Innovation in Surveillance

Our Uneven Fourth Industrial Revolution: How will it play out?

Ann Marie Kimball, MD,MPH, FACPM

The ROCKEFELLER FOUNDATION

CHATHAM HOUSE
The Royal Institute of International Affairs

Innovations in Surveillance

- *We are at a pivot point in the Fourth Industrial Revolution: Great promise.*
- *Who:* How to assure equity of benefit.
- *What* are we looking for: molecules and signals of infection.
- *When*: How fast can we learn? AMR challenge.
- *Where*: Do we understand geo-ecological risk? Can we "redeploy" assets to enhance response?

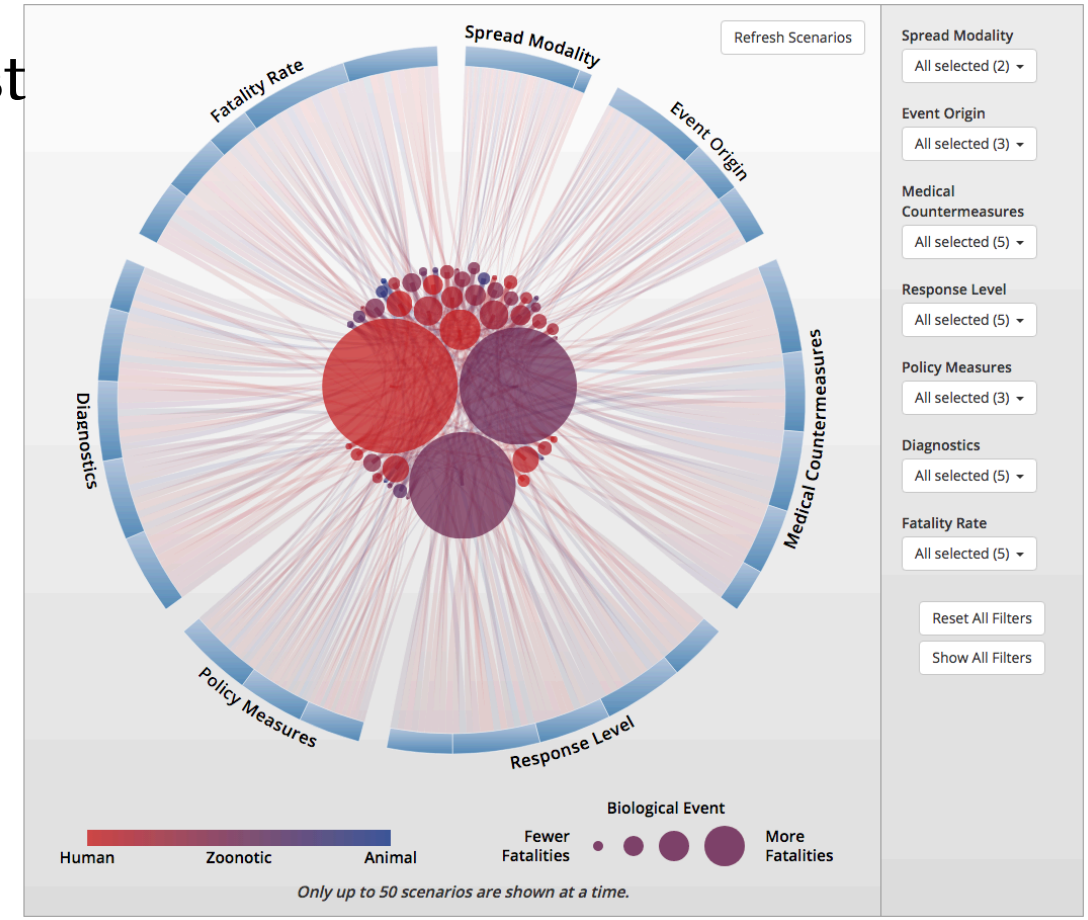
Whose Innovation?

"The World Bank's World Development Report (January) confirms these asymmetries with some sobering statistics: 4.4 billion people have never been online, almost two billion are untouched by digital technologies and 400 million live outside the mobile cellular signal range. Eighty per cent of India has not been online; a little over 70 per cent of Africans have never been online…."

Bhaskar Chakravorti, Senior Assoc. Dean of International Business & Finance, The Fletcher School at Tufts University, Founding Exec. Director, Institute for Business in the Global Context

Cross sectoral “all society” conversations are key

- New tools can assist in illustrating the complexity.
- Important to proactively engage stakeholders.
- Scenario exercises.



Katz, R., Graeden, E., Kerr, J. *The Complexity of Biological Events*, The Lancet; Vol 6 February 2018

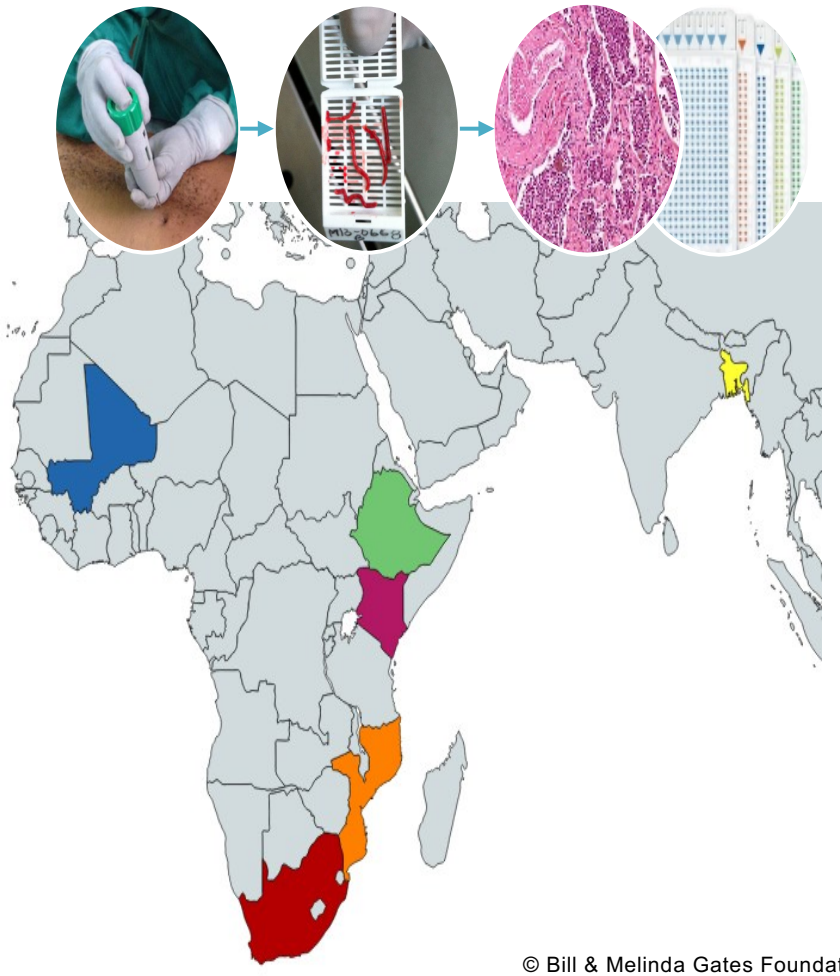
What are we looking for?

- Clusters of illness, death among humans- *Events*
- New pathogen circulation
- Antimicrobial resistance in known pathogens

CHAMPS and cause of death

- Clusters of childhood deaths often create first alerts
- New mortality based surveillance for children are being put in place
- Potential to eventually allow powerful timely post-mortem diagnoses.

The child health and mortality prevention surveillance (CHAMPS) network: Building KNOWLEDGE TO SAVE CHILDREN's LIVES



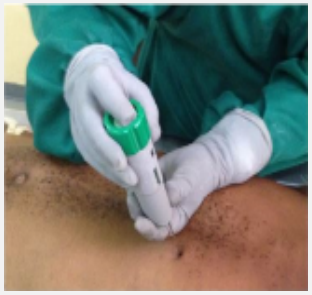
CHAMPS

- Six active sites
- Preparatory activities underway in Sierra Leone
- Based in health and demographic surveillance sites (HDSS)
- Prospective, population-based
- Cause of death determined by minimally invasive tissue sampling (MITS) plus verbal autopsy (VA)

Reminder of CHAMPS network objectives

Primary Objective:

To track causes of childhood death globally: Emphasizing high-mortality areas, focusing on preventable deaths, including neonatal deaths and stillbirths, prioritizing autopsies as the gold standard

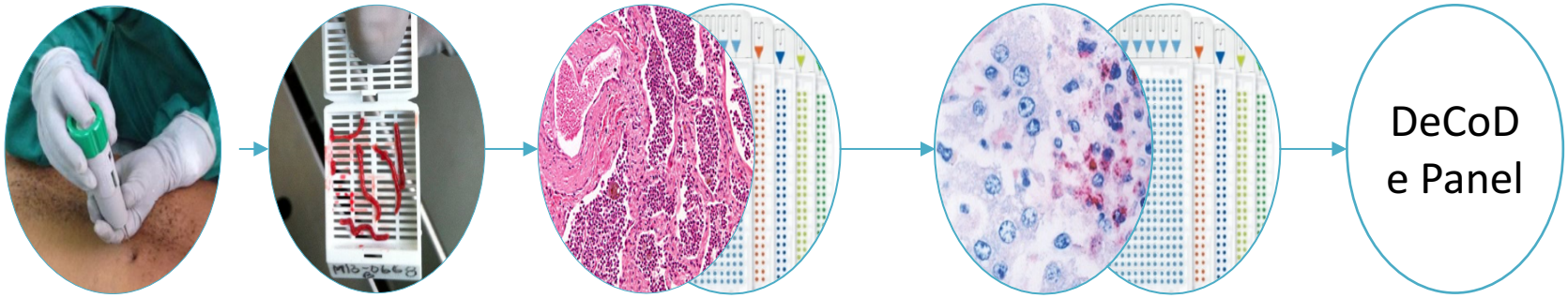


Secondary Objectives

- Track incidence of cause-specific severe disease among children < 5 years of age, including neonates
- Establish surveillance platform from which time limiting modules can be added to address epidemics

CHAMPS Child Health and Mortality Prevention Surveillance

CHAMPS Lab testing: minimally invasive tissue sample (MITS) histopathology and TaqMan PCR Array Cards



In-Country Lab

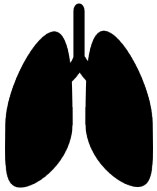
- Basic histopathology
- TaqMan PCR Array Cards
- Biobanking for future analysis
- Focused microbiology
- Expert panel to Determine Cause of Death

Reference Lab

- Advanced histopathology
- TaqMan PCR Array Cards for quality assurance
- Biobanking for future analysis
- Expert panel to Determine Cause of Death for QA

Specimen collection: minimally invasive tissue sampling

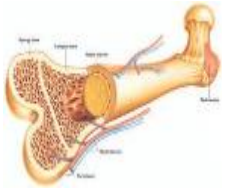
Brain



Lung

Heart

Liver



Bone Marrow

Blood

CSF

Stool

NP/OP swab

• **Abdominal approach - spleen / kidney**
• Placenta (P) , umbilical cord (U) if stillbirth or death immediately following birth
• Skin lesion if present and lymph node if palpable

CHAMPS will use the standard WHO Cause of Death certificate

- **Cause of Death (i.e. Underlying CoD)**: Causal chain of events (disease or injury) that led to death
- **Immediate Cause of Death**: Final event in the causal sequence that occurred closest to time of death.

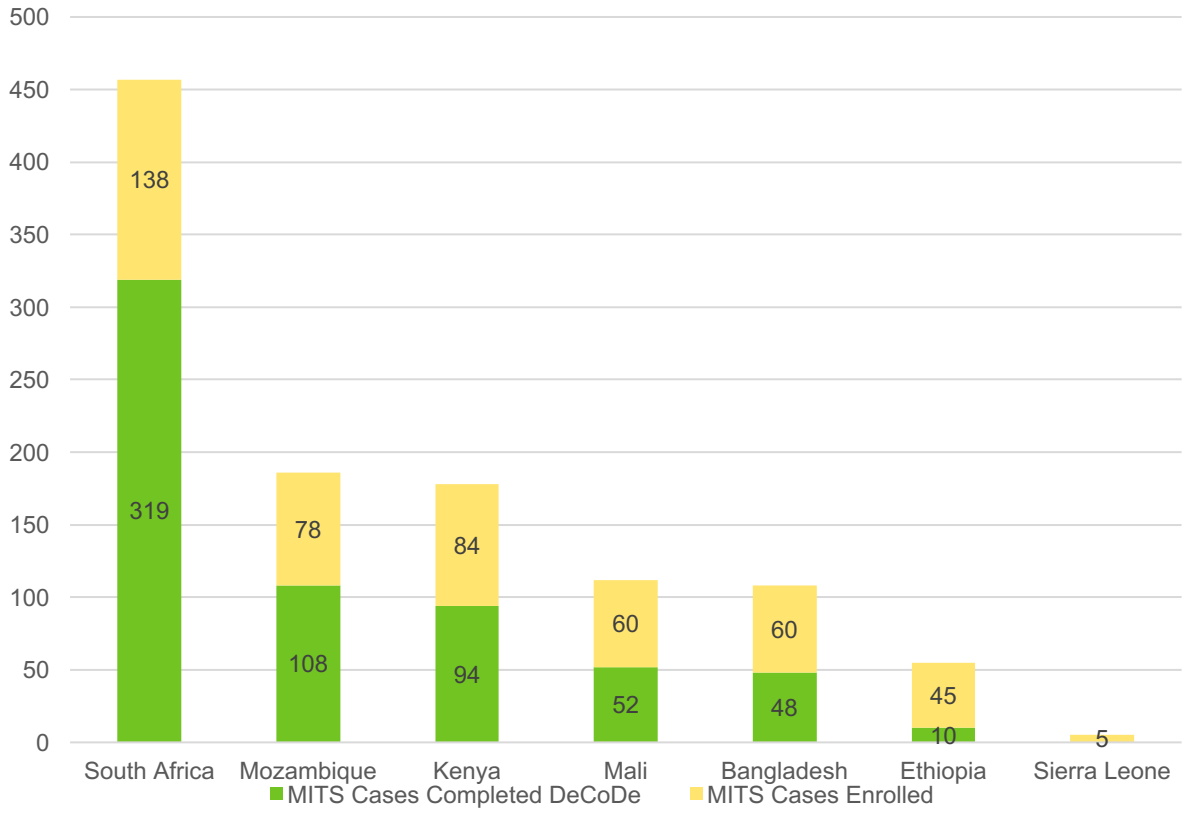
INTERNATIONAL FORM OF MEDICAL CERTIFICATE OF CAUSE OF DEATH

Cause of death		Approximate interval between onset and death
I Disease or condition directly leading to death*	(a)	.....
	due to (or as a consequence of)	
Antecedent causes Morbid conditions, if any, giving rise to the above cause, stating the underlying condition last	(b)	.....
	due to (or as a consequence of)	
	(c)	.....
	due to (or as a consequence of)	
	(d)	.....
II Other significant conditions contributing to the death, but not related to the disease or condition causing it	.....	.....
	.....	.....

**This does not mean the mode of dying, e.g. heart failure, respiratory failure. It means the disease, injury, or complication that caused death.*

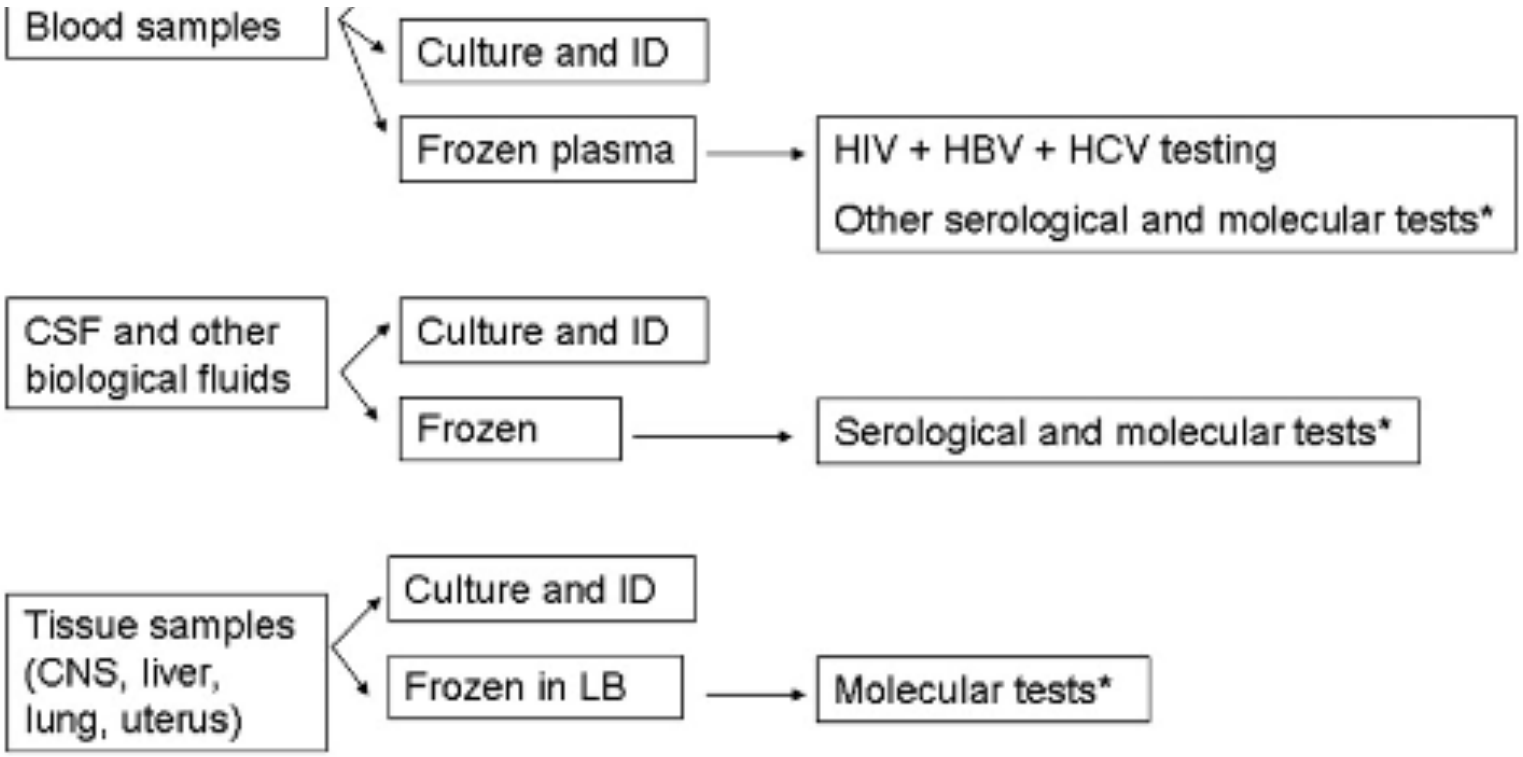
Key data - MITS Cases, June 2018

1,101 MITS cases have been conducted; **631 MITS cases have completed DeCoDe causes of death assigned**



Bill and Melinda Gates Foundation used with permission

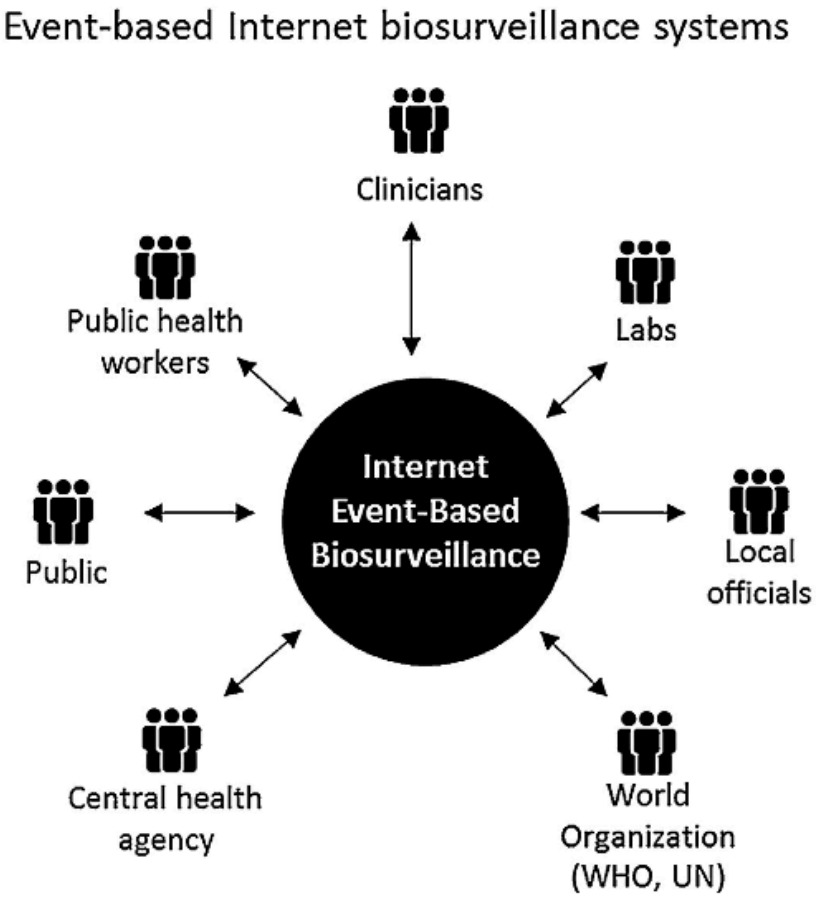
MIA (MITS) Procedure for Infectious Disease Diagnosis



ID: identification; LB: Lysis buffer; *: Testing depends on the pathological-histological results; CNS: central nervous system; HIV: Human Immunodeficiency Virus; HBV: Hepatitis B Virus; HCV: Hepatitis C Virus

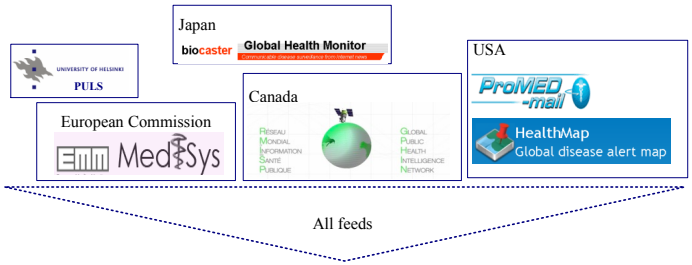
Event Based Surveillance

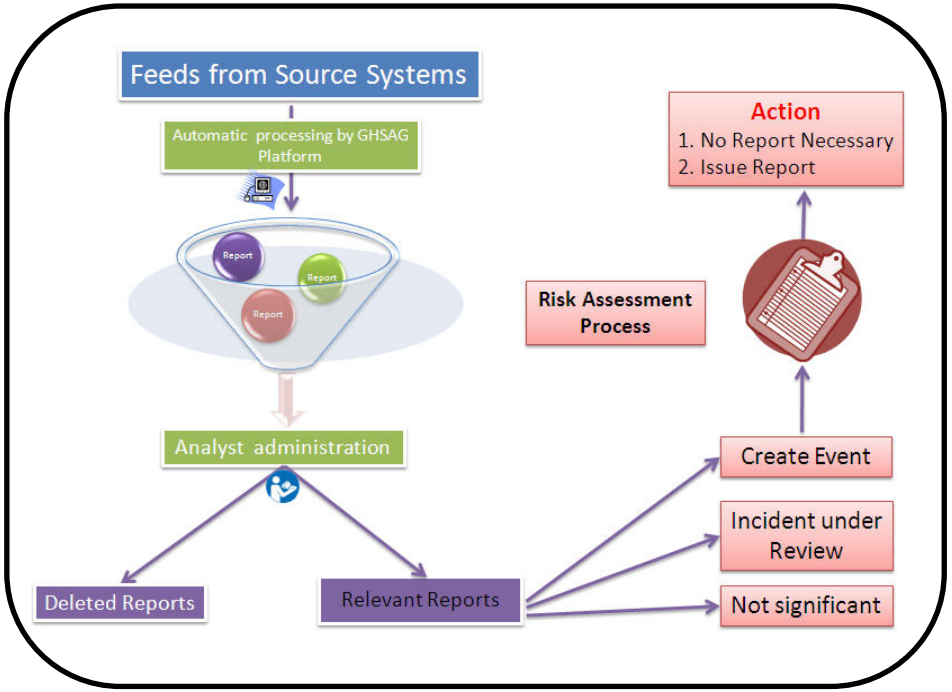
- Multiple sources
- At least 50 systems currently on line
- Unevenly distributed
- Community based systems a subset



O'Shea, J., *Digital disease detection: A systematic review of event-based internet biosurveillance systems,* International Journal of Medical Informatics; 101 (2017), p.17

EAR Operations: Platform and Process Flow

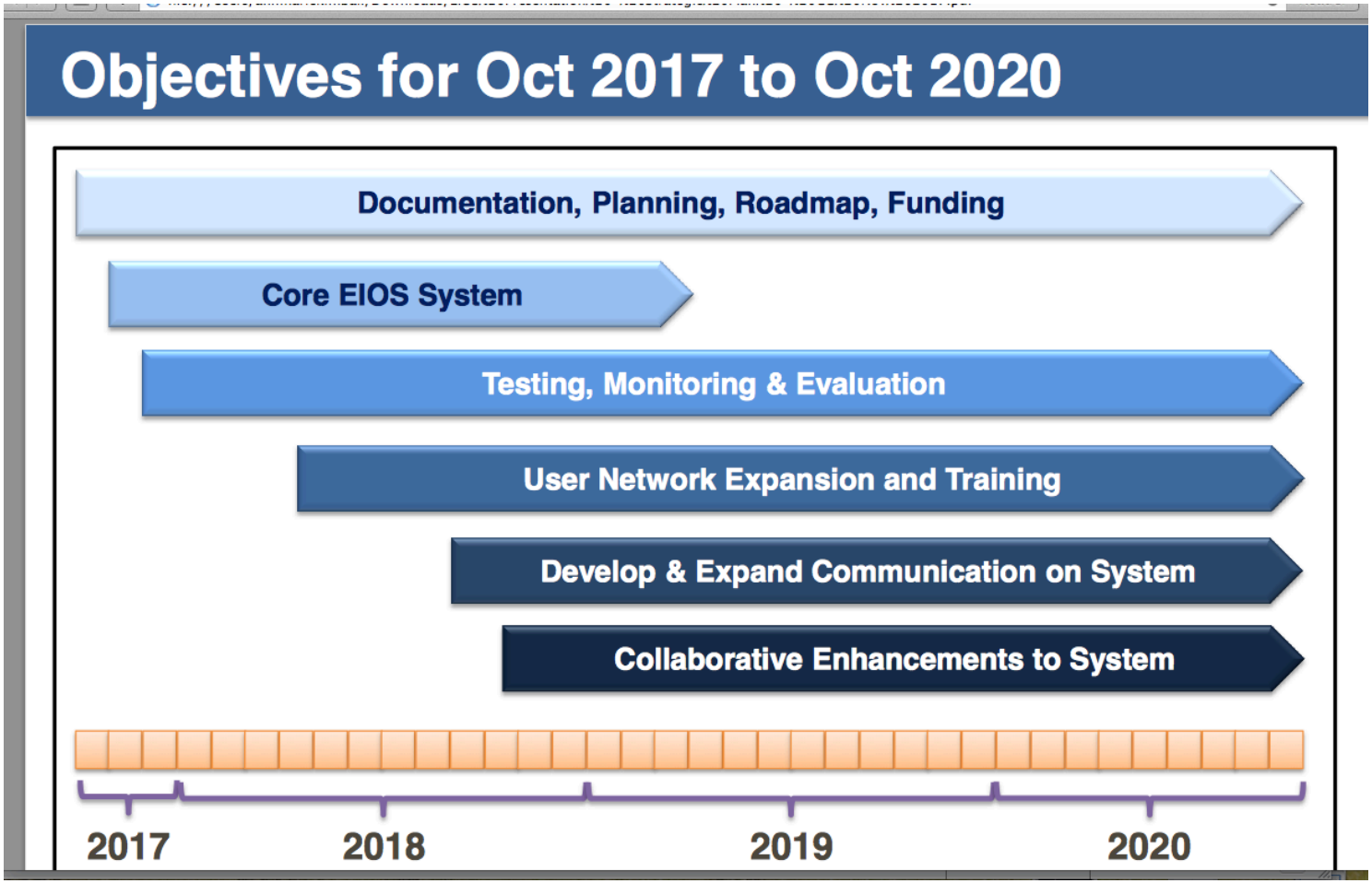




- The EAR Project common platform enables the automated gathering and displaying of information from several event-based surveillance systems.

- The process flow consists in both automated (computer) and manual (person) processes :
  - Gathering information (computer)
  - Relevancy analysis (computer + person)
  - **Risk Assessment** (person)
  - Action (person)

EIOS (Epidemic Intelligence Open Source): Brief history, coming soon



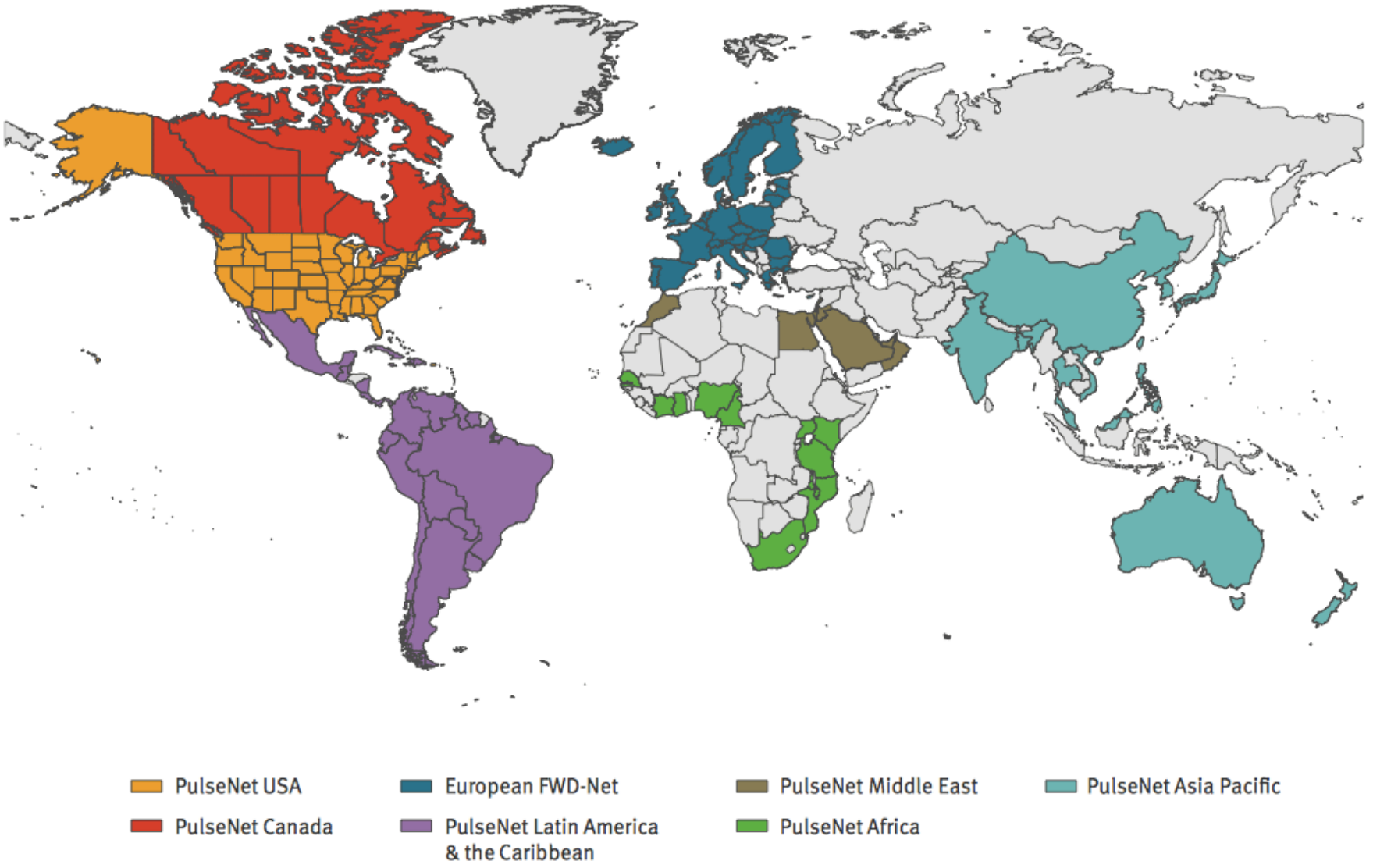
With permission from WHO

AMR: The Unseen Wave

- AMR is an international problem crossing multiple diseases/pathogens and affecting multiple “one-health” sectors.
- Information on cultural practices suggest antibiotics used extensively when hygiene is challenging for food storage etc.
- Trust & data-sharing challenges must be addressed.
- Facilities, personnel for timely detection are extremely unevenly distributed.
- WGS may assist with metagenomics of resistance independent of sensitivity assays in culture.

PULSENET INTERNATIONAL LABORATORIES

Map of PulseNet International participating countries, May 2017



NGS Data Sharing: Automatic?

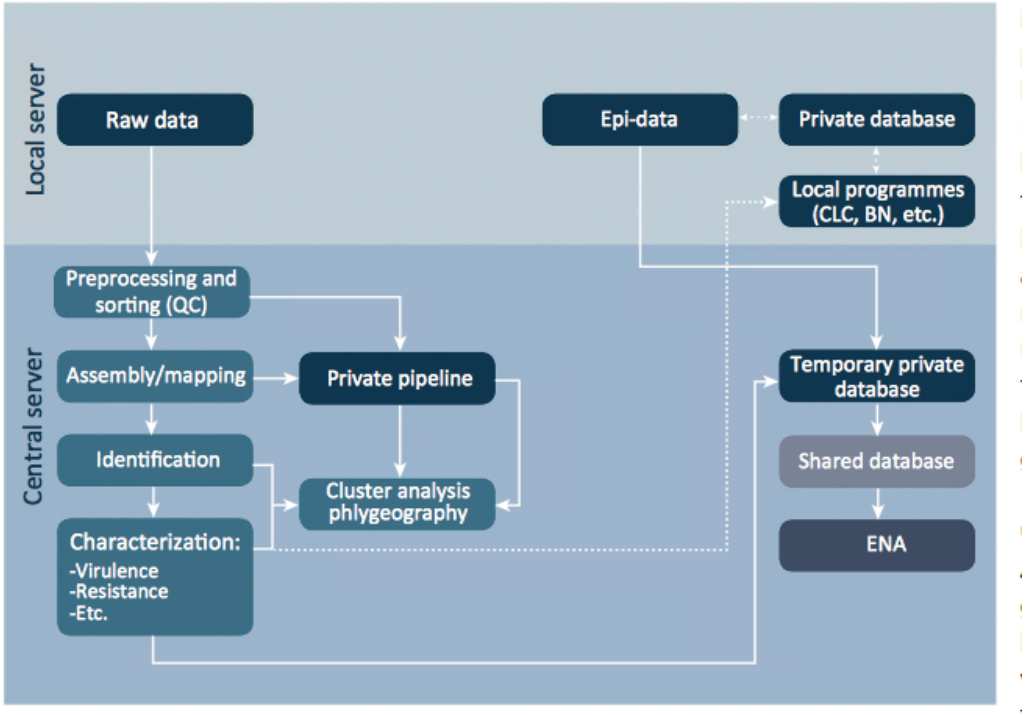
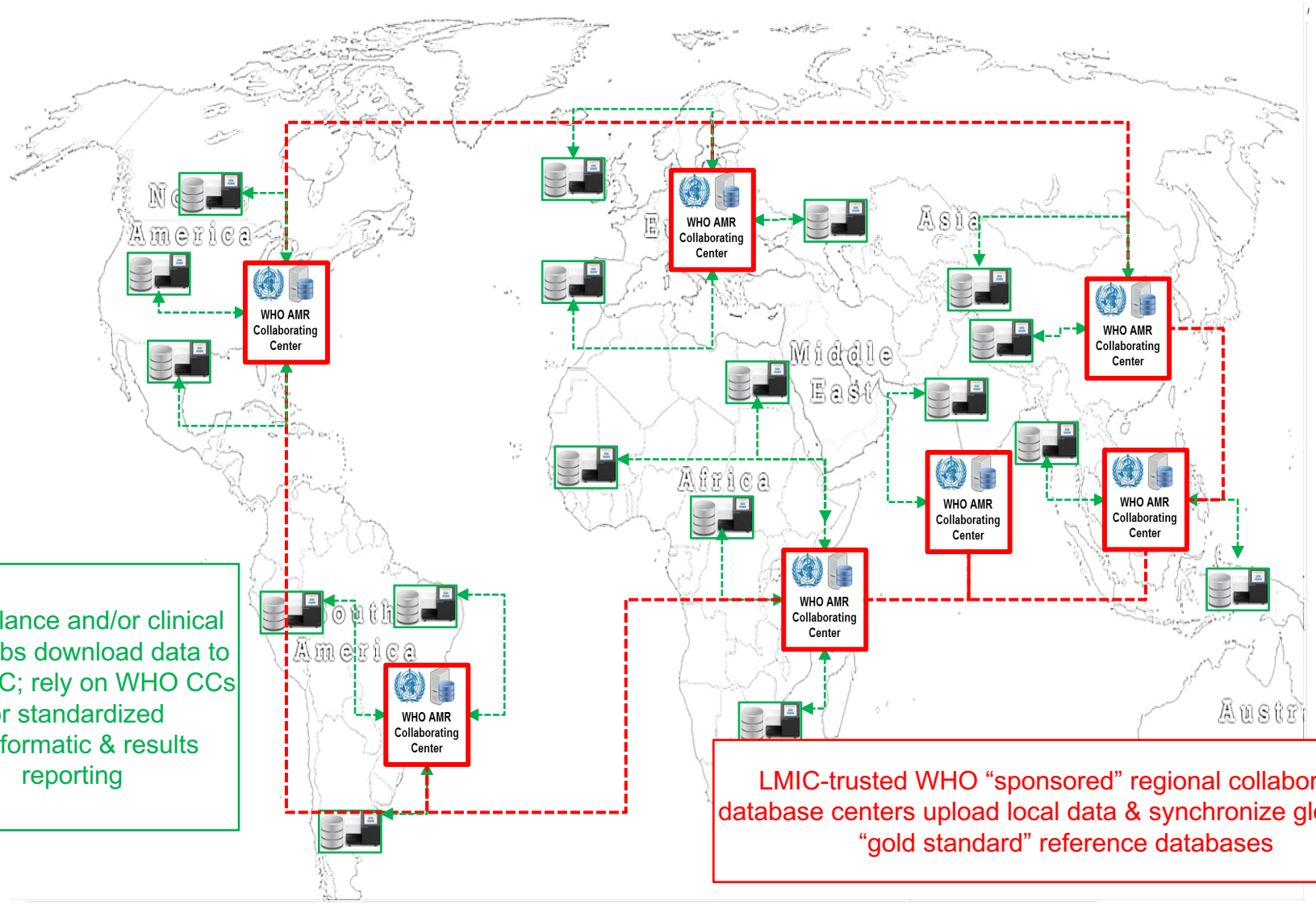


Figure 1. Proposed System for Sharing Next-Generation Sequence (NGS) Data in Combination with Minimum Epidemiological Data. Raw NGS data and minimum epidemiological data (Epi-data) are uploaded to a central system from a private server. Here, the NGS data are processed using a default analytic pipeline and all information stored in a temporary staging database that may be private if required, from where it easily can be transferred into a shared or public repository. The processed data may also be downloaded locally for further investigations combined with more sensitive epidemiological data. Solid lines indicate default pipeline; dashed lines indicate additional options. Abbreviations: ENA, European Nucleotide Archive; CLC, CLCbio; BN, BioNumerics.

Aarestrup, F., Koopmans, M., *Sharing Data for Global Infectious Disease Surveillance and Outbreak Detection,* Trends in Microbiology, April 2016, Vol. 24, No. 4, p. 244.

Program Objective – Develop globally harmonized interoperable AMR databases linked to national NGS facilities

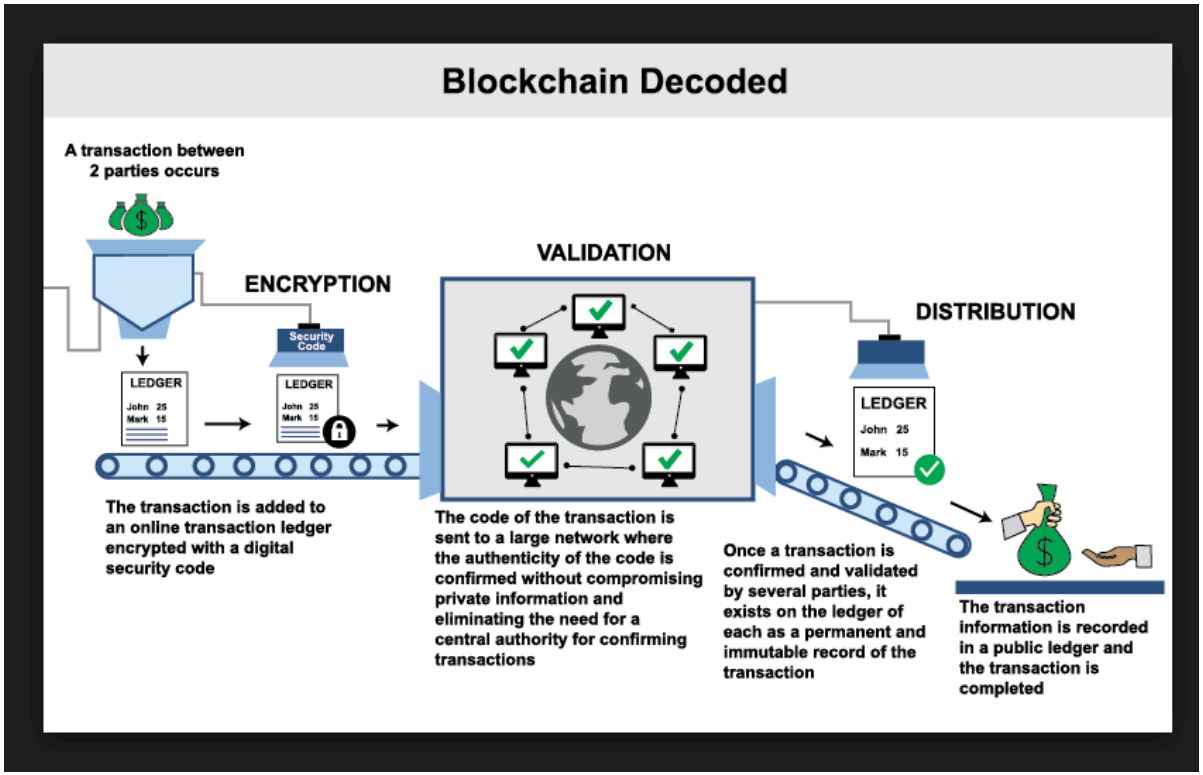


Surveillance and/or clinical AMR labs download data to WHO CC; rely on WHO CCs for standardized bioinformatic & results reporting

LMIC-trusted WHO "sponsored" regional collaborating database centers upload local data & synchronize globally as "gold standard" reference databases

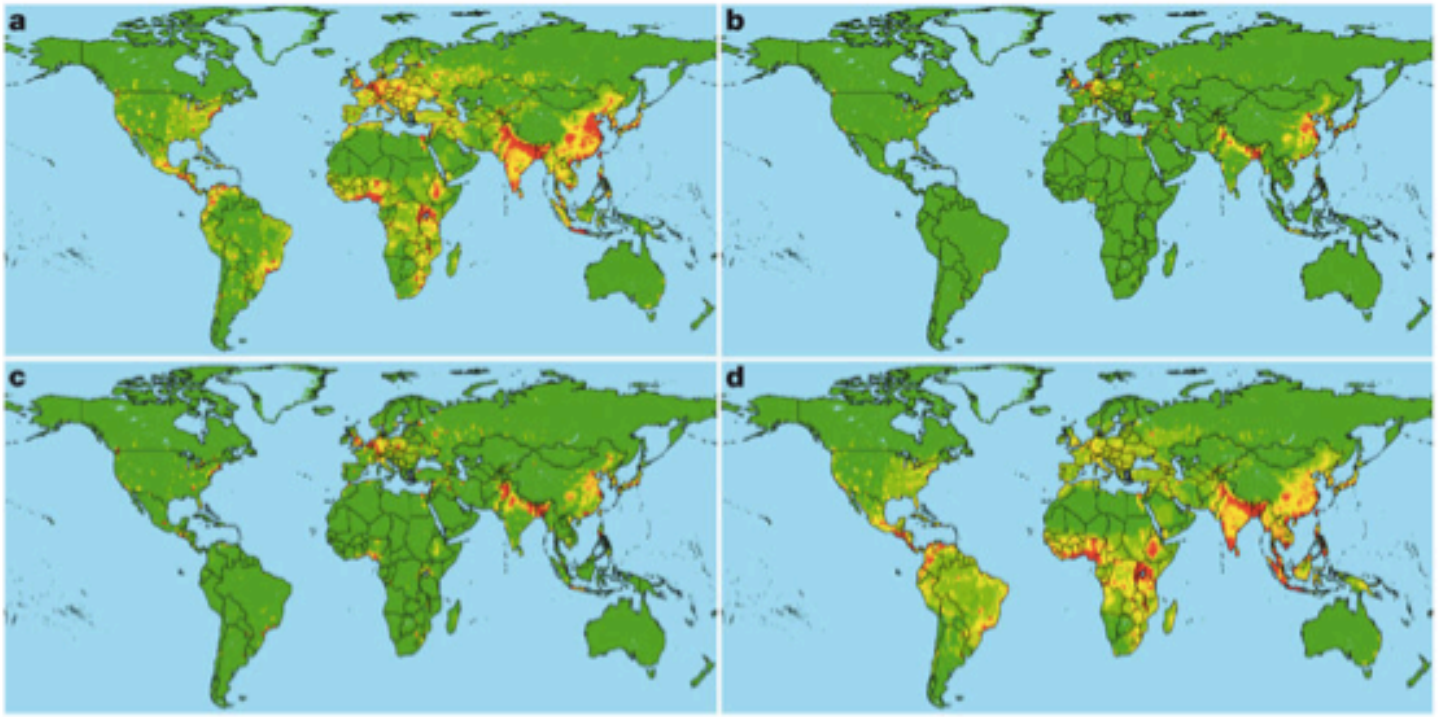
Trust is the essence of networks

- Trust has always been the “secret sauce” of data sharing and collaborative response
- Historically relies on relationship building, or “trusted broker” institutions
- Can Block Chain help?



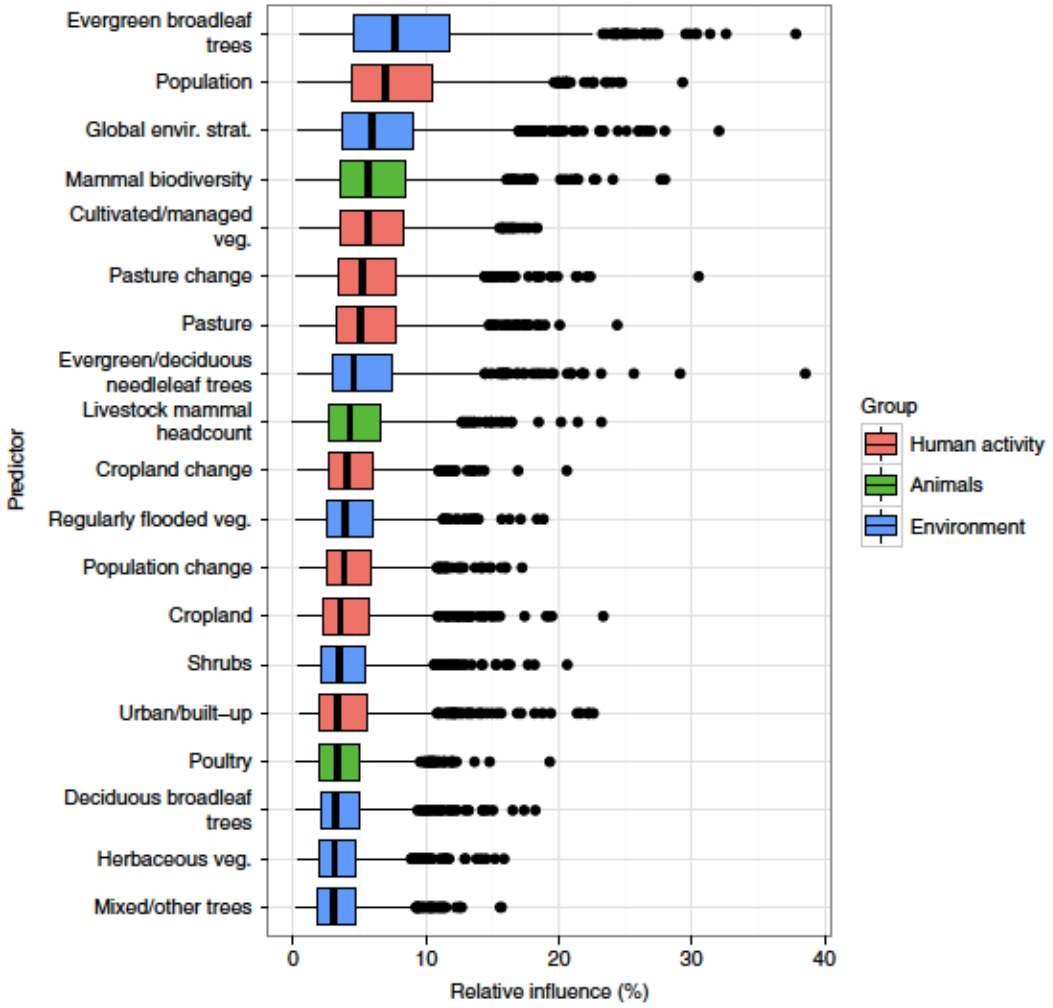
Geo-ecological risk : Hotspots concept

From: Global trends in emerging infectious diseases



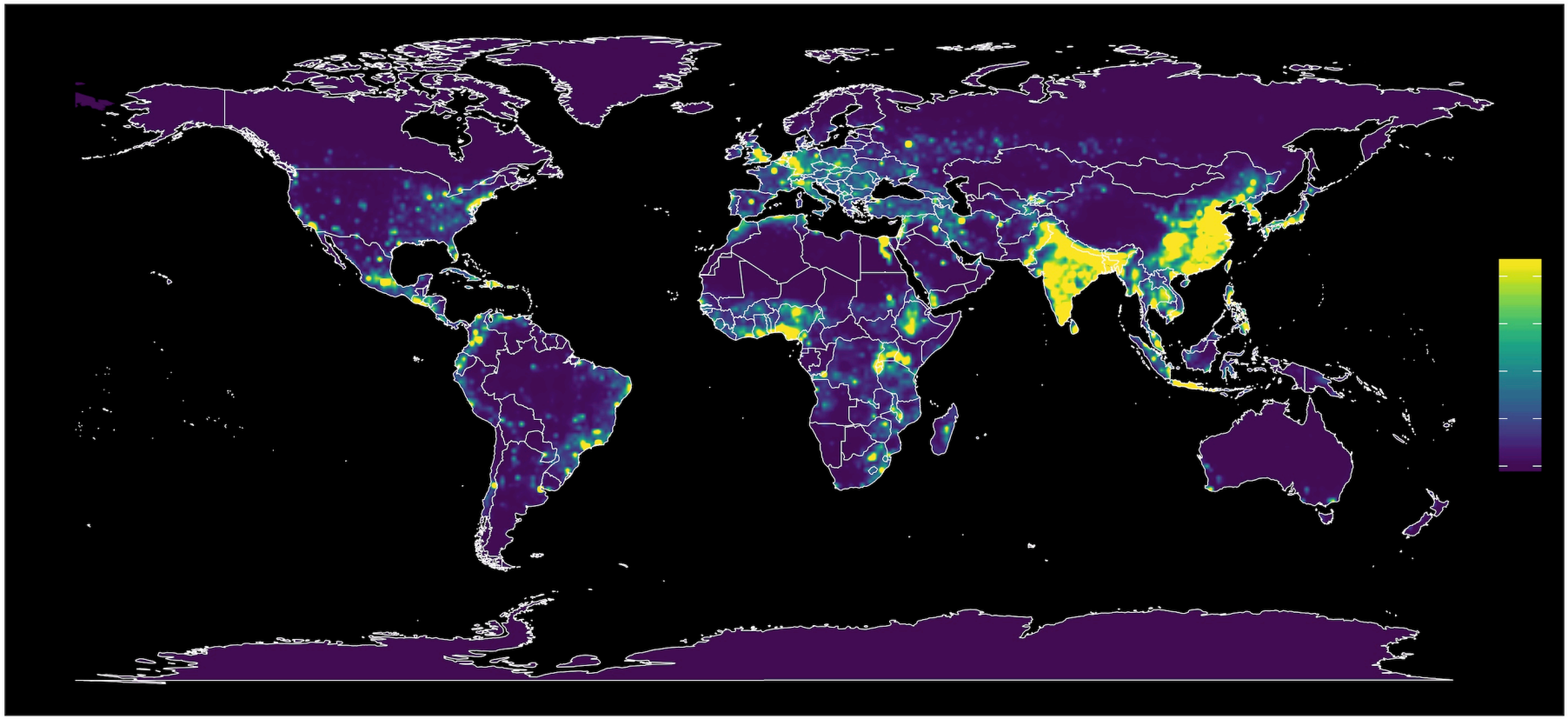
Maps are derived for EID events caused by **a**, zoonotic pathogens from wildlife, **b**, zoonotic pathogens from non-wildlife, **c**, drug-resistant pathogens and **d**, vector-borne pathogens. The relative risk is calculated from regression coefficients and variable values in Table 1 (omitting the variable measuring reporting effort), categorized by standard deviations from the

Box and whiskers graph - risk of EID



Allen, T., Murray, K., Zambrana-Torrelio, C. et al, *Global hotspots and correlates of emerging zoonotic diseases*, Nature Communications; 24 October 2017, 8: 1124, p. 2.

Emerging Zoonotic Disease 'Hotspots'



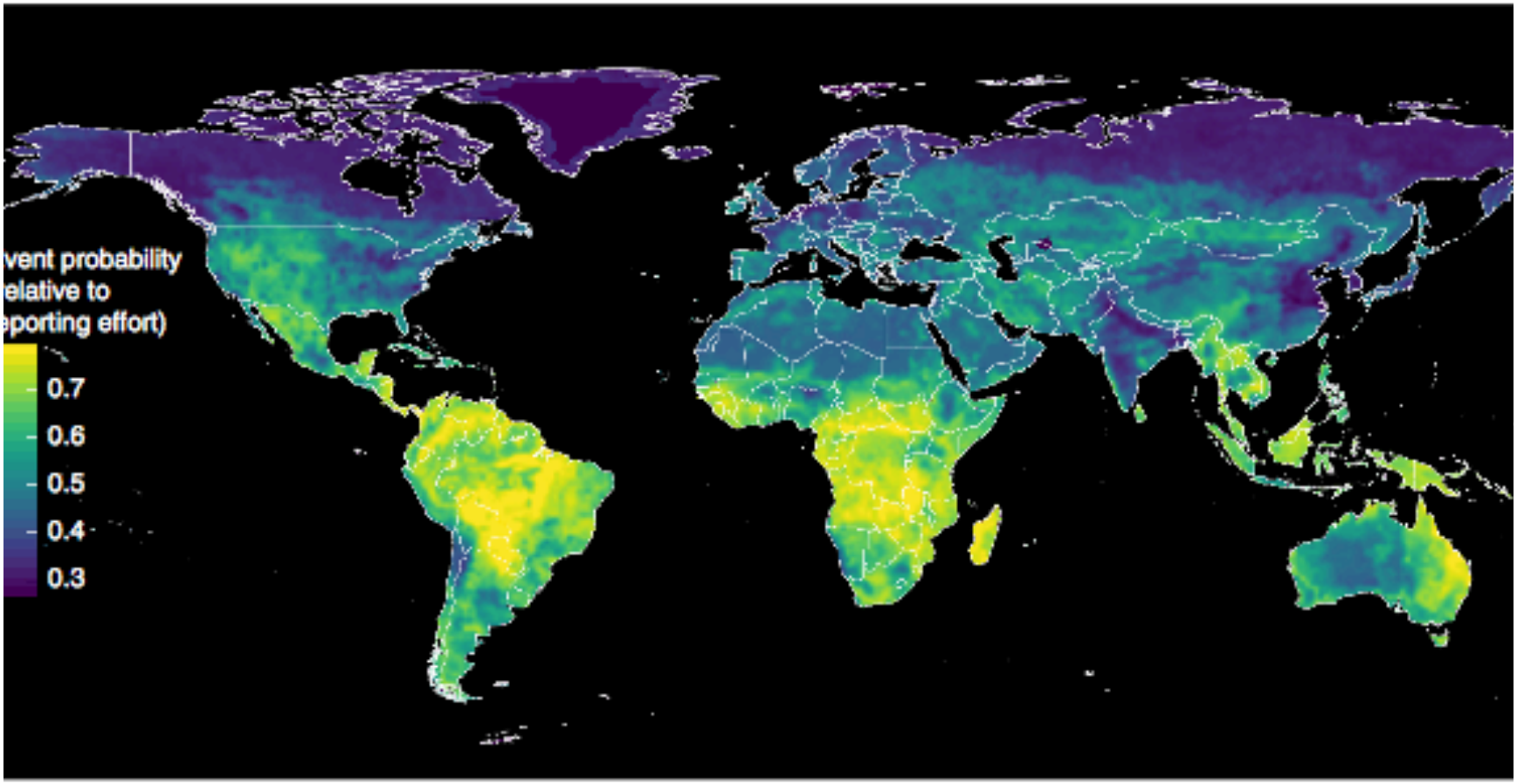
DOI: 10.1038/s41467-017-00923-8 OPEN

Global hotspots and correlates of emerging zoonotic diseases

Toph Allen[1], Kris A. Murray[2,3], Carlos Zambrana-Torrelio[1], Stephen S. Morse[4], Carlo Rondinini[5], Moreno Di Marco[6,7], Nathan Breit[1], Kevin J. Olival[1] & Peter Daszak[1]

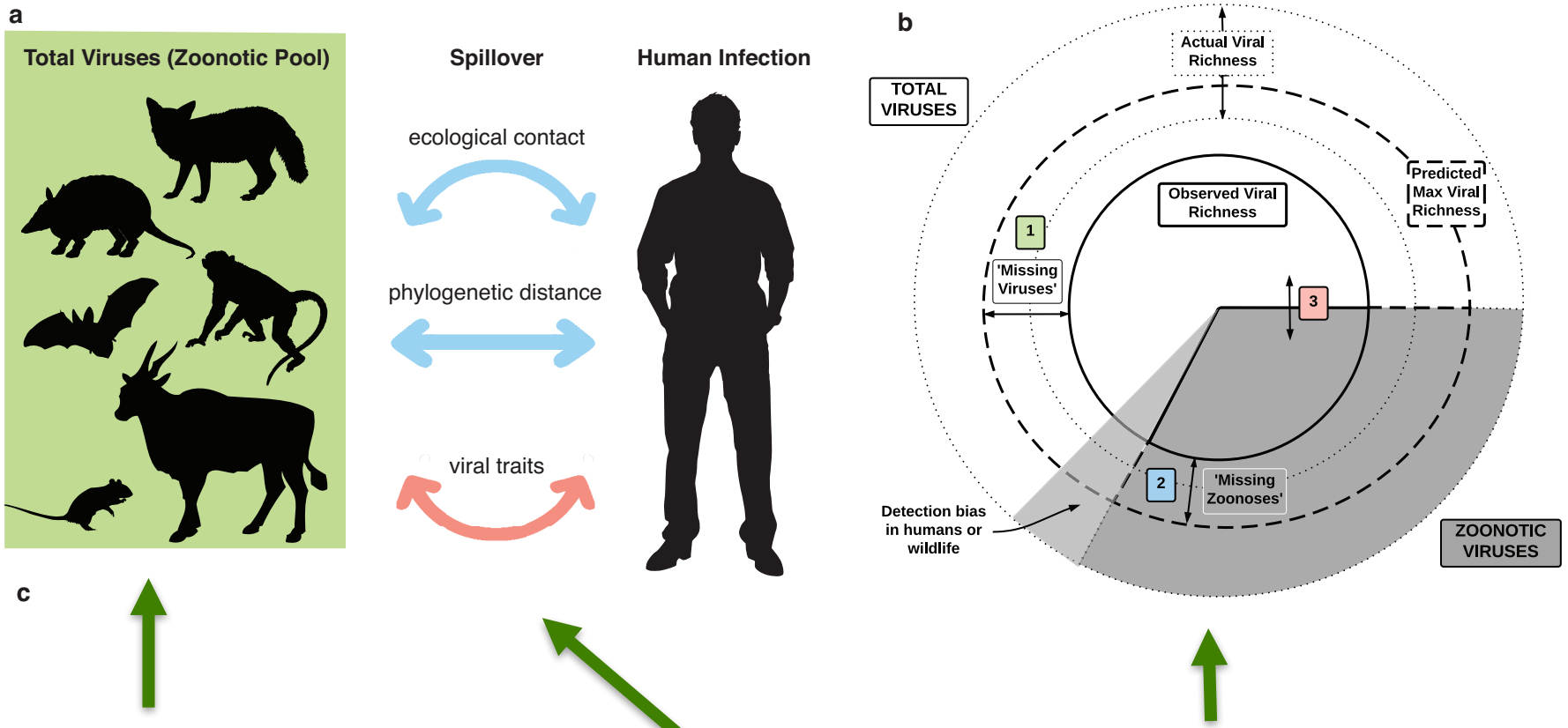
EcoHealth Alliance

Remodeled emerging infections risk map



Allen, T., Murray, K., Zambrana-Torrelio, C. et al, *Global hotspots and correlates of emerging zoonotic diseases*, Nature Communications; 24 October 2017, 8: 1124, p. 5.

Objectives + conceptual framework



Host factors and viral richness

Host and viral traits and zoonotic spillover

Estimating 'missing' viruses and zoonoses

Olival et al. 2017, *Nature*

Spillover: Bats to Humans

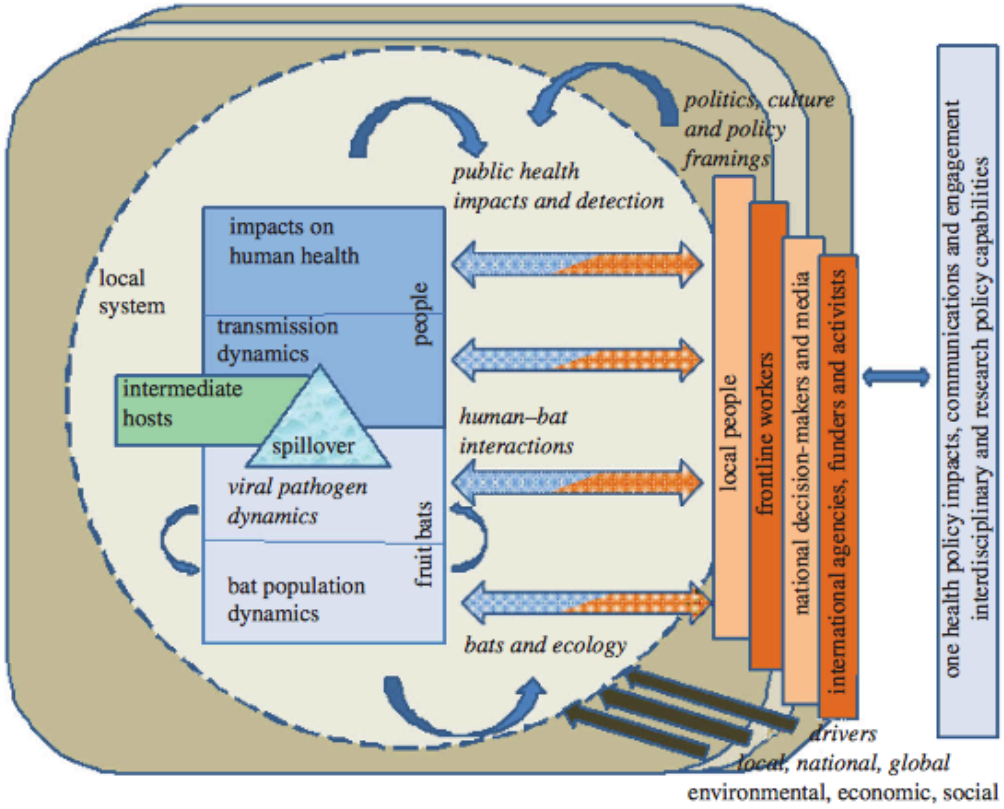


Figure 1. A conceptual framework for the study of wildlife derived zoonoses, focused on bat infections.

Strategic Needs

- Trust building- Block Chain or Human?
- Transparency and consolidation of assets.
- Systematic inclusion of LMIC stakeholders.
- Attention to geo-ecological risk.
- Informal and formal, network the networks.

Thank you