

# **The Age of Pandemics: How to Prepare and How to Respond**

Gairdner Global Health Symposium  
October 2020

**Peter Piot**

LONDON  
SCHOOL of  
HYGIENE  
& TROPICAL  
MEDICINE



London School of Hygiene & Tropical Medicine

# Emerging infectious diseases in history

(Morens & Fauci, Cell, 2020)

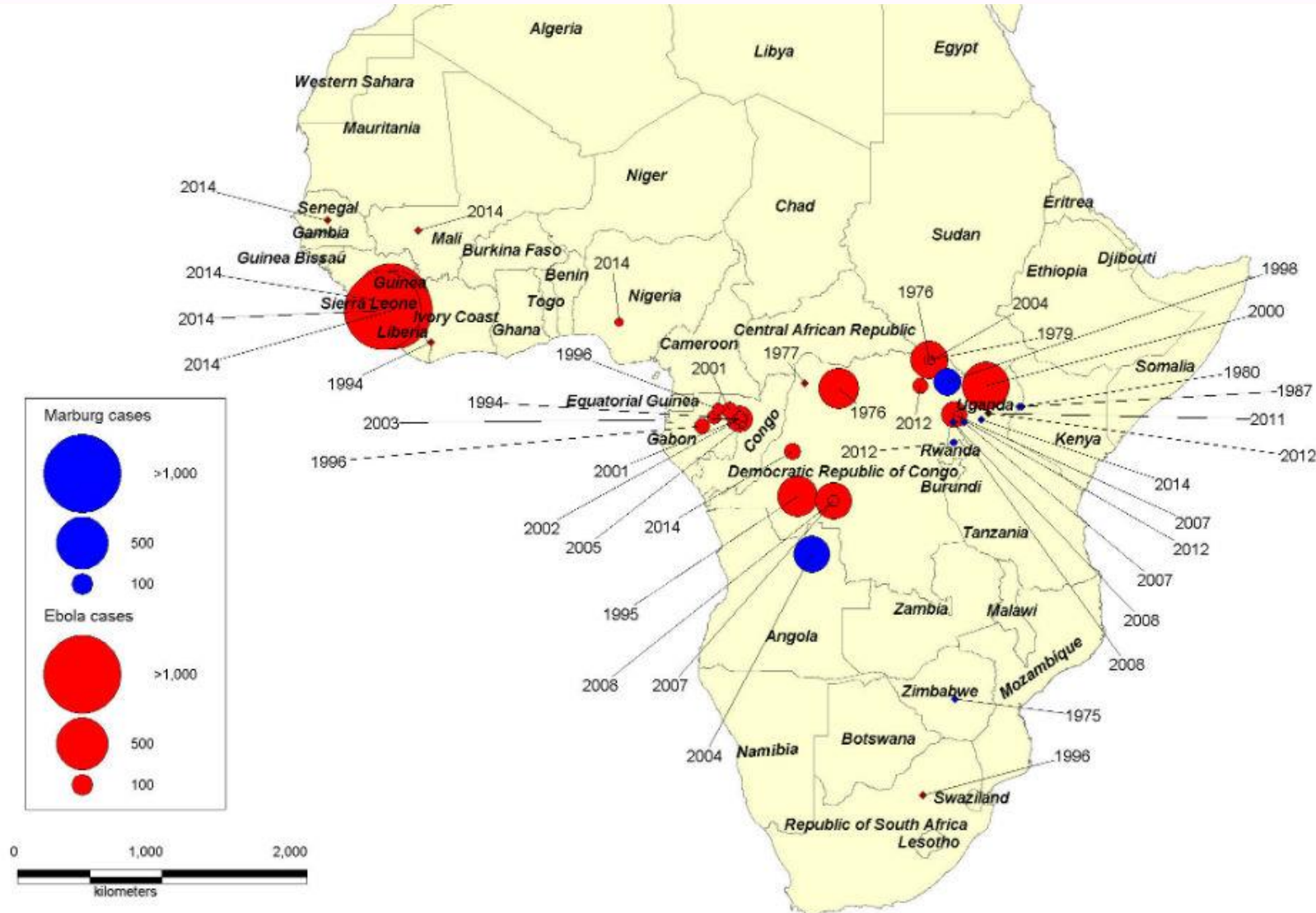
**Table 1. Emerging Infectious Diseases in History**

Year	Name	Deaths	Comments
430 BCE	"Plague of Athens"	~100,000	First identified trans-regional pandemic
541	Justinian plague ( <i>Yersinia pestis</i> )	30–50 million	Pandemic; killed half of world population
1340s	"Black Death" ( <i>Yersinia pestis</i> )	~50 million	Pandemic; killed at least a quarter of world population
1494	Syphilis ( <i>Treponema pallidum</i> )	>50,000	Pandemic brought to Europe from the Americas
c. 1500	Tuberculosis	High millions	Ancient disease; became pandemic in Middle Ages
1520	Hueyztahuatl ( <i>Varicella major</i> )	3.5 million	Pandemic brought to New World by Europeans
1793–1798	"The American plague"	~25,000	Yellow fever terrorized colonial America
1832	2nd cholera pandemic (Paris)	18,402	Spread from India to Europe/Western Hemisphere
1918	"Spanish" influenza	~50 million	Led to additional pandemics in 1957, 1968, 2009
1976–2020	Ebola	15,258	First recognized in 1976; 29 regional epidemics to 2020
1981	Acute hemorrhagic conjunctivitis	rare deaths	First recognized in 1969; pandemic in 1981
1981	HIV/AIDS	~37 million	First recognized 1981; ongoing pandemic
2002	SARS	813	Near-pandemic
2009	H1N1 "swine flu"	284,000	5th influenza pandemic of century
2014	Chikungunya	uncommon	Pandemic, mosquito-borne
2015	Zika	~1,000?*	Pandemic, mosquito-borne

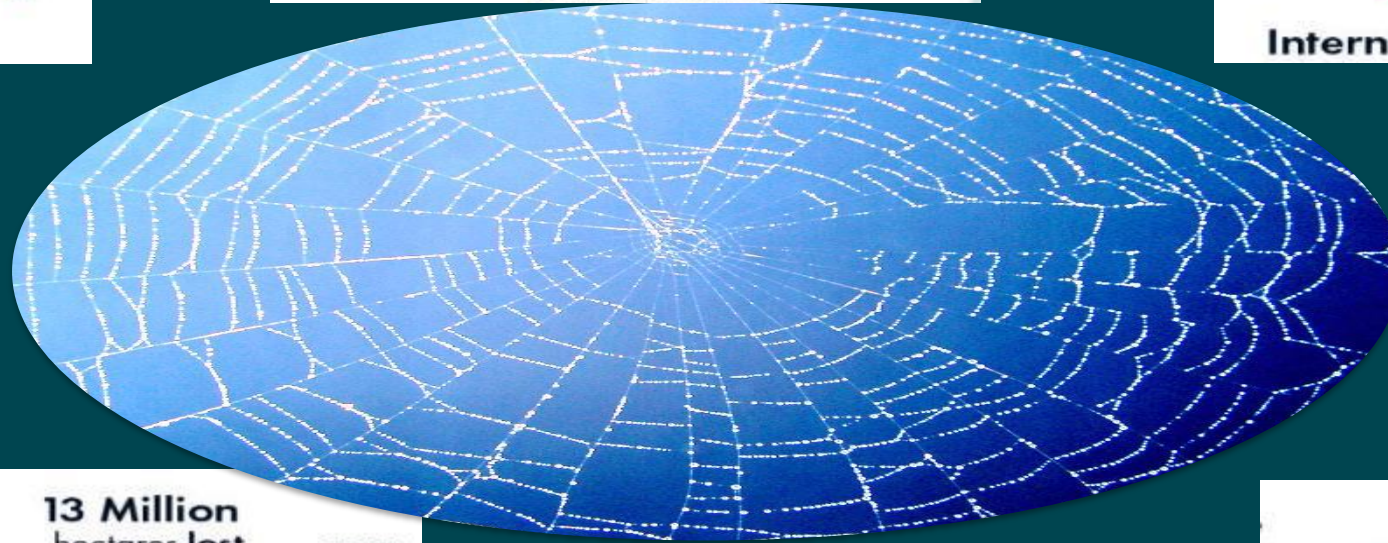
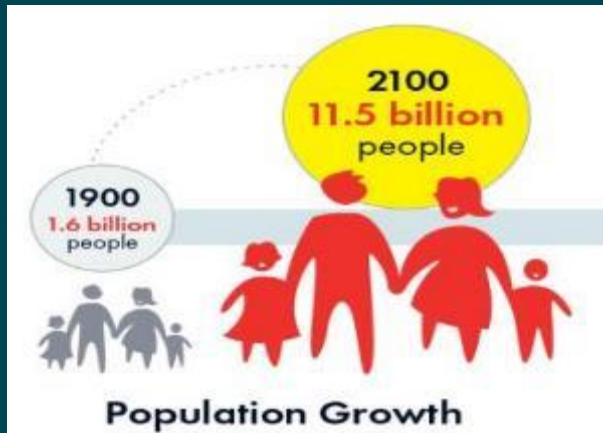
Selected important emerging and re-emerging infectious diseases of the past and present, 430 BCE–2020 CE. Mortality estimates are in most cases imprecise; see text.

\*Zika mortality has not been fully established. Most deaths are fetal or related to outcomes of severe congenital infections.

# Ebola & Marburg Virus Outbreaks in Africa



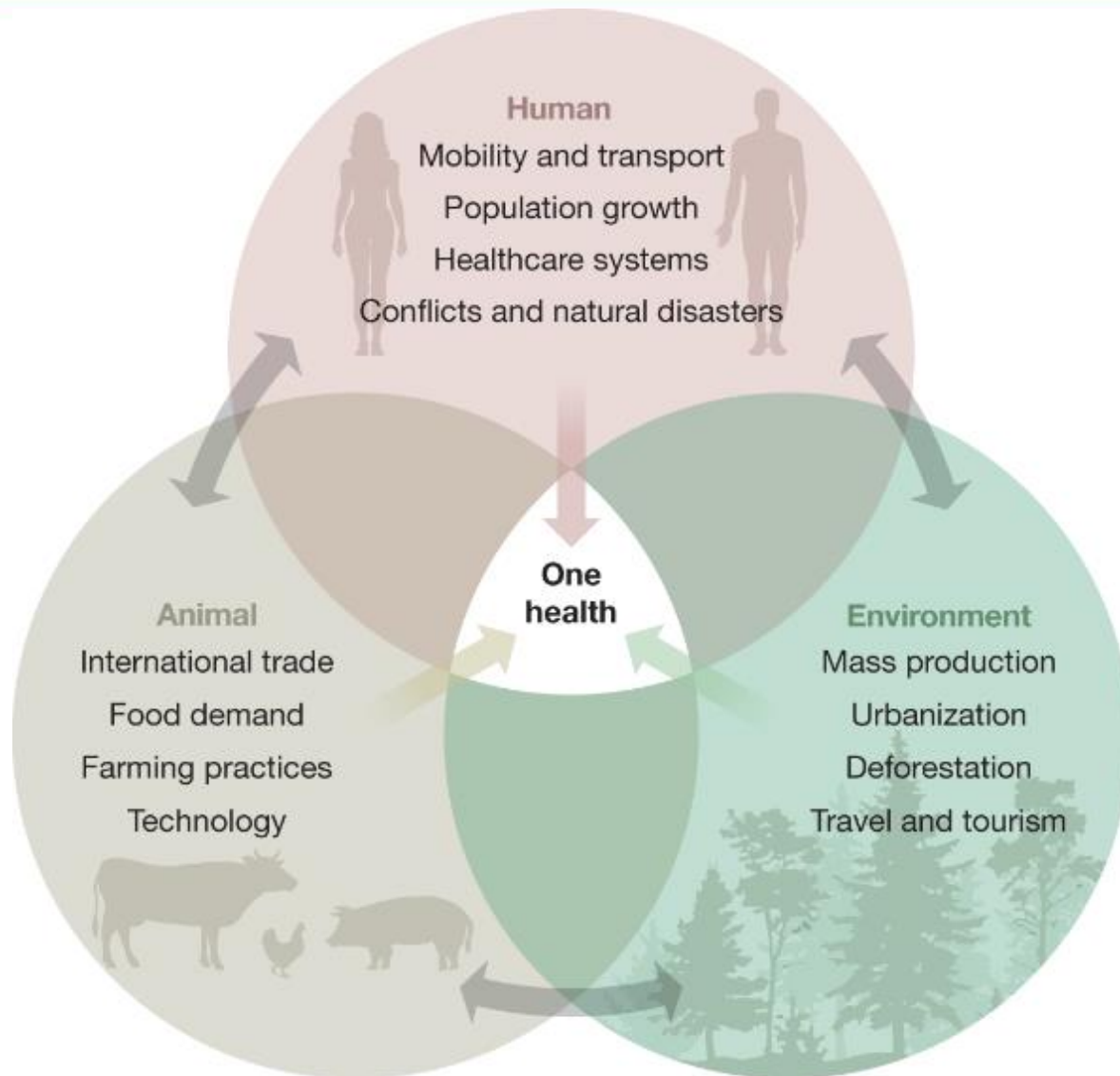




(Quick, The End of Epidemics, 2018)

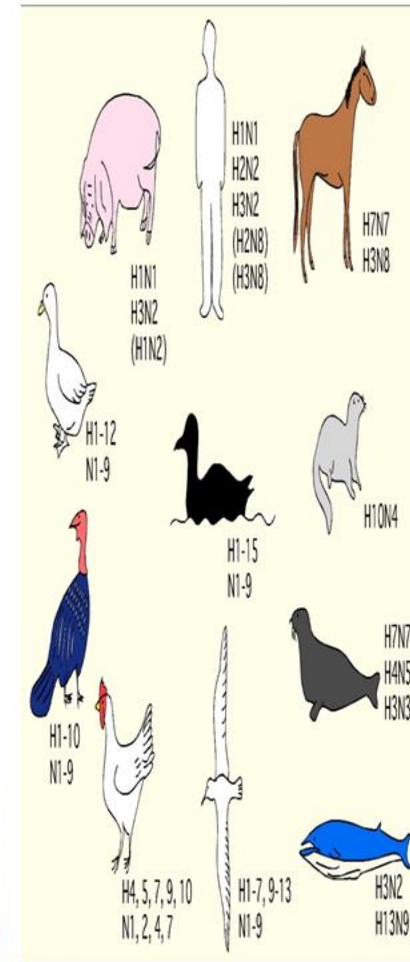


# An Age of Pandemics?



Bedford et al, Nature, 2019

EIDs = Zoonoses



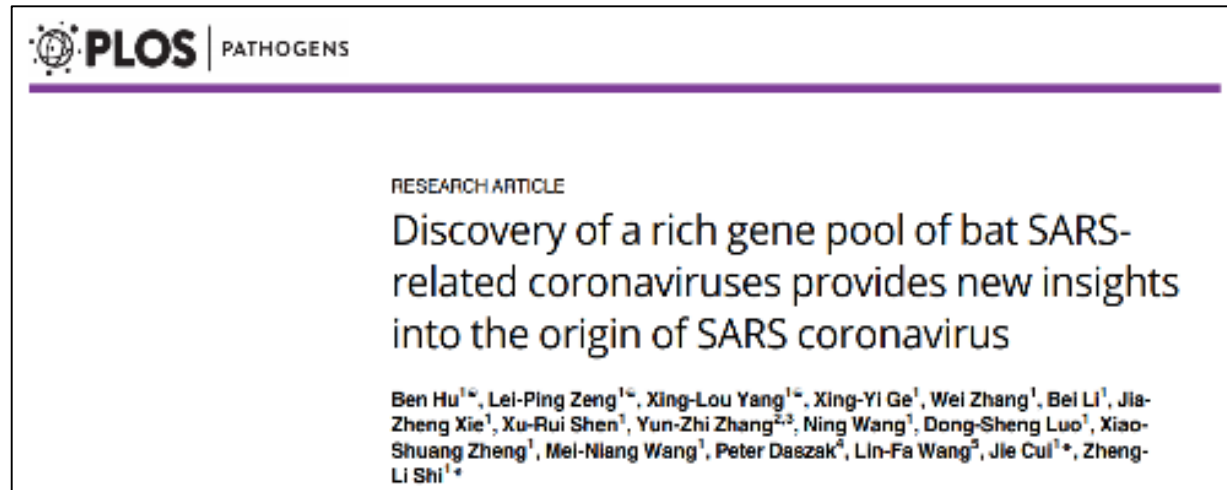
# Discovery of a rich gene pool of bat SARS-related coronaviruses *(Hu et al, PLOS Pathogens, 2017)*



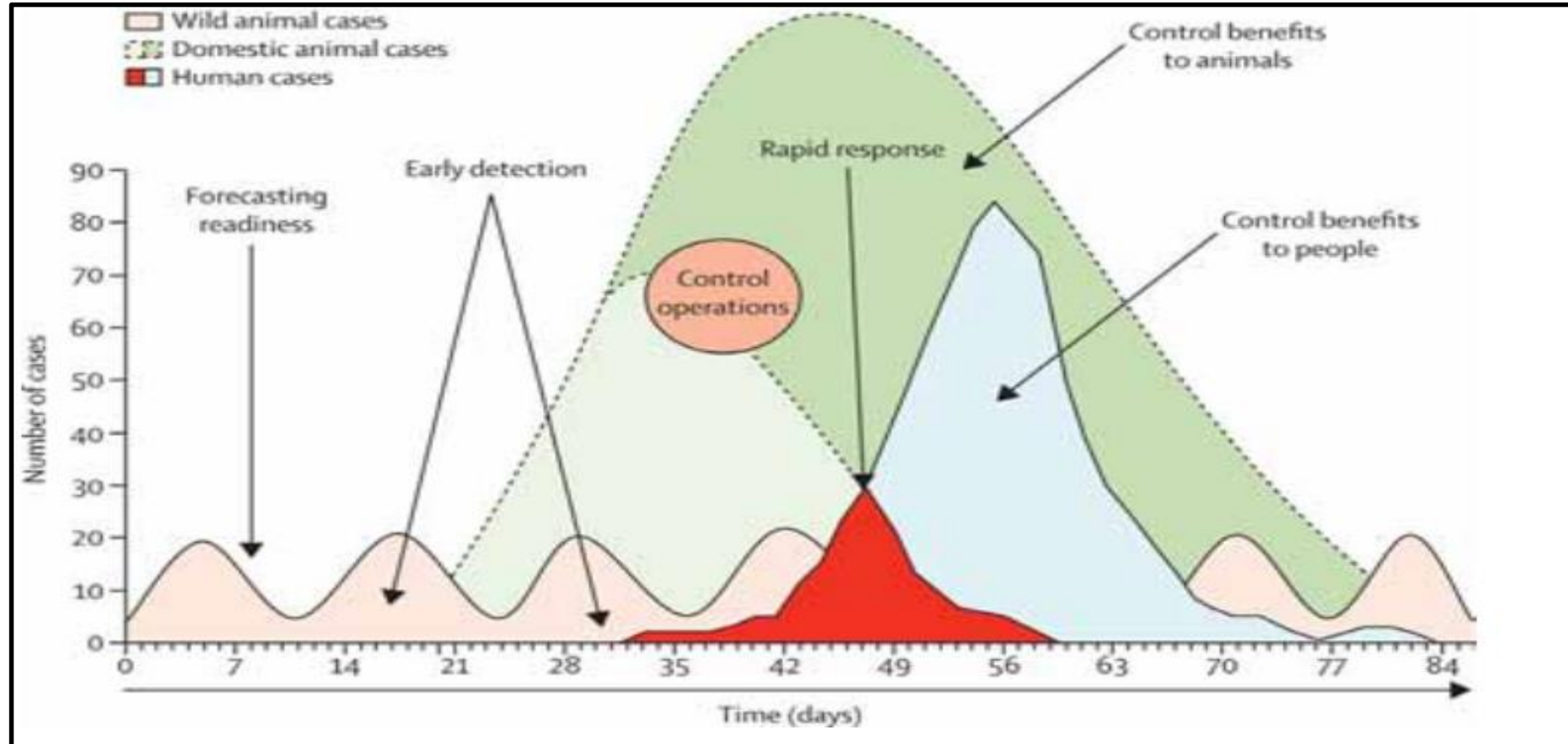
- Hu et al (2017) identified **11 new strains of SARS virus** in multiple species of horseshoe bats in a single cave in **Yunnan Province, China**.
- **Newly identified bat strains**, as well as several strains identified in a previous study of the same bat cave, contained **all the essential genetic building blocks** of the human SARS coronavirus.
- They hypothesized that **genetic recombination between precursor strains** that later evolved into the newly identified strains may also have **given rise to a strain that directly evolved into SARS coronavirus**.
- **Continued monitoring of the cave** they studied, as well as other sites.



Chinese horseshoe bat  
*(Zhang, PLOS, EurekaAlert, 2017)*



# Animal disease surveillance is critical for early detection and rapid response (*World Bank and EcoHealth Alliance, 2018*)



Transmission of infection and amplification in people (bright red) occurs after a pathogen from wild animals (pink) moves into livestock to cause an outbreak (light green) that amplifies the capacity for pathogen transmission to people (*World Bank, One Health Operational Framework, 2018*)



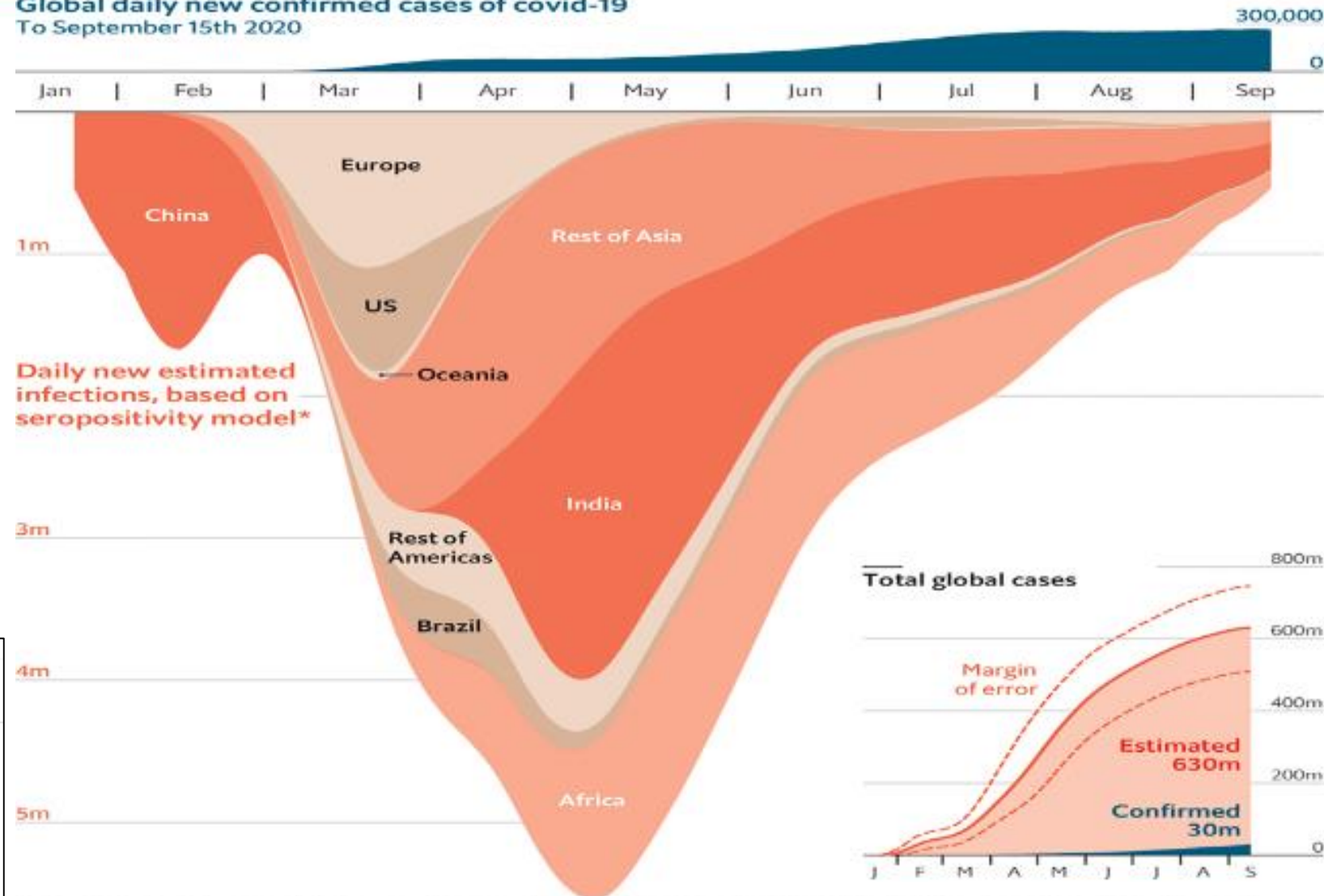
# COVID-19: reported versus actual estimates

As of 20 October:

- **40,652,097** confirmed cases
- **1,222,036** confirmed deaths

*Johns Hopkins, 2020*

Global daily new confirmed cases of covid-19  
To September 15th 2020



The Economist

Today Weekly edition Menu

Briefing

Sep 26th 2020 edition >

One million and counting

## The covid-19 pandemic is worse than official figures show

But some things are improving, and it will not go on for ever

\*Extrapolation from linear model of seroprevalence based on reported cases and confirmed deaths, letting strength of relationships vary by average country income. Sources: Johns Hopkins CSSE; UN; WHO; 279 random-sample serosurveys in general populations; The Economist

The Economist, 2020

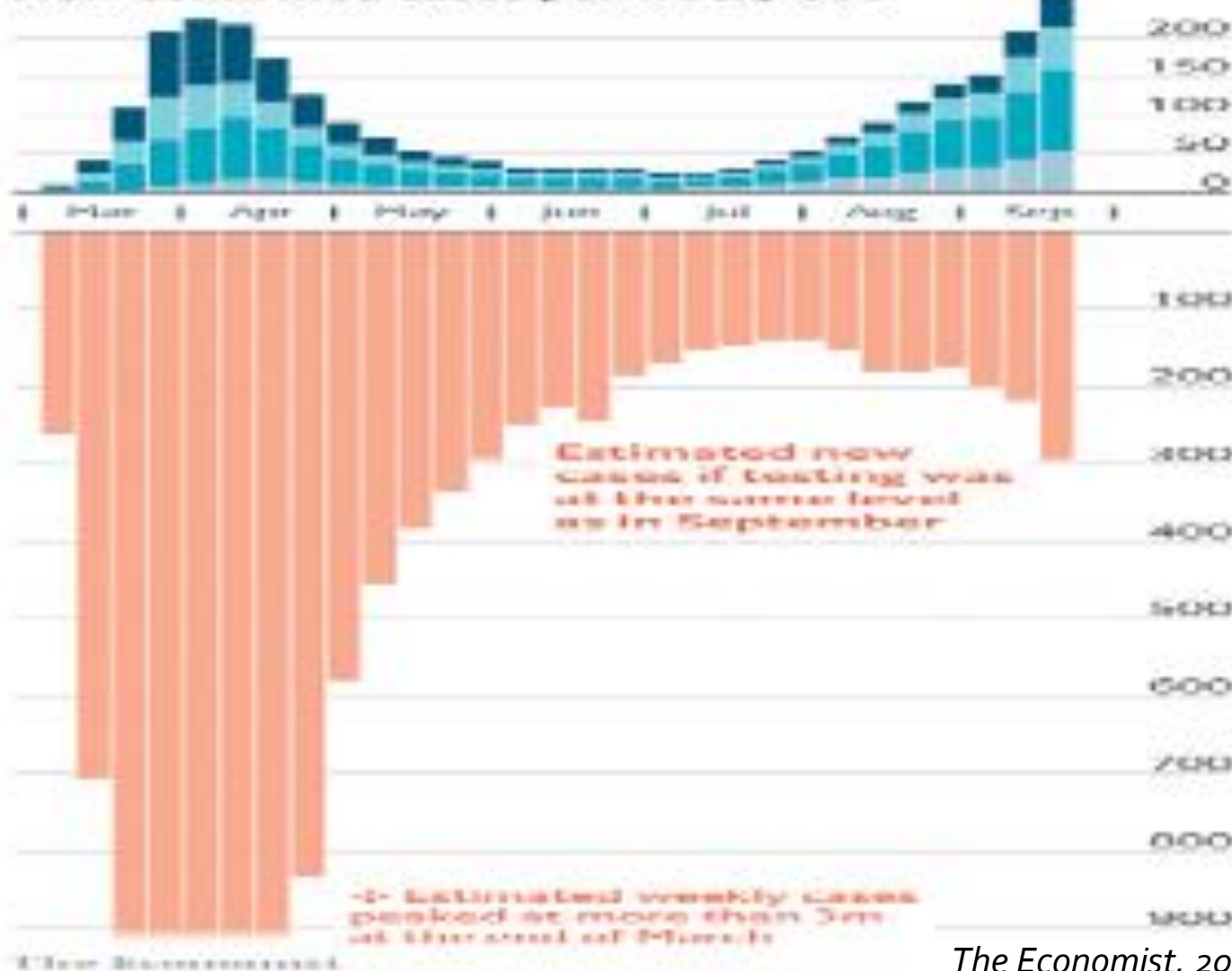


# COVID-19 resurgence in Europe



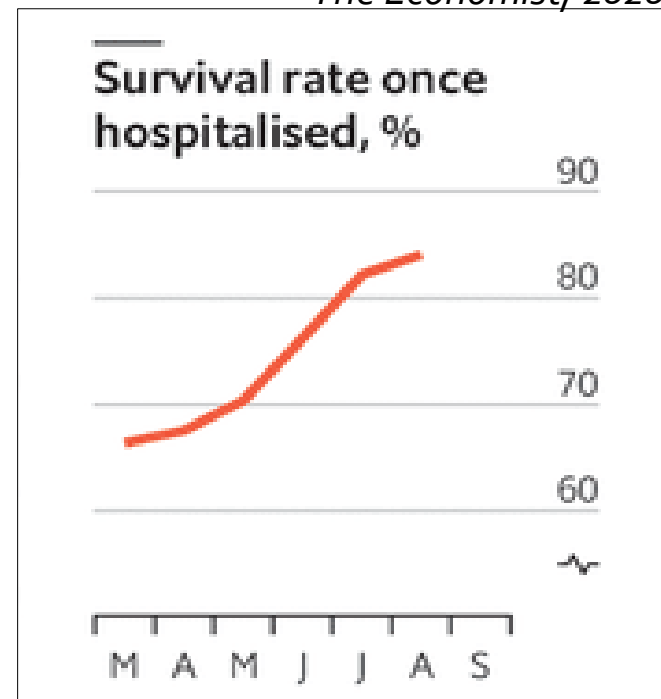
Covid-19 in western Europe\*, to Sep 20th 2020

New confirmed cases per week, \*000



The Economist, 2020

The Economist, 2020



As of 20 October (ECDC):

- **5,039,783** confirmed cases in the EU/EEA and the UK
- **202, 062** deaths in the EU/EEA and the UK

# Long COVID-19

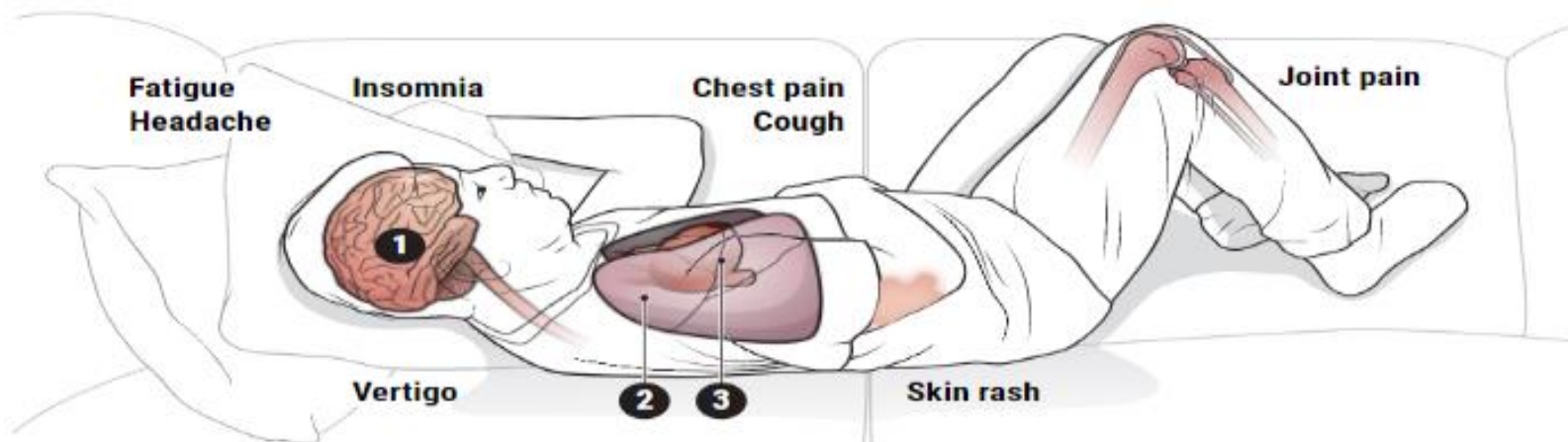
(Couzin-Frankel, Science, 2020)



## Pain that lingers

A subset of COVID-19 patients experiences ongoing symptoms and complications such as organ damage, and researchers are proposing reasons for some of them (bottom). Scientists are trying to identify such symptoms, how common they are, how long they last, who's at risk, and how to treat and prevent them.

Persistent  
fever



### 1 Brain fog

Difficulty thinking can occur after acute COVID-19 infection. The virus may damage brain cells, and inflammation in the brain or body may also cause neurologic complications. Other viral infections can also lead to brain fog.

### 2 Shortness of breath

Doctors are eyeing lung and heart complications including scarring. Patients who become critically ill with COVID-19 seem more likely to have lingering shortness of breath, but those with mild cases are also at risk.

### 3 Heart arrhythmia

The virus can harm the heart, and doctors are concerned about long-term damage. How the heart heals after COVID-19 could help determine whether a patient develops an irregular heartbeat.

### 4 Hypertension

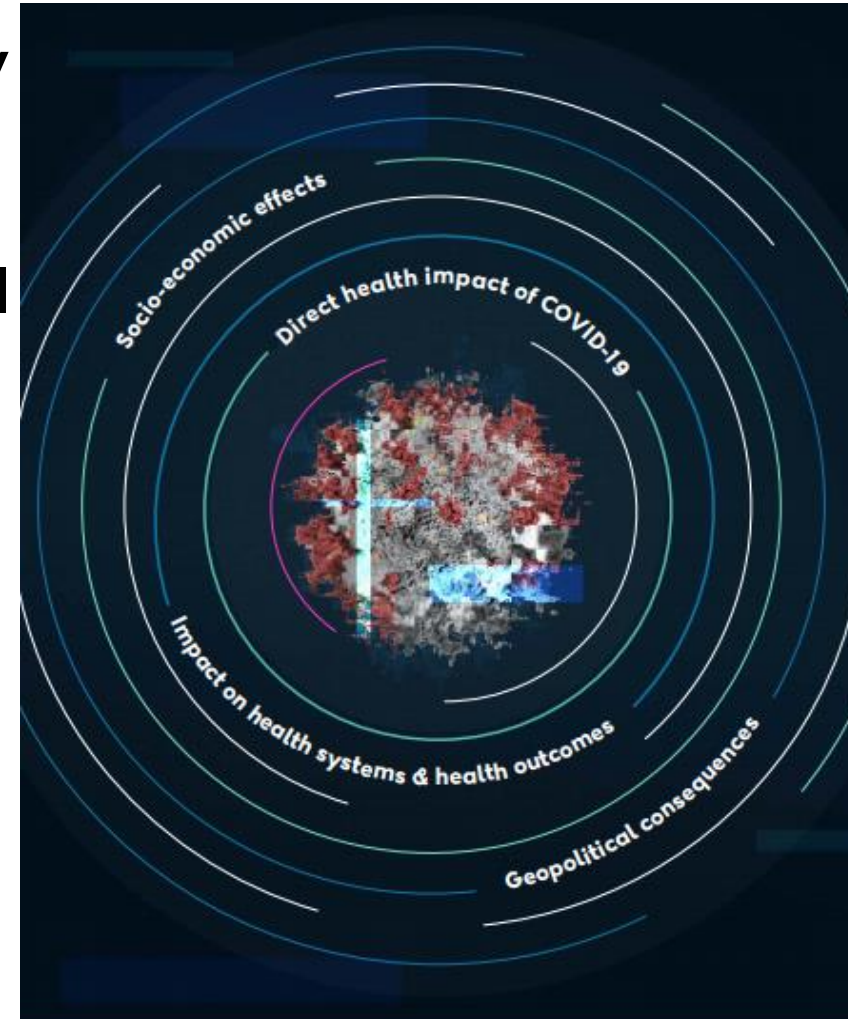
Some patients have high blood pressure after an acute infection, even when cases were relatively mild and people were previously healthy, possibly because the virus targets blood vessels and heart cells.

# Shockwaves for the years to come

(Global Preparedness Monitoring Board, 2020)



- Huge impacts on **health outcomes beyond COVID**
- Nearly **100 million** more people at risk of extreme poverty **in 2020**
- Growing **food insecurity** worldwide
- More than a **billion** children are or have been out of school
- **Mental health crisis**
- Increased **risk of violence** and **threatened social cohesion**
- **Deepens social inequalities**



**FIGURE 6** Global Economic Impact of COVID-19



Per capita GDP growth in low, lower, upper-middle and high income countries from 1996-2024. Source: IMF/World Bank.



# Herd immunity?

- Only a **proportion** of a population needs to be immune to stop an epidemic
- $R = (1 - pC)(1 - pI)R_0$  with herd immunity:  $R < 1$   
SARS-Cov-2  $R_0$  is 2.5 – 4
- Herd immunity threshold around **67%**, and probably at least 50% of population must be immune (for how long? Several rounds of *re-infection*? *Duration* of immunity? ...)
- In influenza herd immunity after 2 or 3 *waves*
- **Mortality** can be enormous at 0.3-1.3% infection fatality rate = >15 million deaths for 7.8 billion population

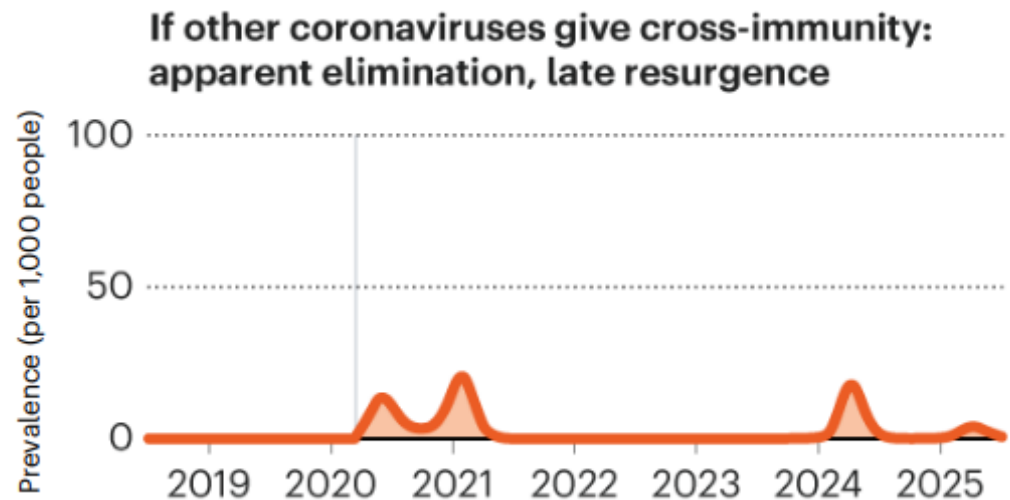
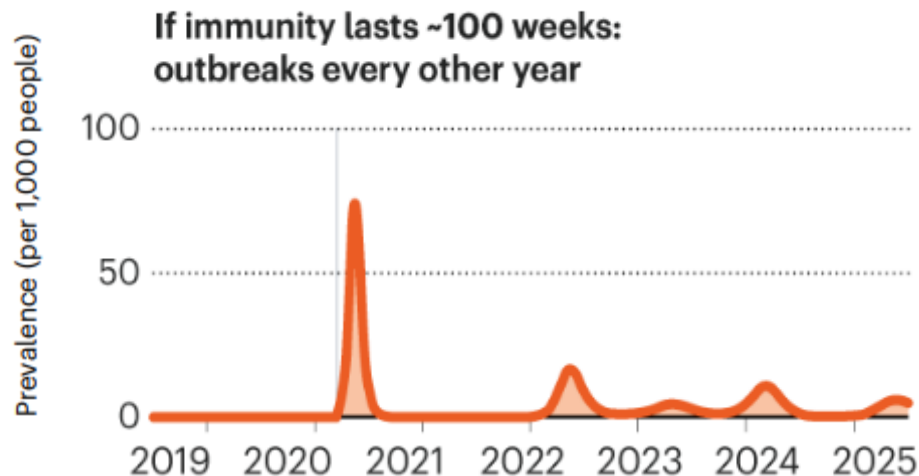
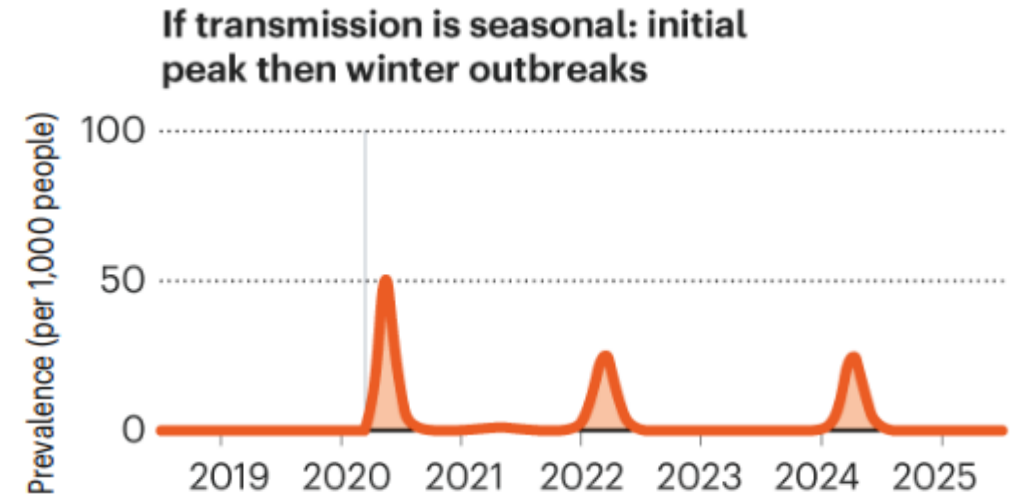
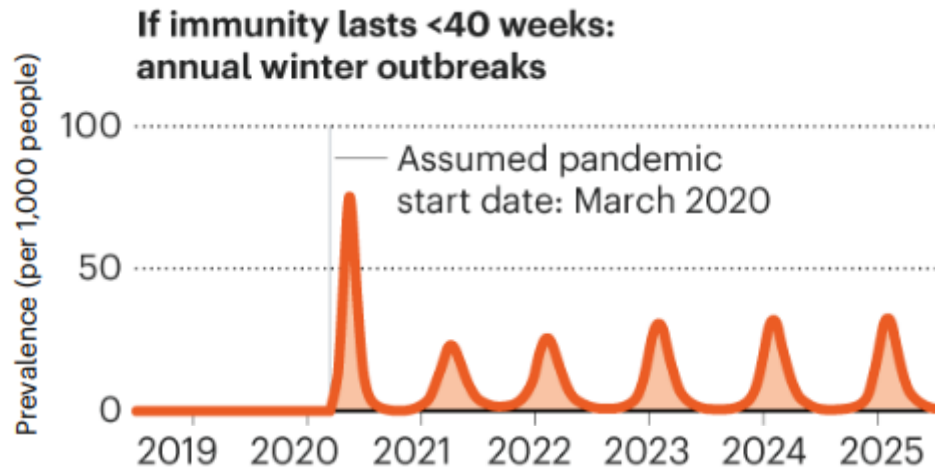
# The future?



René Magritte, *La Clairvoyance*

# Future course of the pandemic?

(Scudellari, *Nature*, 2020)





# Will SARS-CoV-2 become endemic?

(Shaman & Galanti, Science, 2020)

Science

SPECIAL SECTION

EMERGING INFECTIOUS DISEASES

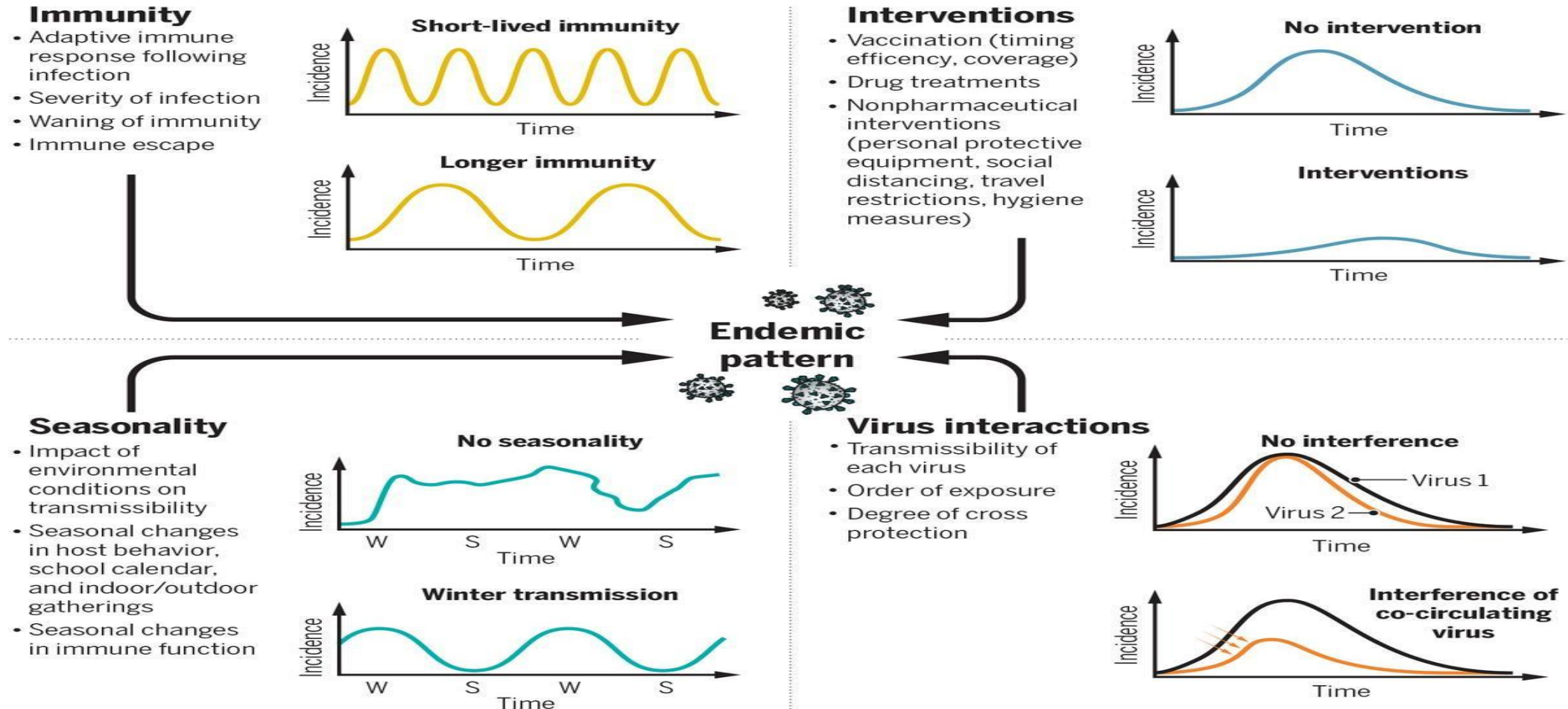
REVIEW

## When an emerging disease becomes endemic

Graham F. Medley\* and Anna Vassall

### Factors influencing postpandemic transmission of SARS-CoV-2

Rates of repeat infection, factors modulating seasonality, competition with other circulating respiratory viruses, and control measures will influence the endemic pattern of severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) transmission.



# COVID-19 vaccine candidates in Phase III

(LSHTM Vaccine Centre, 18 October, 2020)

1. BioNTech/Fosun Pharma/Pfizer
2. Moderna/NIAID
3. CanSino Biological Inc/Beijing Institute of Biotechnology
4. Gamaleya Research Institute
5. Janssen Pharmaceutical Companies
6. University of Oxford/AstraZeneca
7. Beijing Institute of Biological Products/Sinopharm
8. Sinovac/Instituto Butantan
9. Novavax
10. Wuhan Institute of Biological Products/Sinopharm

## Phase III:

Testing of vaccine in a large number of healthy volunteers (1,000-10,000+)

Primary questions: Is the vaccine **effective** at preventing disease? Is the vaccine **safe** in a larger, more varied population?

248



vaccine candidates

49



in clinical testing

# How long does it take to make a vaccine?





# Solid progress against Ebola in recent years

- Merck's **Ebola vaccine** - rVSV-ZEBOV (ERVEBO)- **licensed** by EC (11.2019) and FDA (12.2019)
  - **2002**: Vaccine developed at the Public Health Agency of Canada's National Microbiology Laboratory; **research began years earlier**
- **Janssen's Ebola vaccine regimen** - Zabdeno (Ad26.ZEBOV) and Mvabea (MVA-BN-Filo) - **approved** by EC (7.2020)
  - **2002**: Crucell (Janssen) begins Ebola vaccine research program with NIH support
- **Two treatments that significantly increase the chance of survival** - REGN-EB3 & mAb114



Credit: The Wellcome Trust. Health officials and health workers celebrate the launch of Ebola vaccination programme.

COMMENTARY | STORY BEHIND THE SCIENCE ■ SEPSIS

**cmaj**  
Canadian Medical Association Journal

## The story of Canada's Ebola vaccine

Francis A. Plummer MD DrSc, Steven M. Jones PhD

■ Cite as: *CMAJ* 2017 October 30;189:E1326-7. doi: 10.1503/cmaj.170704

See related article at [www.cmaj.ca/lookup/doi/10.1503/cmaj.170704](http://www.cmaj.ca/lookup/doi/10.1503/cmaj.170704)

# COVID-19 vaccine initiatives



**C**oalition for  
**E**pidemic  
**P**reparedness  
**I**nnovation

**COVAX: Ensuring global equitable access to COVID-19 vaccines**

CEPI Gavi World Health Organization

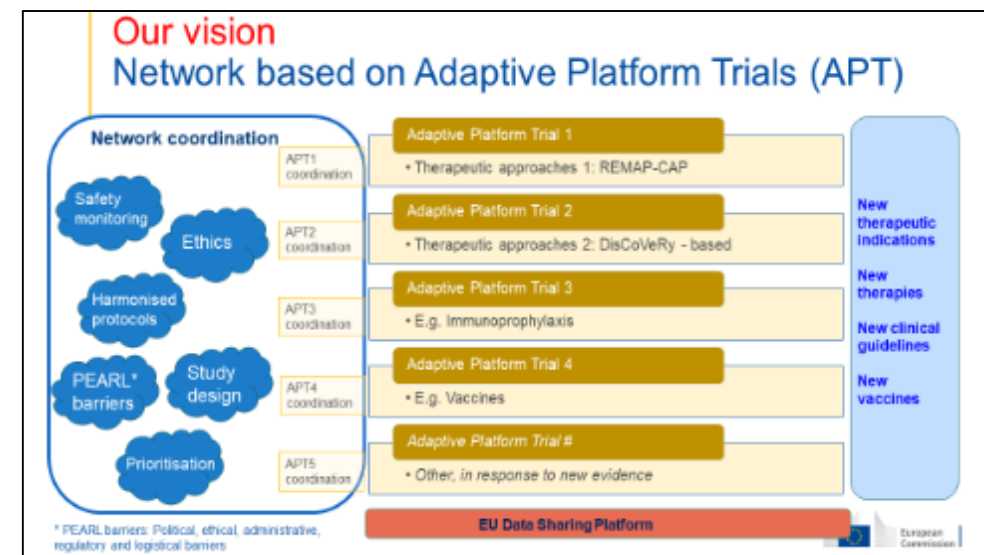


**Coronavirus  
Global Response**



Home / News / Press Releases

**African Union Commission launches Consortium for COVID-19 Vaccine Clinical Trial**

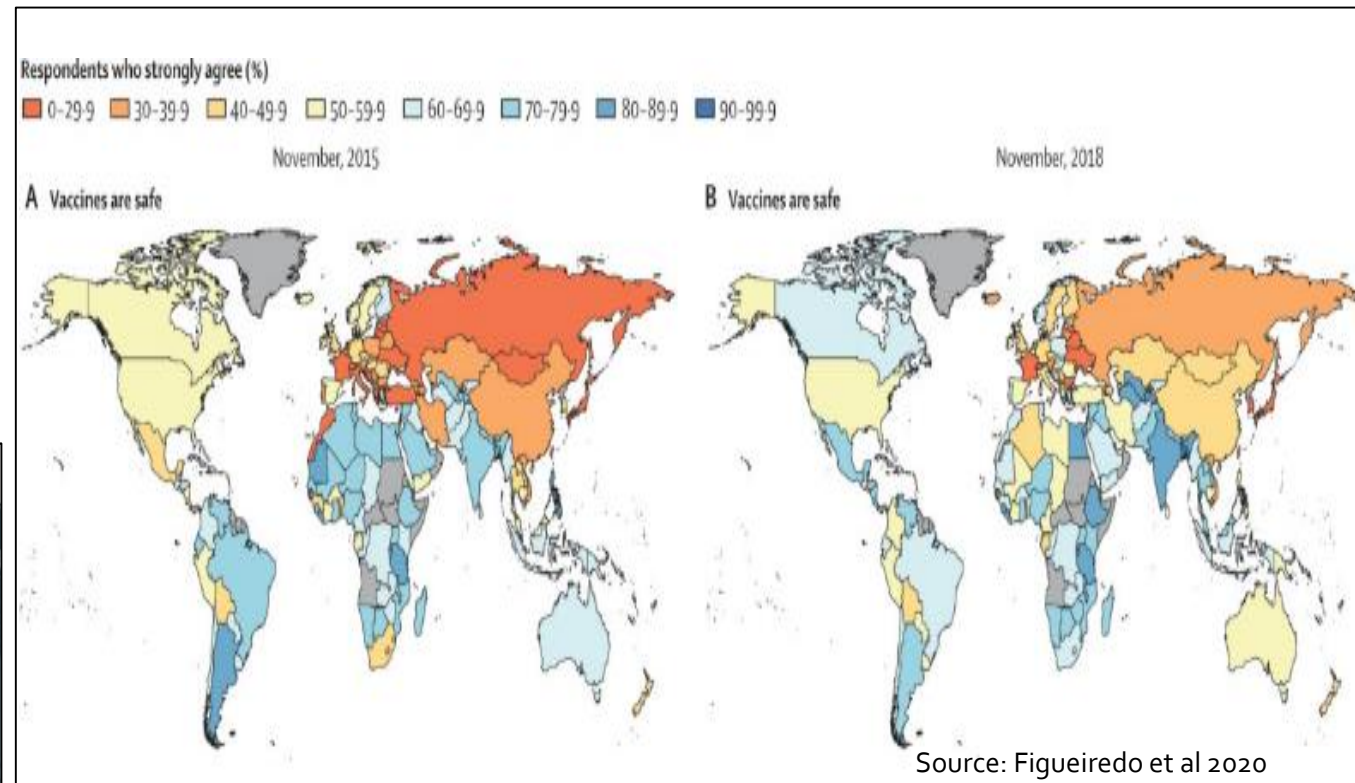




# Will vaccines end the pandemic?

## Challenges ahead for a safe and effective COVID-19 vaccine:

1. Will it work? For how long?
2. Will it be safe?
3. Will there be enough?
4. Who gets it first?
5. Will people accept it?
6. Close cost-marketing monitoring



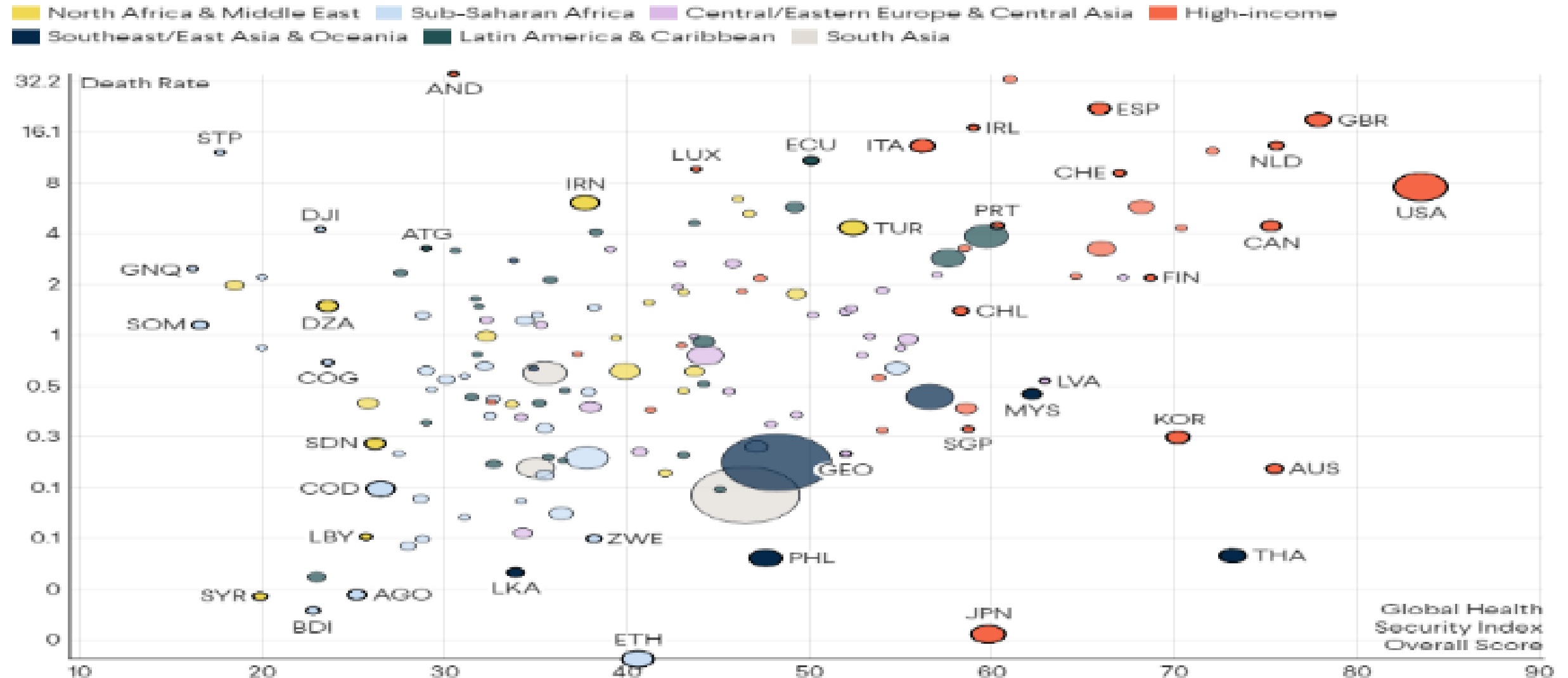


# Standard measures not predictive

(Crosby et al, Think Global Health, 2020)



## Global Health Security Index Scores vs. COVID-19 Death Rates



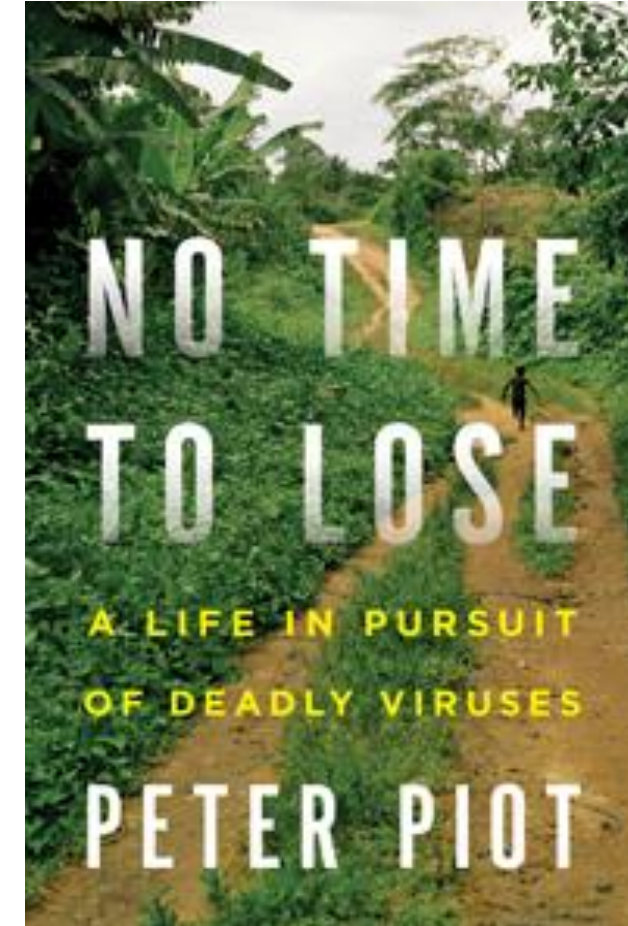
# State of the Union Address by President Ursula von der Leyen, 2020

- **Build a stronger European Health Union:**
  - Strengthen **crisis preparedness** and **management of cross-border** health threats (reinforce **ECDC** and **EMA**)
  - Build a **European BARDA**
  - Discuss question of **health competences**
  - **Learn global lessons** – President von der Leyen, Prime Minister Conte and the G20 to convene a **Global Health Summit** in 2021 in Italy
  - **Vaccine** development and access (ACT-A & Covax)



# Lessons from past epidemics

1. **The sooner you act**, the higher your chance of impact.
2. **Political leadership at the highest levels.**
3. Use **all of tools that science offers** to inform decisions, **promptly adopt innovation**, and massively invest in R&D.
4. **No magic bullets:** use a **combination** of prevention measures, even if when we have a vaccine
5. Invest in public health **systems** and societal preparedness
6. **Build coalitions and involve communities for a whole of society approach!**





# Societies living with COVID-19

- Series of outbreaks & new pandemics
- Change in cultural and behavioural norms
- Strong public health institutions
- Safe spaces for vulnerable communities
- Long-term care for survivors
- Research and innovation
- Mitigate acute and long-term health, social and economic costs
- Change how we live, work, travel, interact with nature



No country is safe,  
unless every country  
is safe



(National University of Singapore, 2020)



# Yambuku Hospital

1976-2014

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# Congratulations Quarraisha and Slim!!!!

