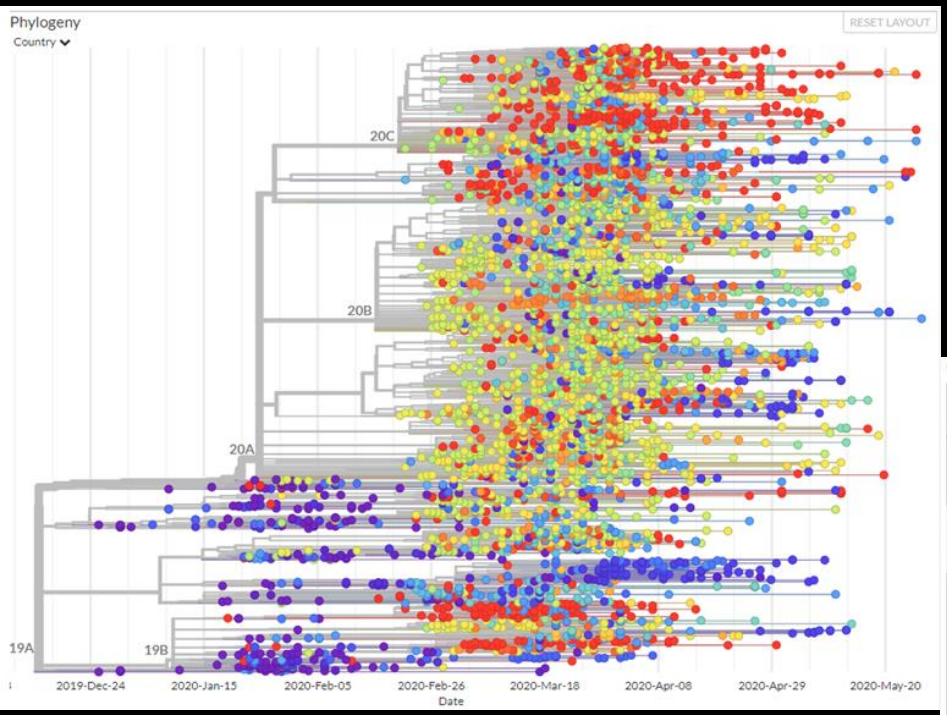


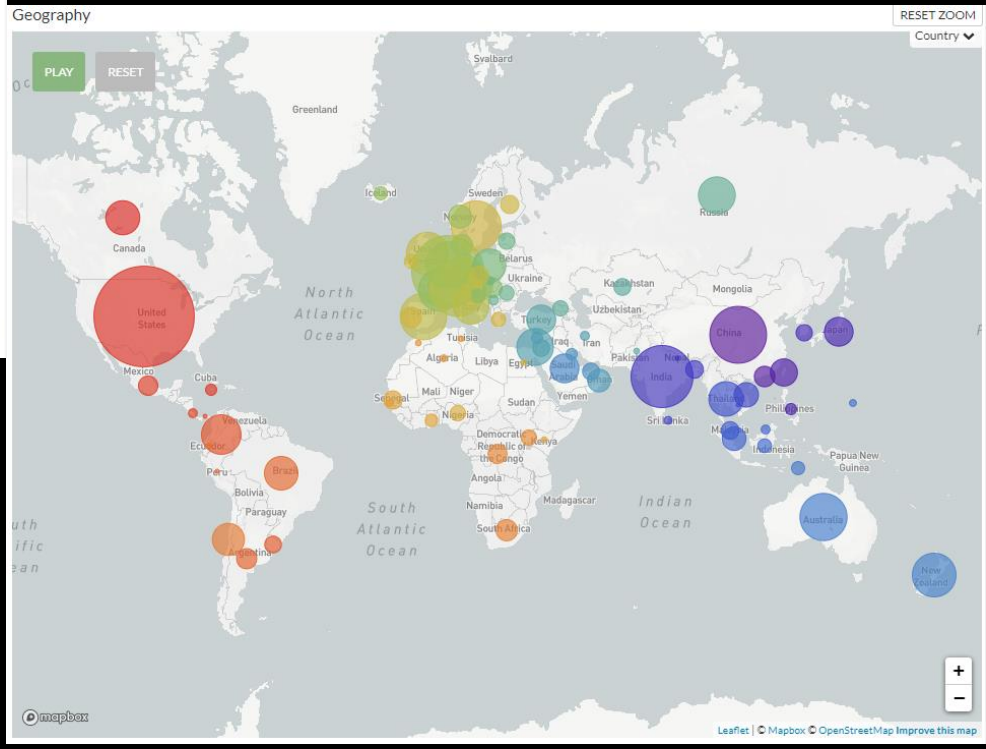
- **deconvolution of complex data streams for optimum decision-support customized to different end users**

The US Public Health System: A Data Backwater

- massive gaps in timely data capture, analysis and sharing during COVID -19 pandemic
- widespread dependence on paper documentation/FAX transmission
- over one-third of local health departments cannot access electronic data from local emergency departments
- fragmented and tardy capture and limited inter-operability of data feeds at Federal level
- a classic case study in the consequences of underinvestment in infrastructure and workforce for robust PRR

Global Tracking of Mutational Changes in SARS-COV-2 Samples





Infectious Disease Forecasting: Integration of Large Scale MultiOmics Data

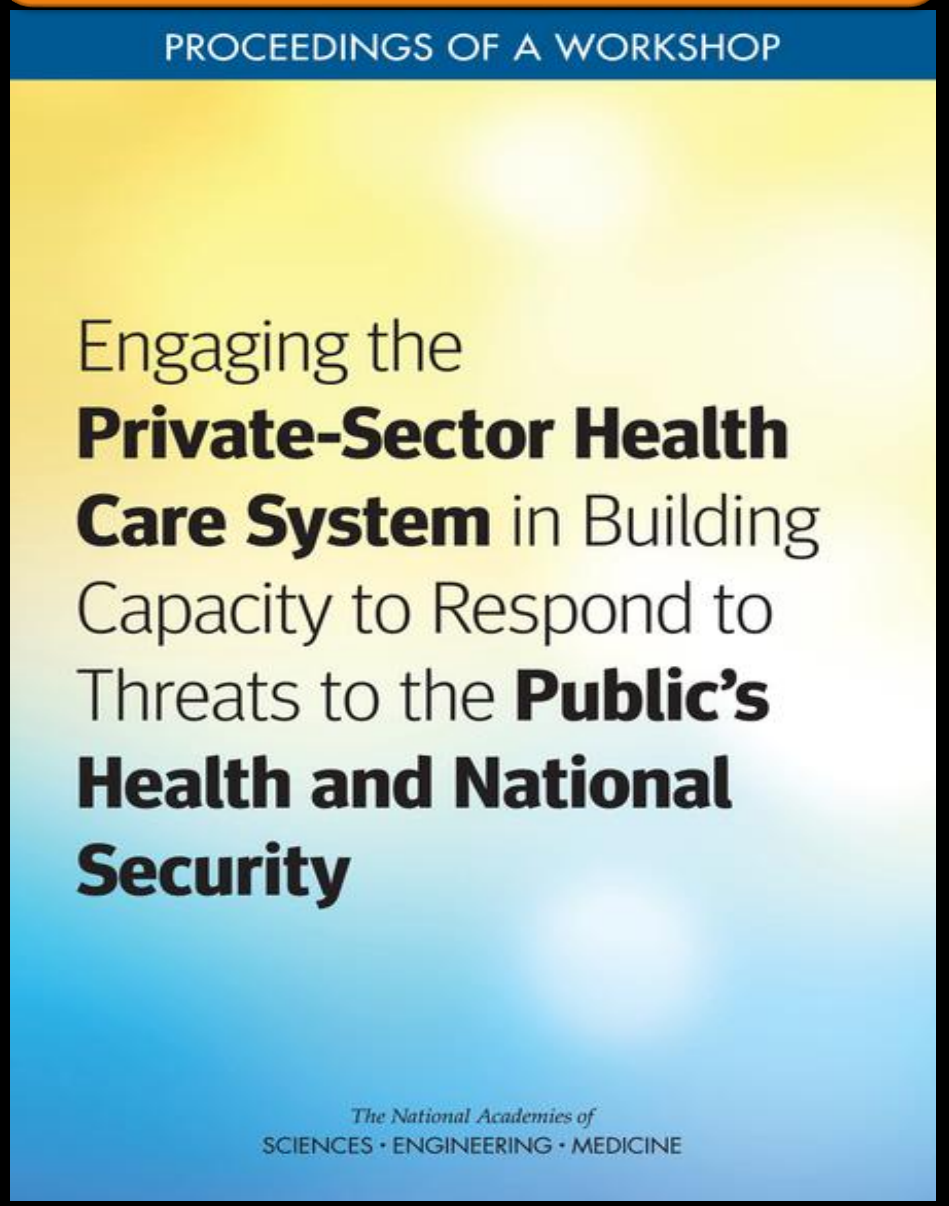
- reconstruction of transmission trees and contact networks in outbreak settings with dense sampling
- longitudinal multiOmics data and dense sampling are critical to robust analysis/prediction of time-dependent changes in pathogen evolution and transmission
- phylogeographic mapping of pathogens and variant emergence
  - importation, local circulation, factors driving transmission
- identification of resistance phenotypes, candidate Rx/Dx/vaccine targets

Emerging Questions from Burgeoning Large Scale MultiOmics Datasets on Pathogens and Hosts

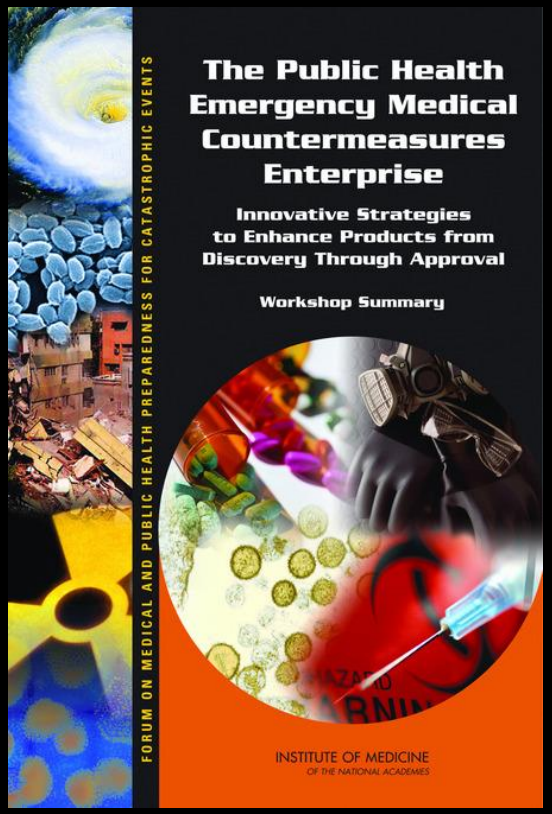
- which previously unrecognized organisms detected in metagenomic sampling exhibit potential pathogenic signatures?
- what are the immune correlates of protection against different pathogen classes (natural infection/vaccination)?
- how does host immune response drive pathogen evolution and vice-versa (immune restriction phenotypes)?
- can genetic determinants of natural selection and evolution of zoonotic pathogens in wildlife provide insight into disease susceptibility/severity/ resistance alleles relevant to human risk and improve livestock breeding?

Who Pays for Preparedness?

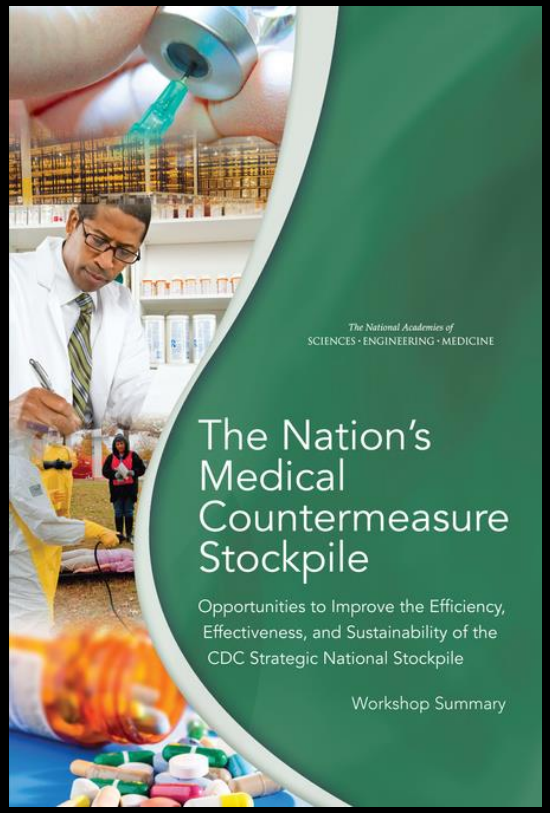
The Obligate Role of Private-Public Partnerships in Biosecurity Policy



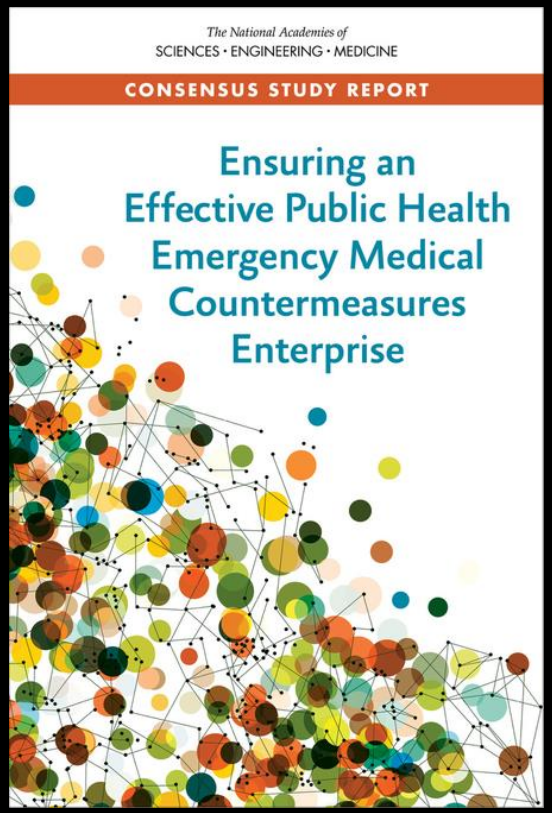
Emergency Medical Countermeasures: Warnings Long Ignored



(2010)



(2016)



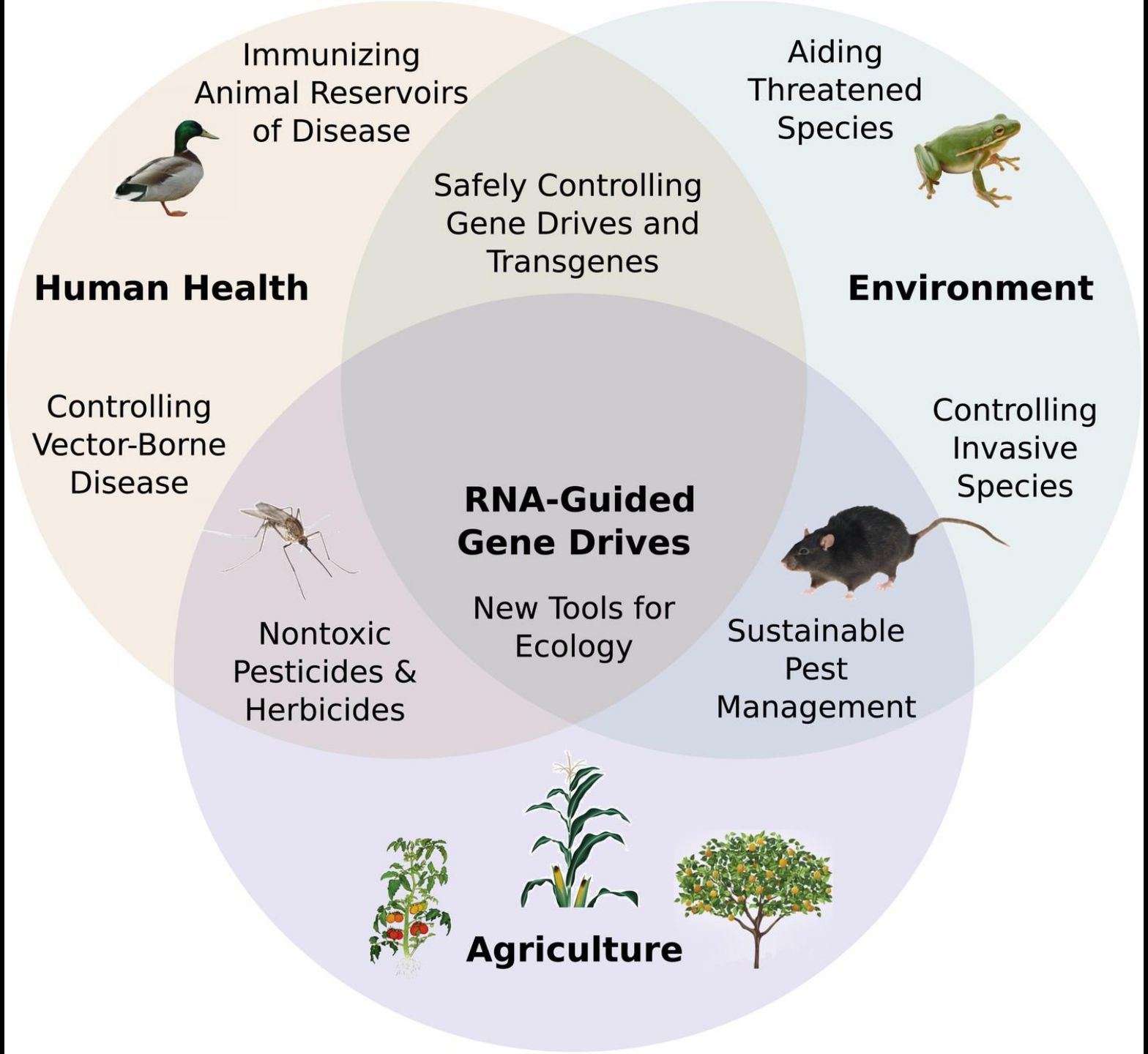
(2021)

Proactive Development and Availability (Stockpiling) of Medical Countermeasures for Potential Pandemic Pathogens and AMR

- ‘market failure’
- lack of incentives for private sector to undertake high-risk/high-cost R&D absent guaranteed markets and ROI
  - neglected diseases of the developing world
  - antibiotic resistance (global)
  - MCMs for EIDs and biowarfare select agents
- outsourcing of critical supply chains (China, India)
  - generic drugs (80% of US prescriptions)
  - active ingredients for key drug classes (antibiotics)
  - PPE
  - devices (ventilators)

CEPI: The 100 Days Mission

- design and delivery of novel vaccine(s) within 100 days of a new viral threat emerging
- construct library of prototype vaccines of viral families viewed as posing greatest risk
  - focus on human infections but large-scale epizootics also pose significant socio-economic threats
- technology gaps
  - computational prediction of optimum T-and B-cell epitopes
  - polyvalent antigen delivery systems (antigens and/or mRNA coding sequences)
- regulatory issues
  - mass deployment (EUA) without traditional clinical trial protocols
  - large-scale distribution logistics and global equity

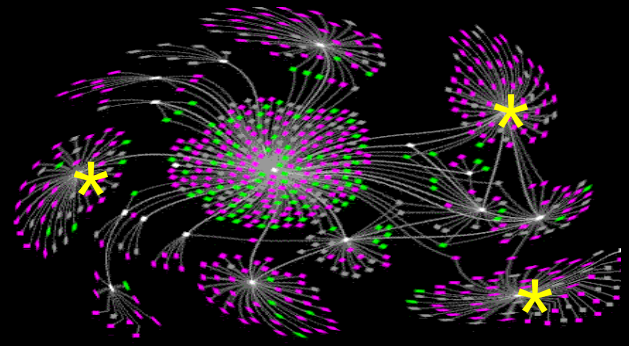

Immunizing
Animal Reservoirs
of Disease
Aiding
Threatened
Species
Safely Controlling
Gene Drives and
Transgenes
Human Health
Environment
Controlling
Vector-Borne
Disease
Controlling
Invasive
Species
RNA-Guided
Gene Drives
New Tools for
Ecology
Nontoxic
Pesticides &
Herbicides
Sustainable
Pest
Management
Agriculture

New Technologies and Increased Complexity of Dual-Use Issues in Biosecurity: Synthetic Biology, Genome Editing and Manipulation of Biological Pathways

digital biology: "it from bits"

de novo synthesis of organisms

engineered virulence



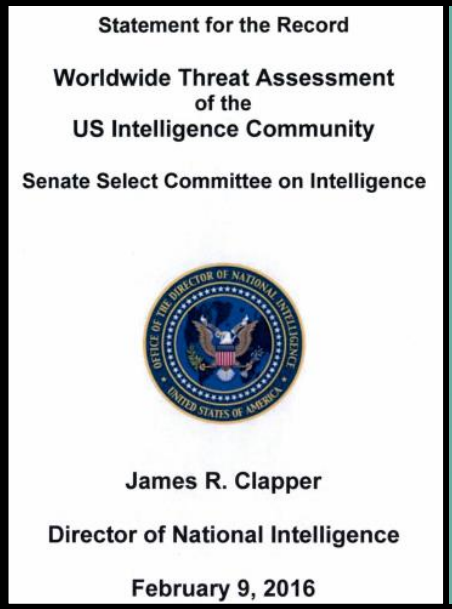
华大基因学院
BGI college
华大基因研究院
BGI research

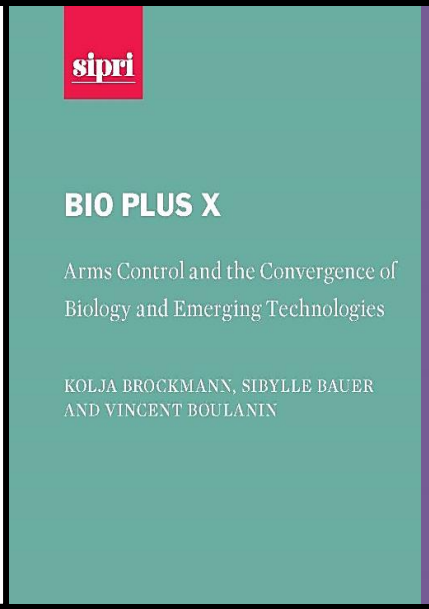
targeted modification of any biological pathway in any organ

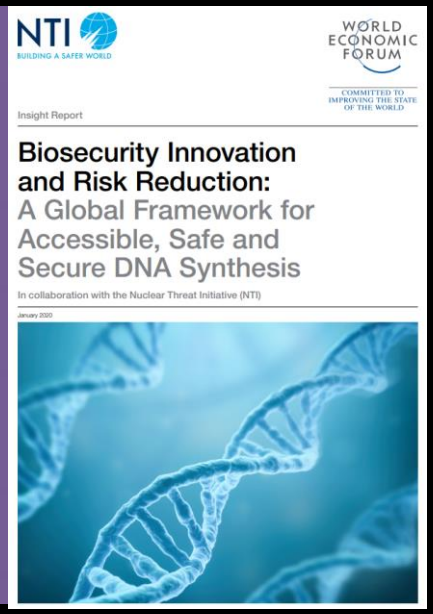
modulation of neural sensory and cognitive pathways

rapid global technology diffusion and competition

Dual-Use Applications of Synthetic Biology and the Expanded Threat Spectrum







- beneficent and maleficent applications of same knowledge
- potential to cause profound societal disruptions based on deliberate misuse, error or accident
- automation, simplification and cost reduction
- rapid global technology diffusion competition and adversarial risk
- new oversight mechanisms and international harmonization

The Origin of SARS-CoV-2:
Natural Zoonose or PRC Wuhan BSL-4 Laboratory GOF Studies and Inadvertent Biocontainment Breach?

EcoHealth Alliance

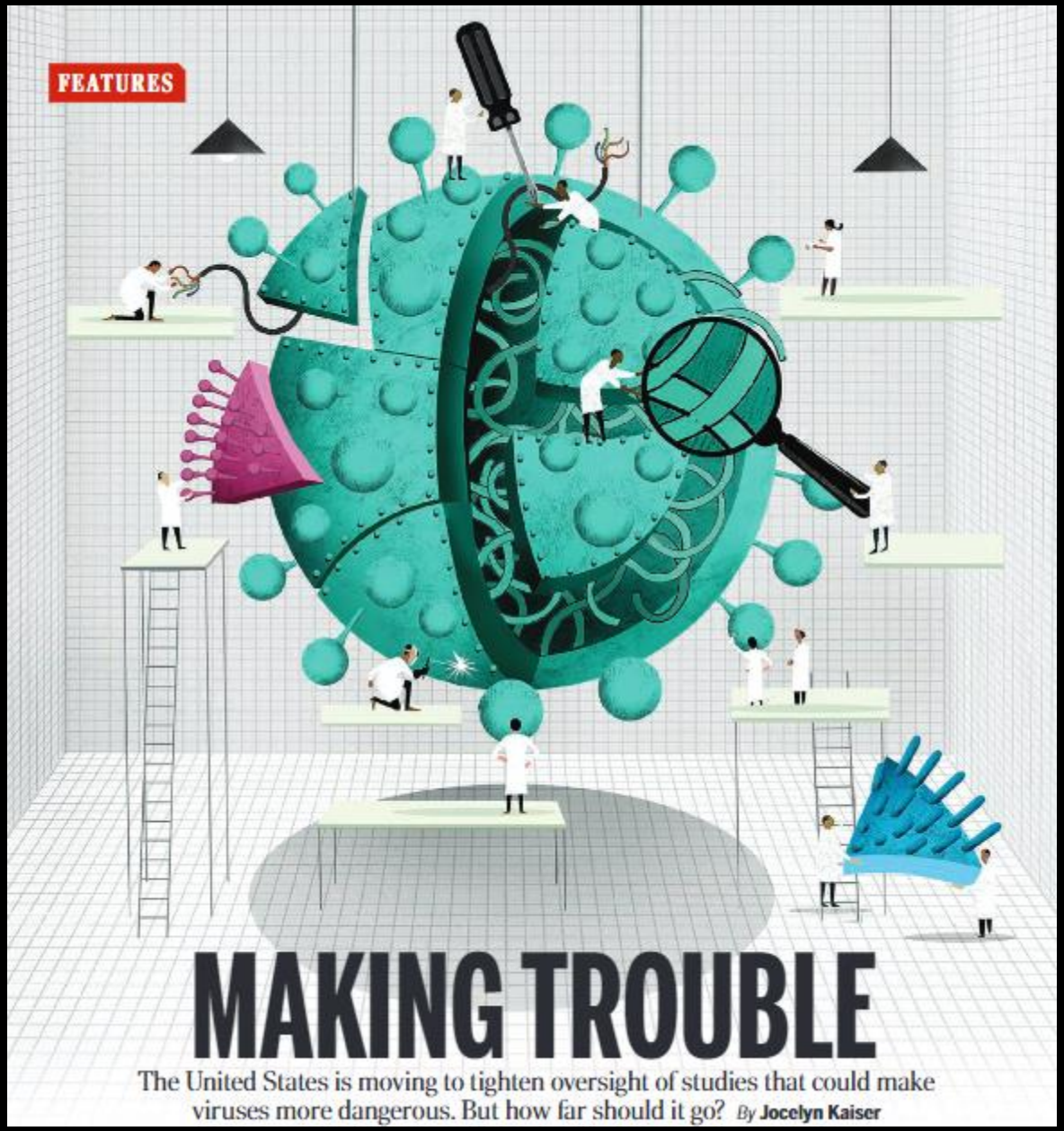
An Analysis of the Origins of the COVID-19 Pandemic

Interim Report

Senate Committee on Health Education, Labor and Pensions

Minority Oversight Staff

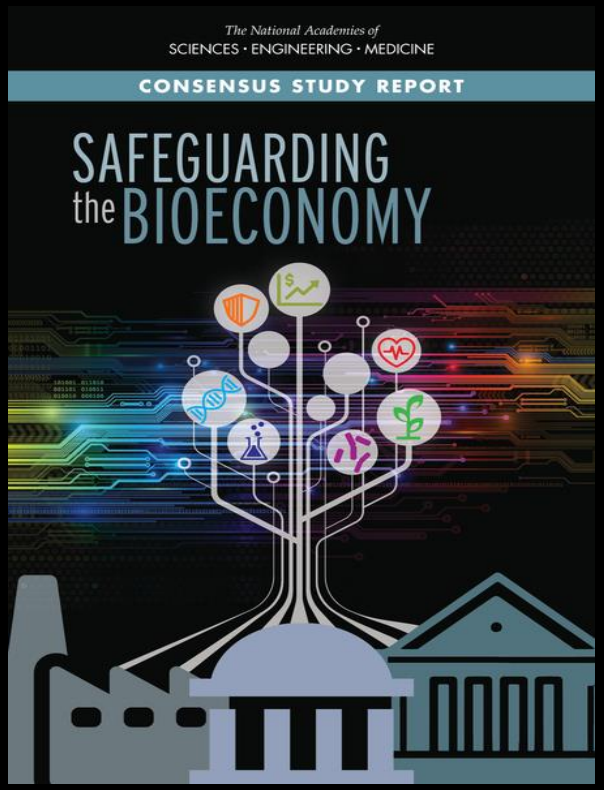
October 2022

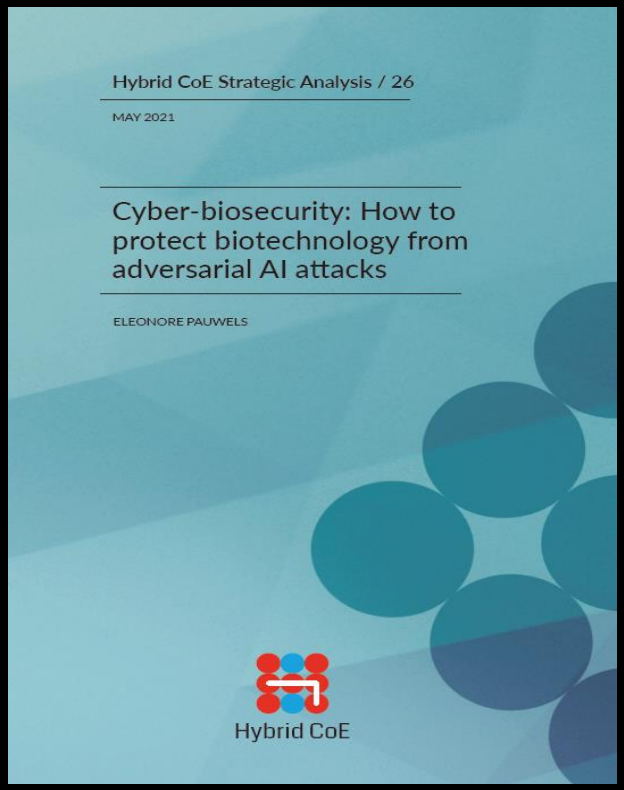


Science (2022) 378, 202

Global Expansion of High Biosafety Level (BSL-3/4) Laboratories

- COVID-19 pandemic highlighted gaps in preparedness resources for handling high risk pathogens
  - conventional public health (BSL-3)
  - expanded capabilities for translational research (Rx, vaccines)
- plans announced to build 27 new BSL-4 facilities
  - Russia (15), PRC (4), India (4), Kazakhstan, Singapore, Philippines, US (1)
- long lead times for construction and certification
- high operational costs ($15-20 million/year)
  - maintenance, air handling, security
- staff training and (re)certification in stringent-biohazard containment protocols to limit risk of biosecurity breach


The National Academies of
SCIENCES · ENGINEERING · MEDICINE
CONSENSUS STUDY REPORT
SAFEGUARDING
the BIOECONOMY


Hybrid CoE Strategic Analysis / 26
MAY 2021
Cyber-biosecurity: How to protect biotechnology from adversarial AI attacks
ELEONORE PAUWELS
Hybrid CoE


Administration
SEPTEMBER 12, 2022
Executive Order on Advancing Biotechnology and Biomanufacturing Innovation for a Sustainable, Safe, and Secure American Bioeconomy

Commitment

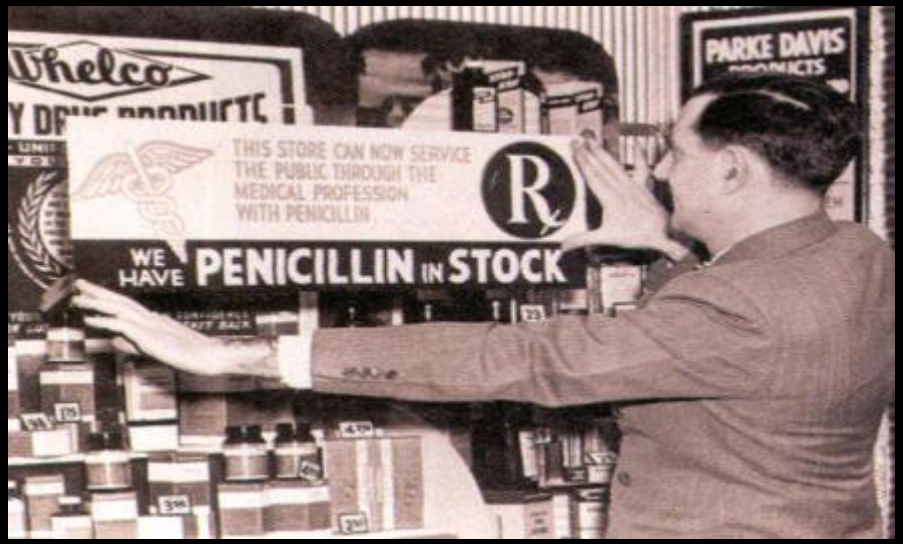
The Evolution of Global Public Health Aspirations: Alma-Ata (1978) to Astana (2018)

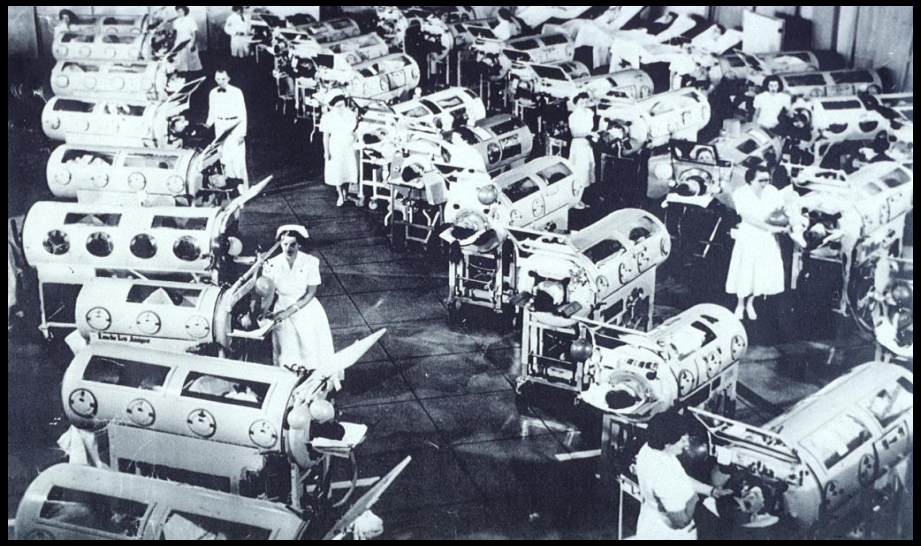
World Health Organization

Global Health Security Agenda

- prevent, detect and respond to infectious disease
- safeguard economies
- end the cycle of panic and neglect
- need for sustained investment commitment
- essential public health capacities represent recurring cost

Comfort and Complacency: The Enemies of Vigilance and Preparedness

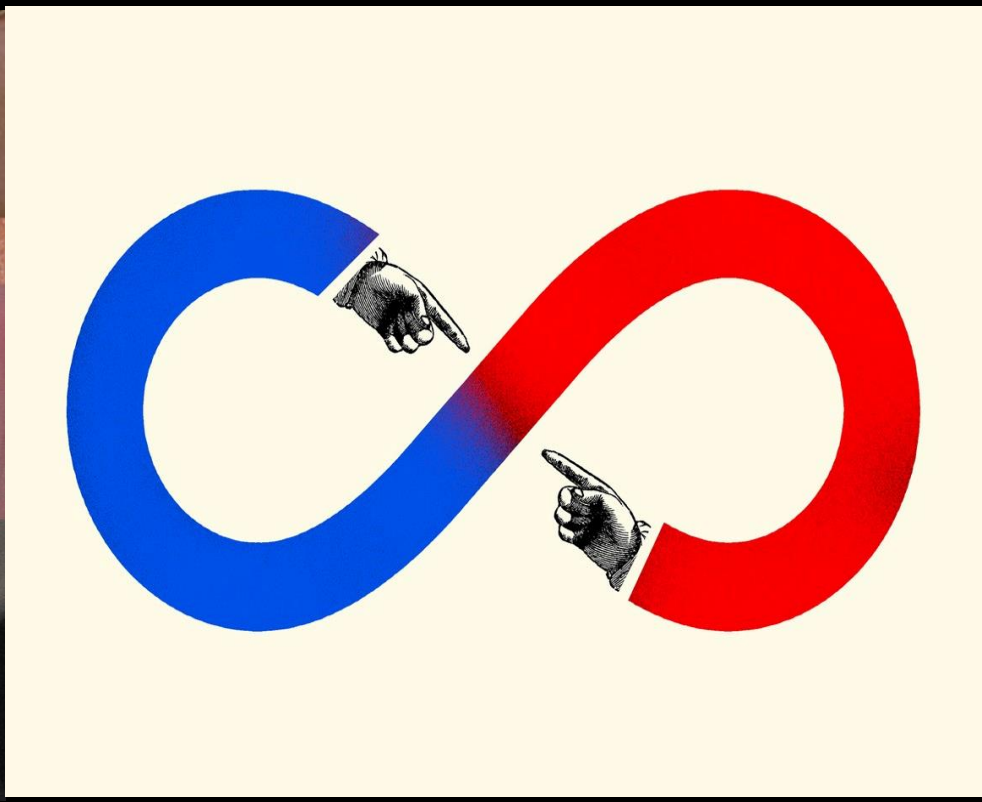




Rude Shocks

- misplaced complacency, indifference and outdated assumptions about American technological superiority and public health capabilities
- confused and conflicting policy messaging from White House, CDC placing policy and economic considerations ahead of rational epidemiological/ public health actions
- pandemic struck at a perilous moment in US politics
  - growing distrust in experts and amplified by partisan political divisions and incendiary social media

A Critique of the US Response to COVID-19



- mix politics and public health-politics wins
- technological illiteracy of both legislative and executive branches
- partisan politics
- ever changing messaging
- media sensationalism
- proliferation of disinformation on social media
- public confusion and mistrust

Risk Assessment and Communication to Build Robust Preparedness, Response and Recovery Capabilities Are Shaped by Socio-Economic, Socio-Political Factors and Human Behavior

- cultural- and context dependent
- community social relations and human behavior
- societal beliefs, perceptions and (dis)trust of public health/government action
- the infodemic: proliferation of disinformation

Countering Disinformation: A Growing Challenge in Public Health Communications and Sustaining Public Trust

- unchecked dissemination of inaccurate information on social media
- controversy and extremism drives clicks=revenue
- manipulate public opinion, increase socio-political tensions and erode trust in authorities/decisions
- active role of PRC and Russia in COVID-19 pandemic

Gray Zone Tweets and Biosecurity: Russian Trolls and Twitter Bots

- purposeful social media disinformation campaigns
- weaponized disinformation in health communications
  - anti-vaccination campaigns
  - anti-GMO movements
  - exploit health disparities and racial tensions
- compromise health care computer systems and or other critical computing capabilities in bioincidents
- Russian FSB Novochok chemical attack on Sergei and Yulia Skripal in UK (3/4/2018)
  - Salisbury UK hospital computers hacked
  - thwarted hack of Organization for Prohibition of Chemical Weapons (The Hague) conducting forensic analysis of incident samples

Out-of-Sight: Out-of-Mind

- dismal cycles of panic-fund-forget
- the curse of short-termism in public and private sector priorities
- competing political priorities move center-stage as perception of threat wanes
- economic slow down, government austerity measures and rise of nationalistic attitudes as barriers to sustained funding for biosecurity
  - disproportionate impact on LMICs

THE NEW PANDEMIC FUND AIMS TO:

- *bring additional, dedicated resources*
- *incentivize countries to increase investments*
- *enhance coordination among partners*
- *serve as a platform for advocacy*

WORLD BANK GROUP

World Health Organization

Mobilizing Global Commitments to Enhance Pandemic PRR Capabilities

- (re)build greater resilience in public health and healthcare infrastructure
- essential goals and welcome actions (assumes sustained commitment to delivery)

BUT

- heavily weighted to protection of G20 populations
- focused almost exclusively on pandemic threats and communicable diseases versus threat-agnostic/disaster PRR
- still largely ***'reactive'*** focus on enhanced detection versus the more challenging task of ***'proactive'*** threat elimination at source

Mobilizing Global Commitments to Enhance Pandemic PRR Capabilities

- (re)build greater resilience in public health and healthcare infrastructure
- ess[illegible] delivery sustained com[illegible]
- hea[illegible]
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Collective Myopia and One Critical Omission

ONE HEALTH !

- renewed focus and funding to strengthen global public health is necessary but not sufficient
- without adoption of one health as a core principle in global biosecurity laudable aspirations for human and planetary health will be undermined by continued cycles of emergent zoonotic EIDs, food insecurity and depletion of non-renewable natural resources

Arizona Health Improvement Plan

Summary Document

2021-2025

ARIZONA ONE HEALTH TOOLKIT

ADHS

Food and Agriculture Organization of the United Nations

UN environment programme

World Health Organization

World Organisation for Animal Health
Founded as OIE

Action Track 1. Enhancing One Health capacities to strengthen health systems

Action Track 2. Reducing the risks from emerging and re-emerging zoonotic epidemics and pandemics

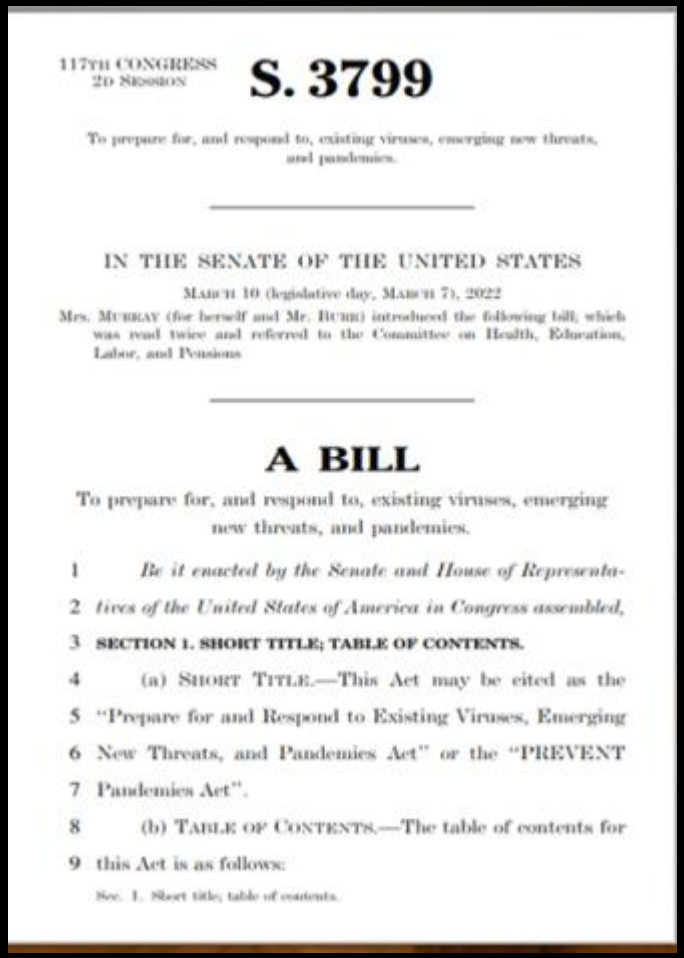
Action Track 3. Controlling and eliminating endemic zoonotic, neglected tropical and vector-borne diseases

Action Track 4. Strengthening the assessment and management of food safety risks

Action Track 5. Curbing the silent pandemic of Antimicrobial Resistance (AMR)

Action Track 6. Integrating the Environment into One Health

Quadripartite One Health Joint Plan of Action (2022-2026)



117TH CONGRESS
2D SESSION

S. 3799

To prepare for, and respond to, existing viruses, emerging new threats, and pandemics.

IN THE SENATE OF THE UNITED STATES

MARCH 10 (legislative day, MARCH 7), 2022

Mrs. MURRAY (for herself and Mr. BURR) introduced the following bill; which was read twice and referred to the Committee on Health, Education, Labor, and Pensions

A BILL

To prepare for, and respond to, existing viruses, emerging new threats, and pandemics.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled,

SECTION 1. SHORT TITLE; TABLE OF CONTENTS.

(a) SHORT TITLE.—This Act may be cited as the "Prepare for and Respond to Existing Viruses, Emerging New Threats, and Pandemics Act" or the "PREVENT Pandemics Act".

(b) TABLE OF CONTENTS.—The table of contents for this Act is as follows:

Sec. 1. Short title; table of contents.

Pending Legislative Actions that Acknowledge the Role of One Health

October 21, 2022

SENATOR GILLIBRAND INTRODUCES GROUNDBREAKING ONE HEALTH BILL TO PREVENT, DETECT, AND RESPOND TO BIOLOGICAL THREATS

Gillibrand Was Joined by Health, Food, and Conservation Experts to Announce Whole-of-Government Approach of the One Health Security Act

https://www.gillibrand.senate.gov/news/press/release/senator-gillibrand-introduces-groundbreaking-one-health-bill-to-prevent-detect-and-respond-to-biological-threats

Building a Global One Health Workforce: Silos Subvert Solutions

- current single discipline, vertically oriented, siloed institutional systems, expertise and funding policies are ill-suited to facile implementation of one health as a holistic systems-based approach to global risk
  - multidisciplinary, multi-institution, multi-sector
- sustained long-term investments
  - performance metrics, accountability, transparency

Building a Global One Health Workforce

- awareness and training in One Health concepts are still largely absent from educational curricula in multiple disciplines needed to implement coherent One Health strategies
  - human and veterinary medicine, ecology and environmental sciences, social sciences
  - urban planning and the built environment
  - economics, financial systems and global supply chain planning
  - law, IP
  - foreign policy and international studies
  - governance frameworks for international cooperation to counter global threats

Silo Busting to Address Global Risks

- embed one health concept and expertise in institutional systems with the requisite global reach and scale to drive multisectoral solutions to global risk
  - national security planning (military, IC, foreign policy)
  - financial services
  - trade and transport
  - large scale macro-engineering projects
- inclusion in ESG metrics (environmental, social and governance) for corporate investment

OHWA

ONE HEALTH WORKFORCE ACADEMIES

About One Health

One Health is a collaborative, transdisciplinary, and multisectoral approach that acknowledges the connection between the health of animals, people and the environment.

On December 1, 2021, United Nation's agencies' One Health High-Level Expert Panel (OHHLEP), released a formal definition of One Health.

https://onehealthworkforceacademies.org/about-one-health/

APTR

ASSOCIATION FOR PREVENTION TEACHING

AAVMC

Association of American Veterinary Medical Colleges

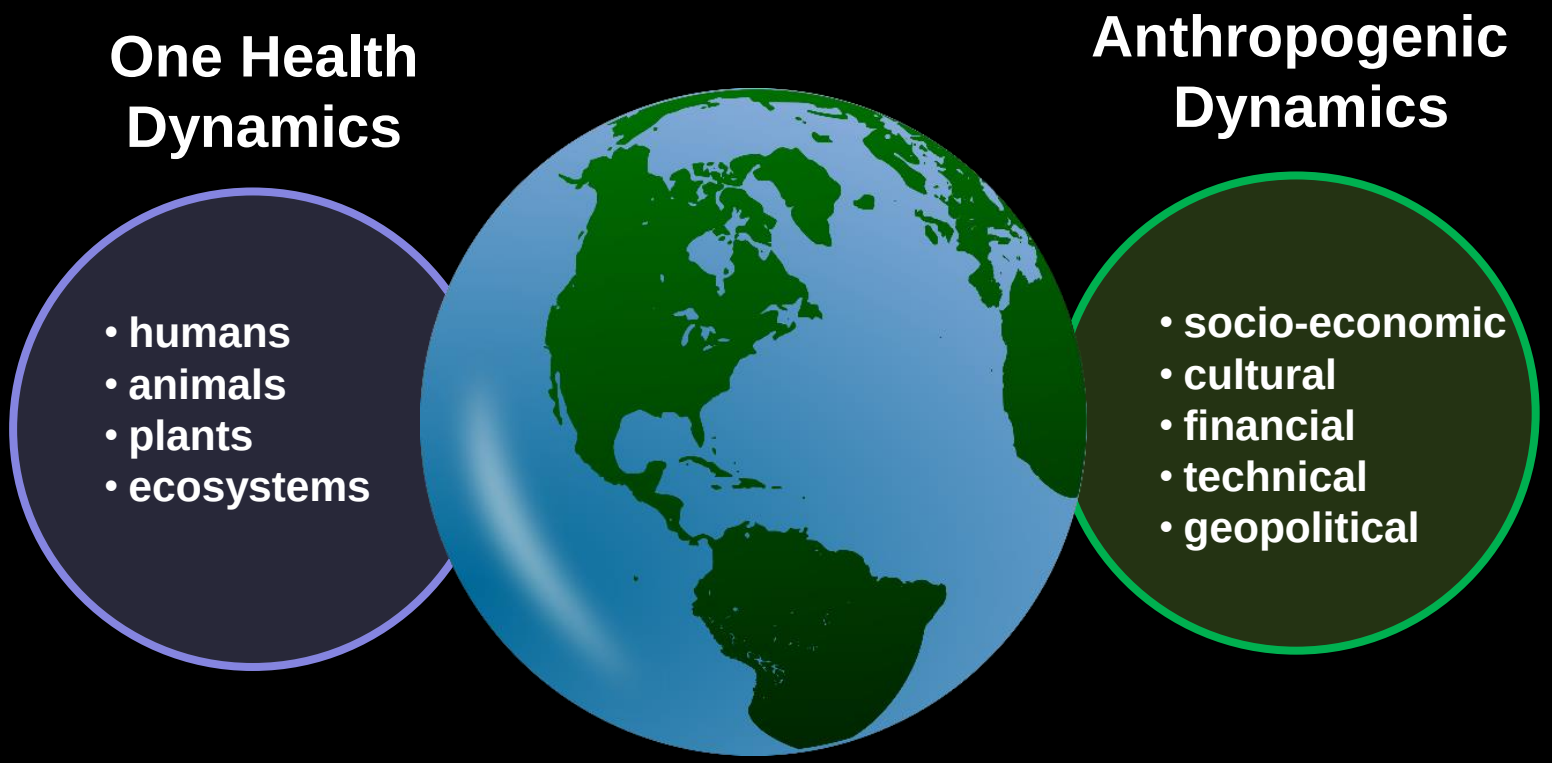
One Health Educational Framework for Health Professional Students

The One Health Educational Framework for Health Professional Students provides a structure for the education of all health professions students to understand the relationship between human health, animal health, and ecosystem health.

One Health: Concept, Complexity and Commitment

Understanding Ecosystem(s) Stability and Disease Dynamics as Complex Adaptive Systems

One Health:
A Unifying Grand Challenge and The Foundational Element for Improved Global Biosecurity and Planetary Health



“Plus ça change, plus c’est la même chose”

“Politics is the art of the possible,
the calculated science of survival”

Prince Otto von Bismarck

“Survival owes little to the art of politics,
but everything to the calculated application
of science”.

Professor Rudolph Virchow
(in reply)

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Slides available @ https://casi.asu.edu/presentations/

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(in reply)