



**How can an improved understanding of the ecology and evolution of
pathogens help us?**

One Health approaches to pandemic avoidance and preparedness

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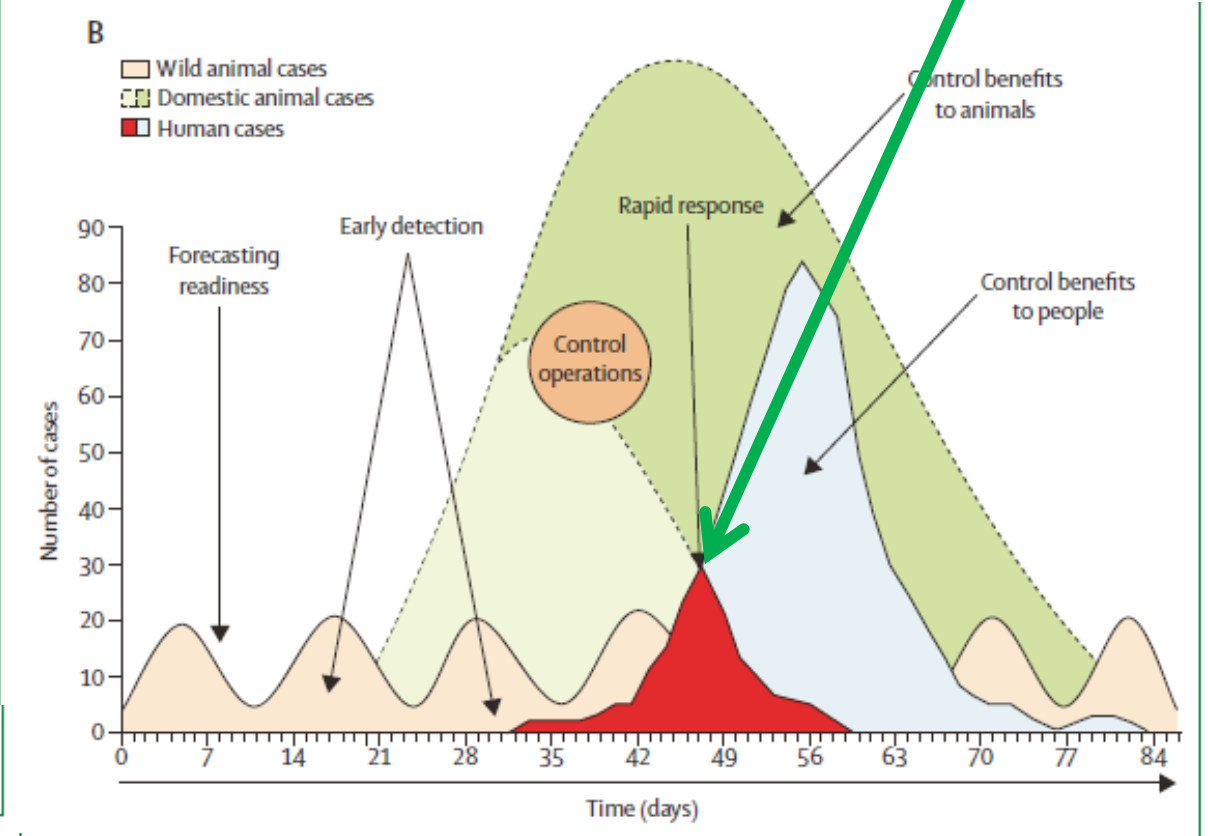
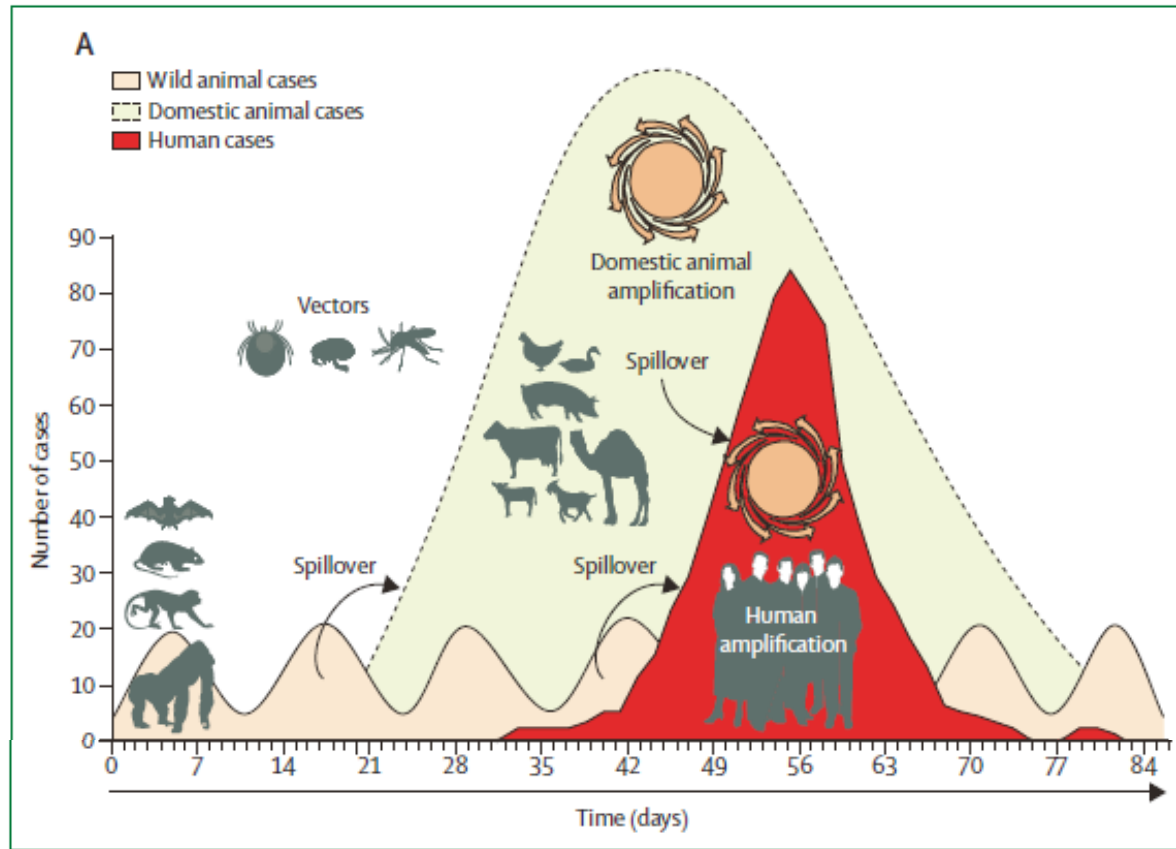
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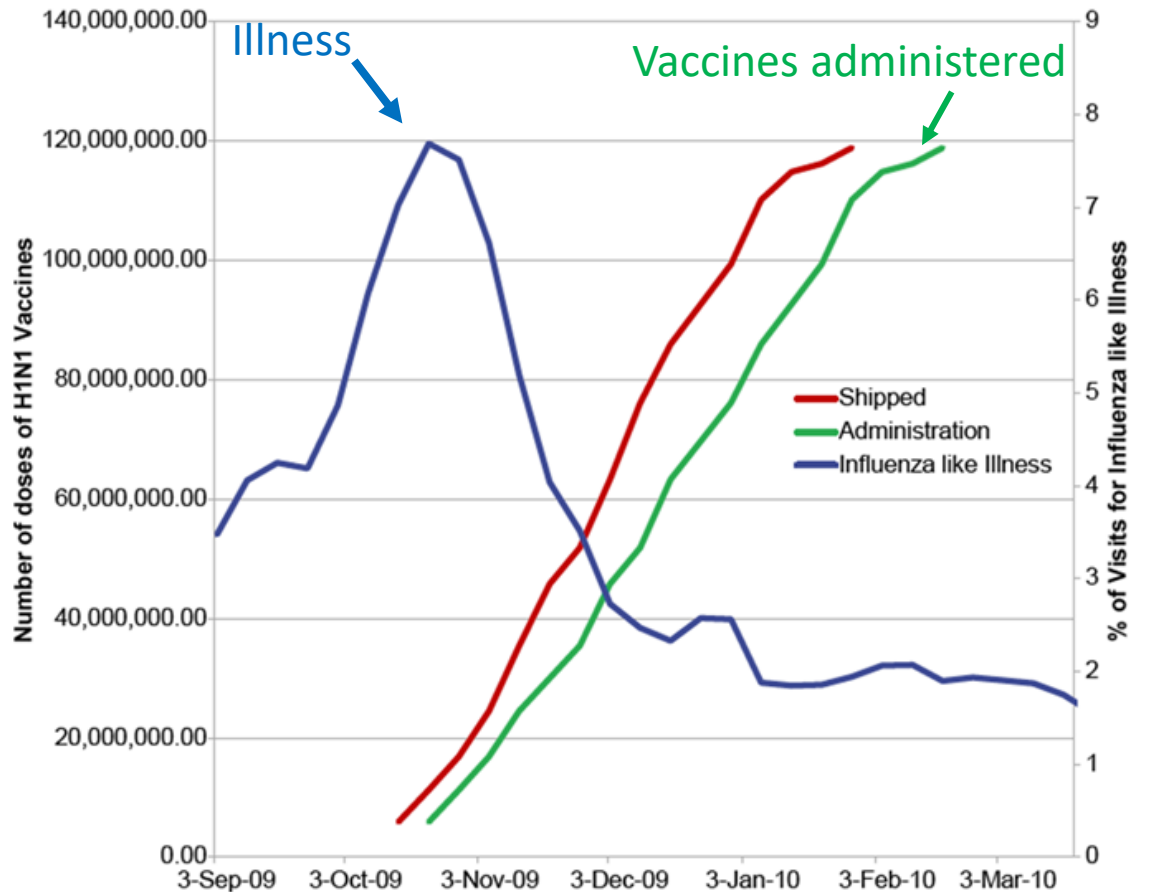
One health approaches to pandemic avoidance & preparedness



Early detection of a human epidemic:
Response: Is this timely enough?

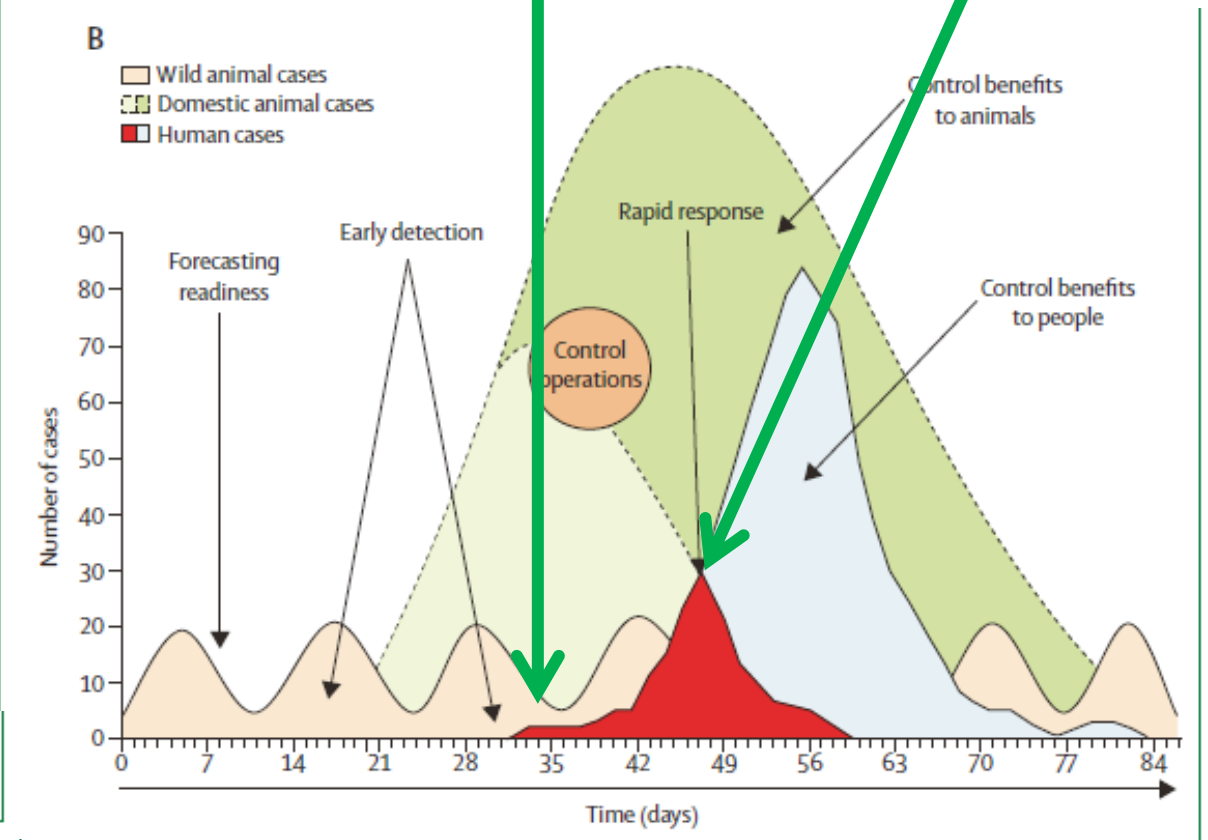
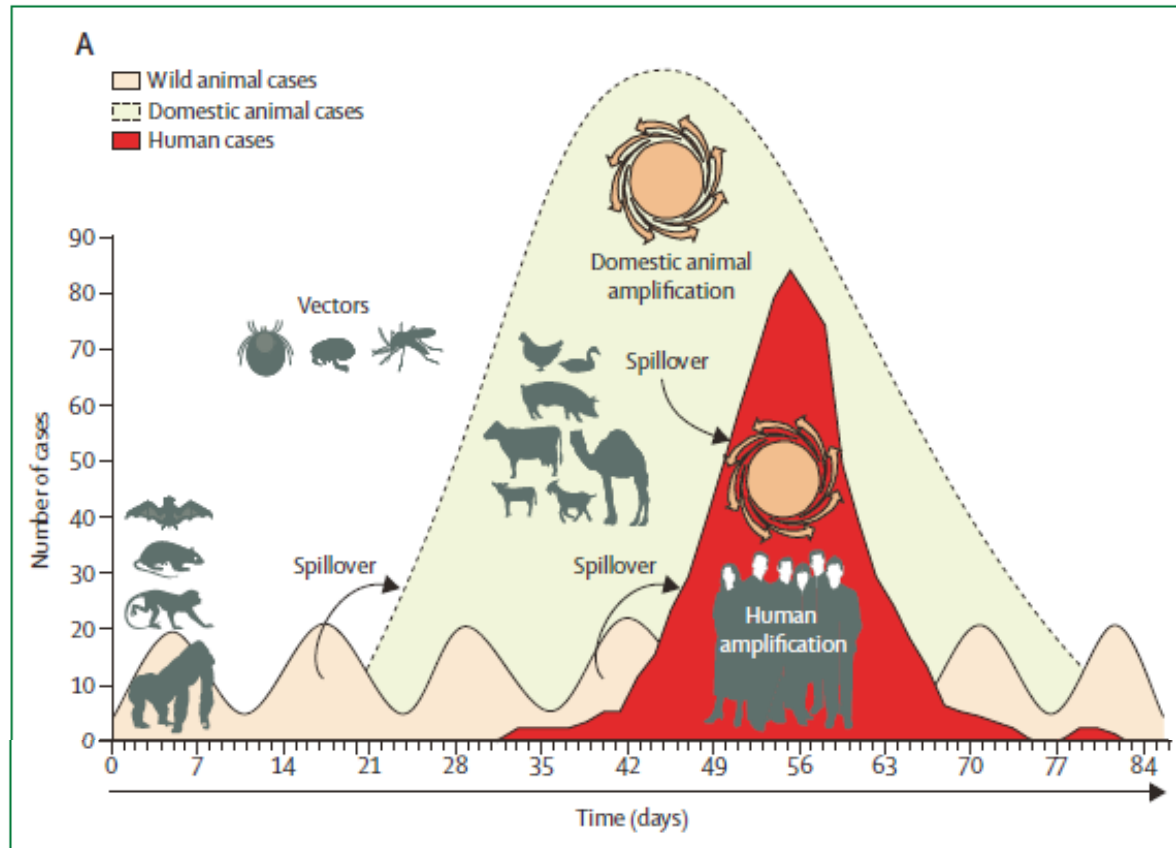
Even when vaccine manufacturing processes and capacity are well established, starting to make pandemic vaccines after recognizing the new pandemic pathogen in humans **will not prevent the first pandemic wave**

First-wave of 2009 influenza H1N1 pandemic: USA



Monto AS & Webster RG Figure 2, Chapter 2; Textbook of Influenza, Eds RG Webster, AS Monto, TJ Braciale, RA Lamb.

One health approaches to pandemic avoidance & preparedness



Tool for Influenza Pandemic Risk Assessment (TIPRA)

Category	Risk element
Virus properties	• Genomic variation • Receptor binding • Transmissibility in animal models • Antiviral susceptibility
Host properties	• Population immunity • Disease severity • Antigenic relationship to existing vaccines
Ecology and epidemiology	• Human infections • Infection in animals • Distribution in animals

Cox et al Curr Top Microbiol 2014



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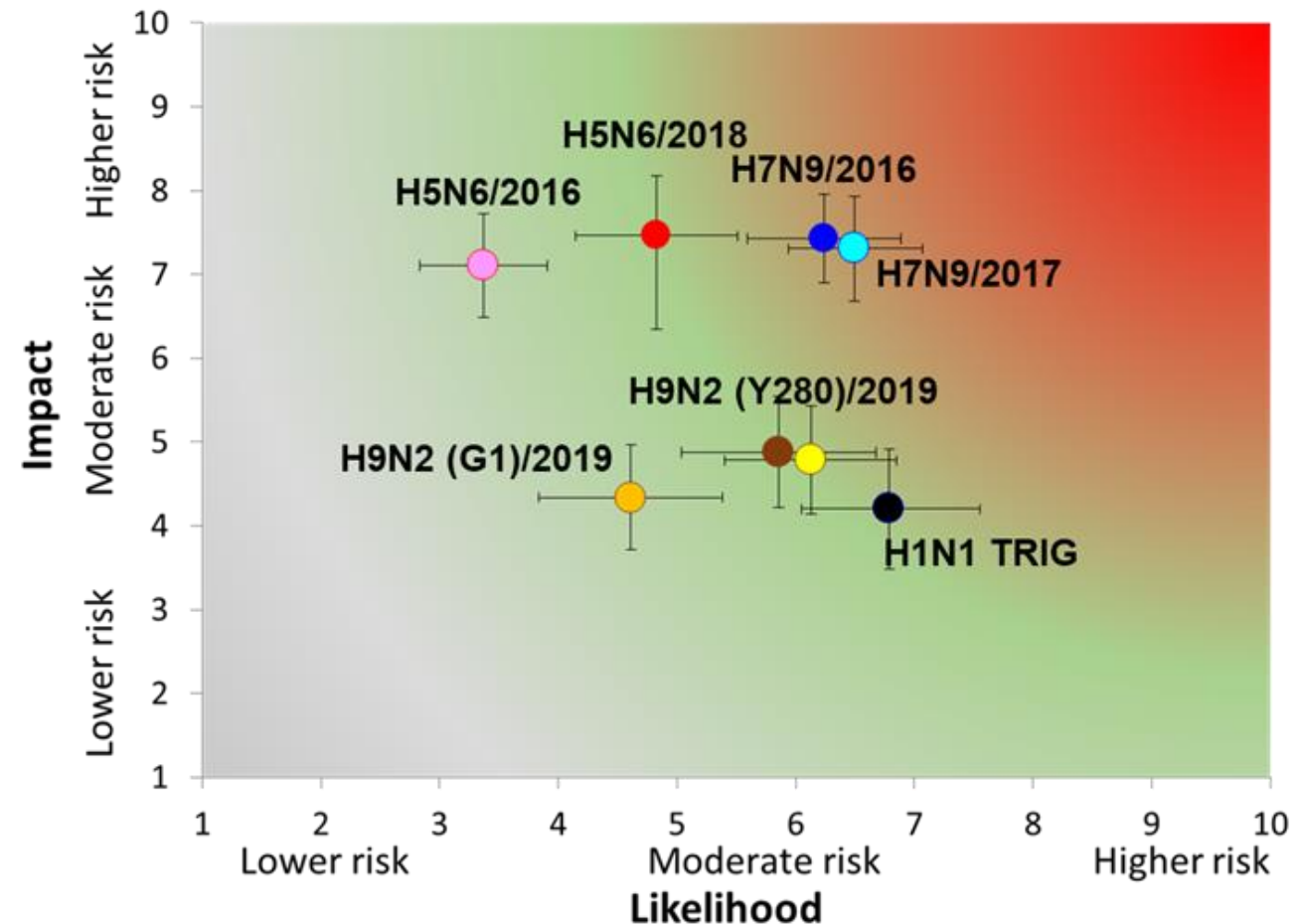
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Influenza surveillance & Risk assessment:

- Ongoing One Health & Quadripartite activity
- Pandemic virus may not cause disease in animals
- Guides decisions for pre-emptive vaccine seed strain development

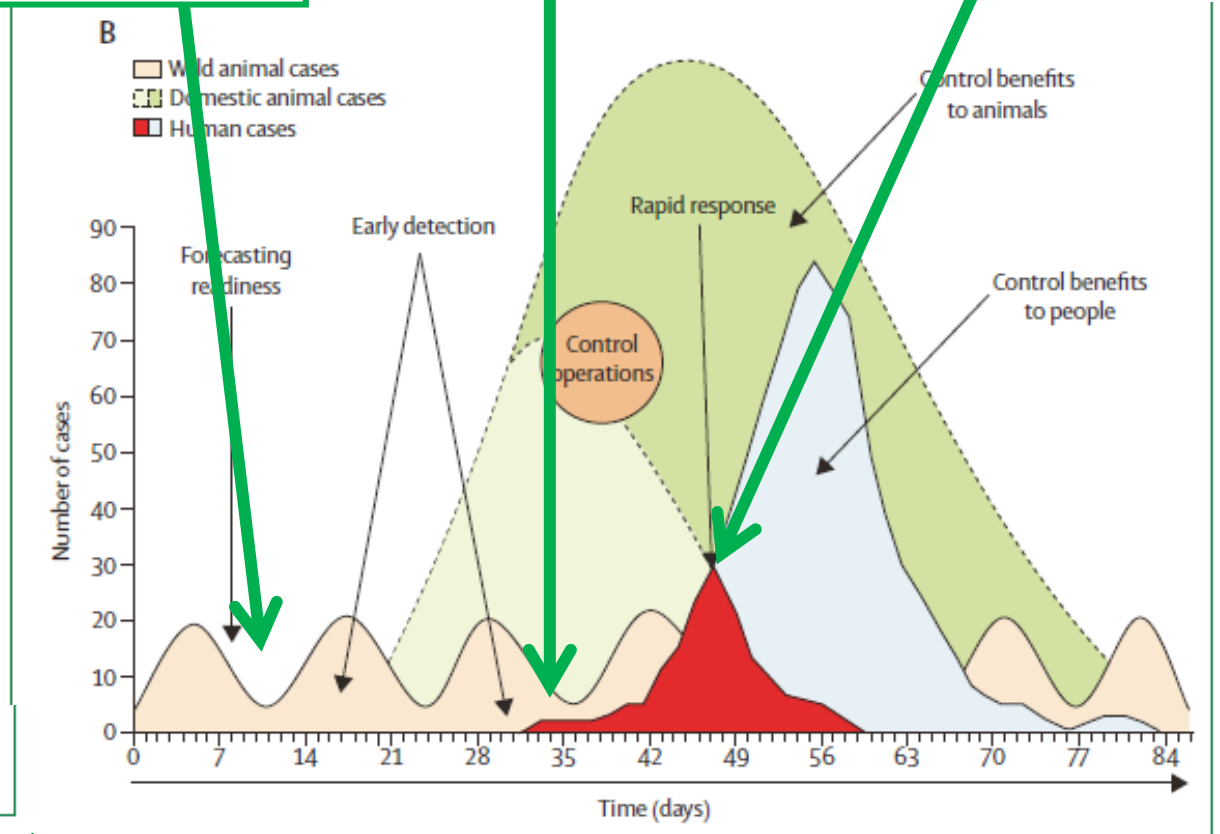
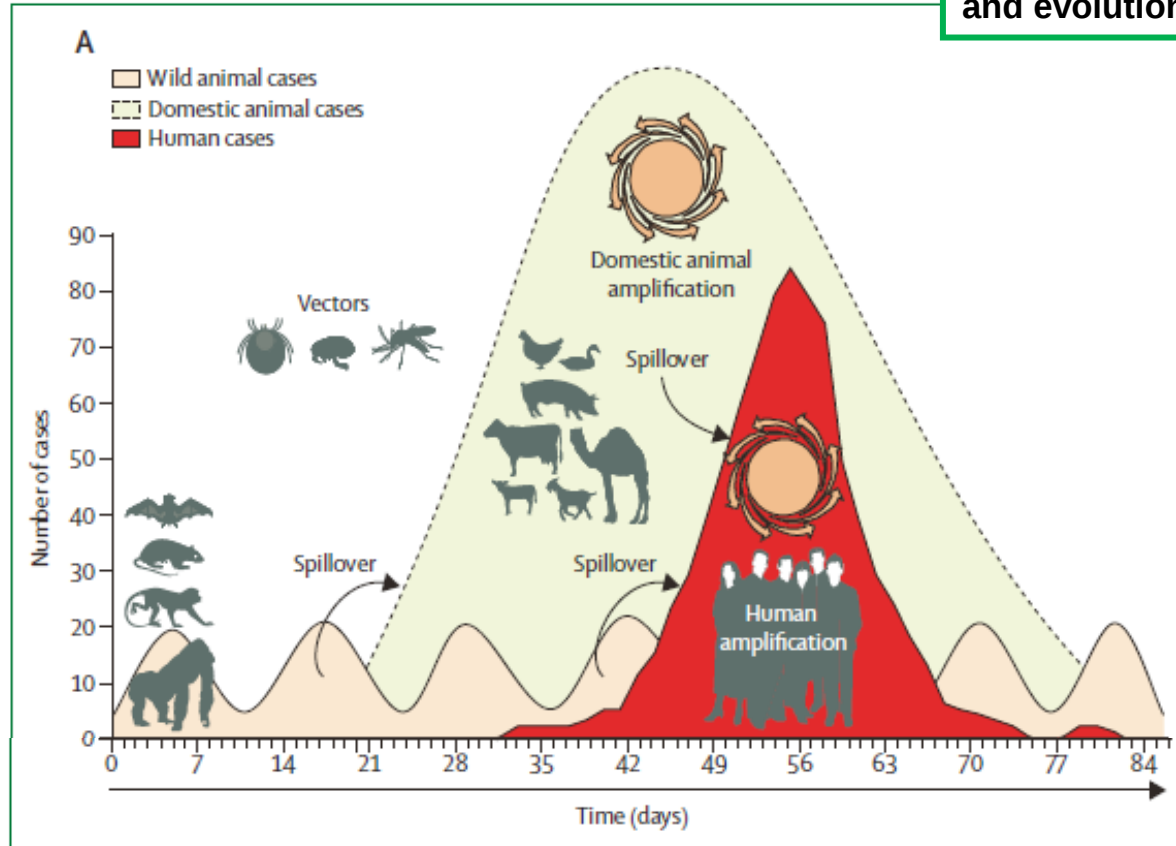


One health approaches to pandemic avoidance & preparedness

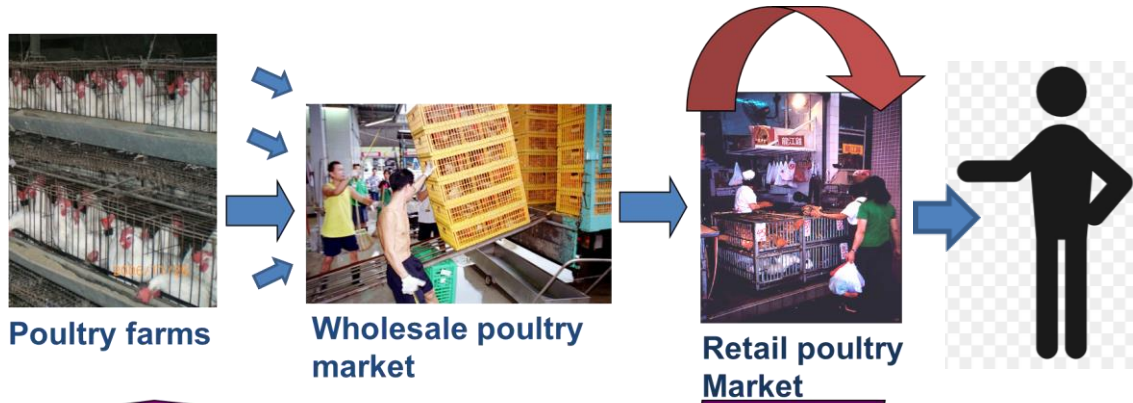
Source control:
Generic measures to reduce chance of zoonotic spillover by understanding ecology and evolution.

Early detection of a zoonotic spill over: intervention, risk-assessment & pre-emptive vaccine development

Early detection of a human epidemic:
Response: Is this timely enough?



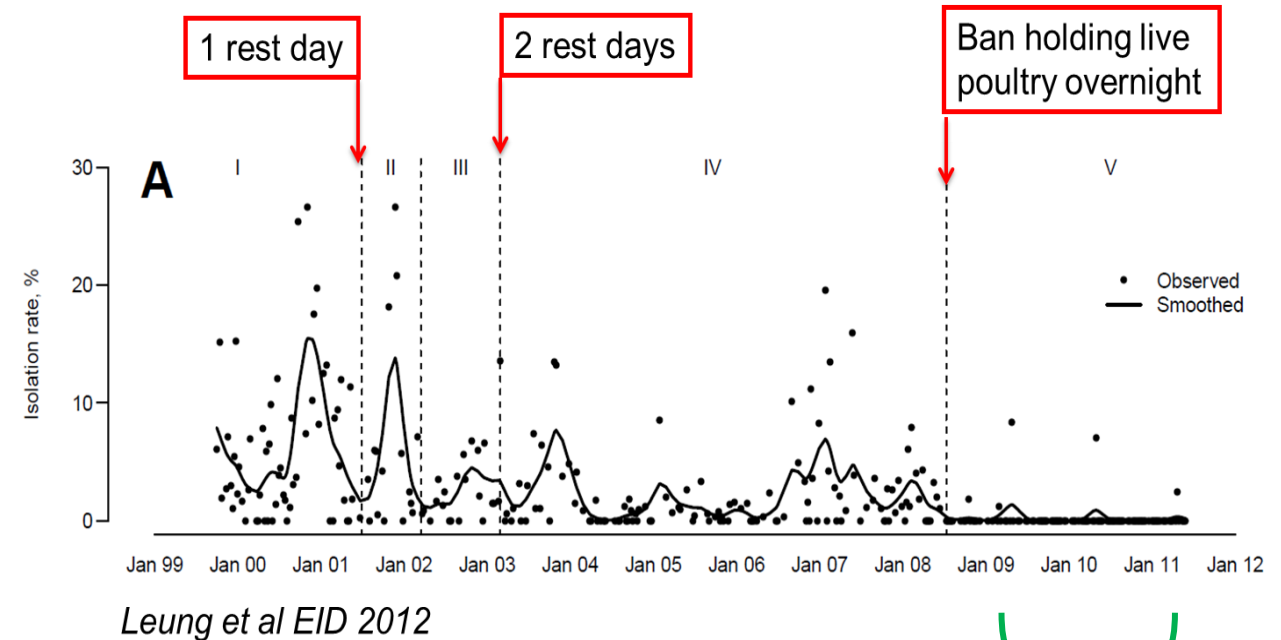
Avian influenza virus transmission dynamics and critical intervention points



Mounts et al 1999
Kung et al Avian Dis 2003
Lau et al EID 2007
Leung et al 2012
Kung et al EID 2007;
Samaan et al 2012
Indriani et al 2010
Zhou et al 2014



Evidence based interventions in live poultry markets *Isolation rates of low pathogenic H9N2 viruses in chicken*



Interventions in live poultry market operations reduced virus circulation in live poultry markets dramatically reduced → Reduced zoonotic risk

Sims & Peiris 2013

Emergence of influenza H7N9 . . . H5N1, H10N8, H3N8

Environmental

H7 & N9/N7/N3/N2 gene pool in waterfowl

Animal

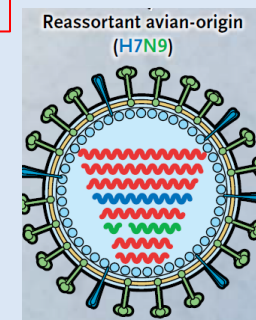
H9N2 pool in poultry

Live poultry market interface

Human

H7N9 emergence

Separating market-chain of live aquatic and terrestrial poultry trade will generically reduce risk of zoonotic virus emergence



Understanding pathway of emergence of SARS 2003 led to interventions that prevented its re-emergence

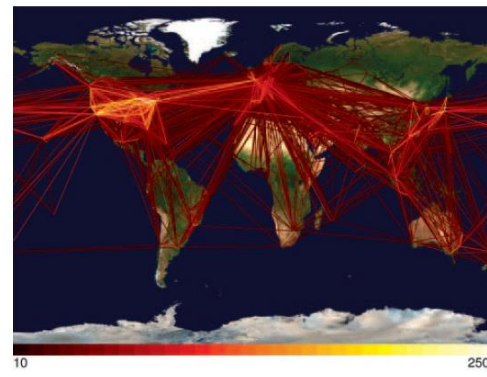


Lau et al PNAS 2005
Li et al Science 2004
Ge et al Nature 2013



Guan et al. Science 2003

Approx 8000 cases
800 deaths
US\$ 40 billion economic cost



May 2003: Live game animal markets implicated as site of spillover

SARS like coronavirus in Himalayan palm civets, raccoon dogs and other small mammals.

Four more zoonotic cases in Dec 2003 / Jan 2004 caused by “Civet-like” virus

*Led to closure of wild-game animal markets in early 2004 **prevented re-emergence of SARS-CoV-1***

Summary (see Keusch GT et al PNAS 2022)

- **Surveillance at animal-human interface needed:** irrespective of disease; risk-based
- Combined with **systematized risk assessment**
- Understanding common **pathways of spill-over** allows interventions that generically reduce risk
- **Bio-safety/biosecurity** needs prioritization. But spill-over exposures from human behaviour are ongoing, whether or not surveillance is being carried out
- **Novel methodologies:**
 - **Antibody detection:** Conventional and broad range multiplex serology using genus/sub-genus specific antigens (*Tan et al NEJM 2021*) and “panvirus” detection platforms (e.g. Virscan) for detecting known / unknown viruses (*Xu et al Science 2015*)
 - **Novel strategies:** sampling waste-water and bio-aerosol sampling (*Xu et al Sci Total Environ 2021; Coleman et al Sci Rep 2018; Xie et al Clin Infect Dis 2020*)
 - Strategies that can be applied “in the field”
- A **global One Health based EID surveillance network** with rapid data-sharing and risk assessment needed. e.g. global influenza program, Sykdomspulsen (Disease Pulse) (Norway), VEO (Versatile Emerging Infectious Disease Observatory)
- **Responses need to be rapid and coordinated when “signals” are detected.**