



Columbia University
MAILMAN SCHOOL
OF PUBLIC HEALTH

Why Do Infections Emerge, and What Can We Do to Stop Them?

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**MfPH Workshop on Early Warning Systems for
Emerging and Re-emerging Diseases
January 23, 2023, The Fields Institute**



"And it was so typically brilliant of you to have invited an epidemiologist."

W. D. Hamilton
CN
COLLECTION

An interesting time to be an
Epidemiologist!

Some Famous Microbial Invaders in History

- The Black Death (plague, 1348)
- Smallpox
- Cholera (19th Century and after)
- 1918 Influenza
- HIV/AIDS (1980's --)

Influenza Pandemic, 1918



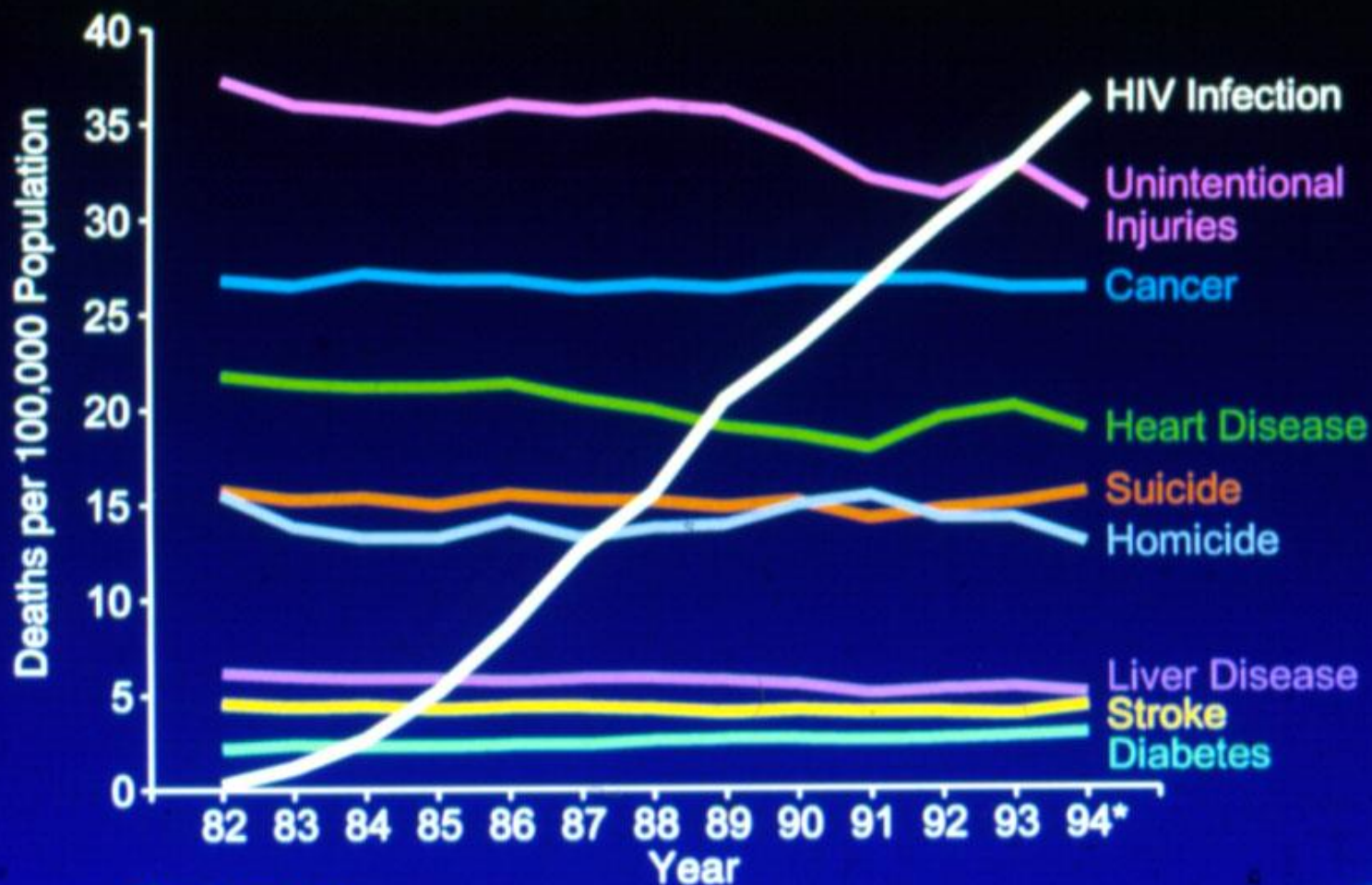
Influenza Pandemic 1918 at Camp Funston (Kansas)



Influenza pandemics and recent outbreaks

<i>Year</i>	<i>Colloquial name & subtype</i>	<i>Affected ages</i>	<i>No. deaths</i>
Pandemics:			
1918	"Spanish flu" (H1N1)	all ages	~50 million
1957	"Asian flu" (H2N2)	> 65 and under five *	
1968	"Hong Kong flu" (H3N2)	> 65 and under five *	
* Est. 4.5 M total deaths for 1957+1968			
2009	2009-H1N1 (H1N1, "swine-like")		
Other outbreaks of interest:			
1976	Swine flu (H1N1)	all ages	2
1997	Avian flu (H5N1)	all ages	6 (18 cases)
2003--	Avian flu (H5N1)	all ages	449
2013--	Avian flu (H7N9)	all ages	275

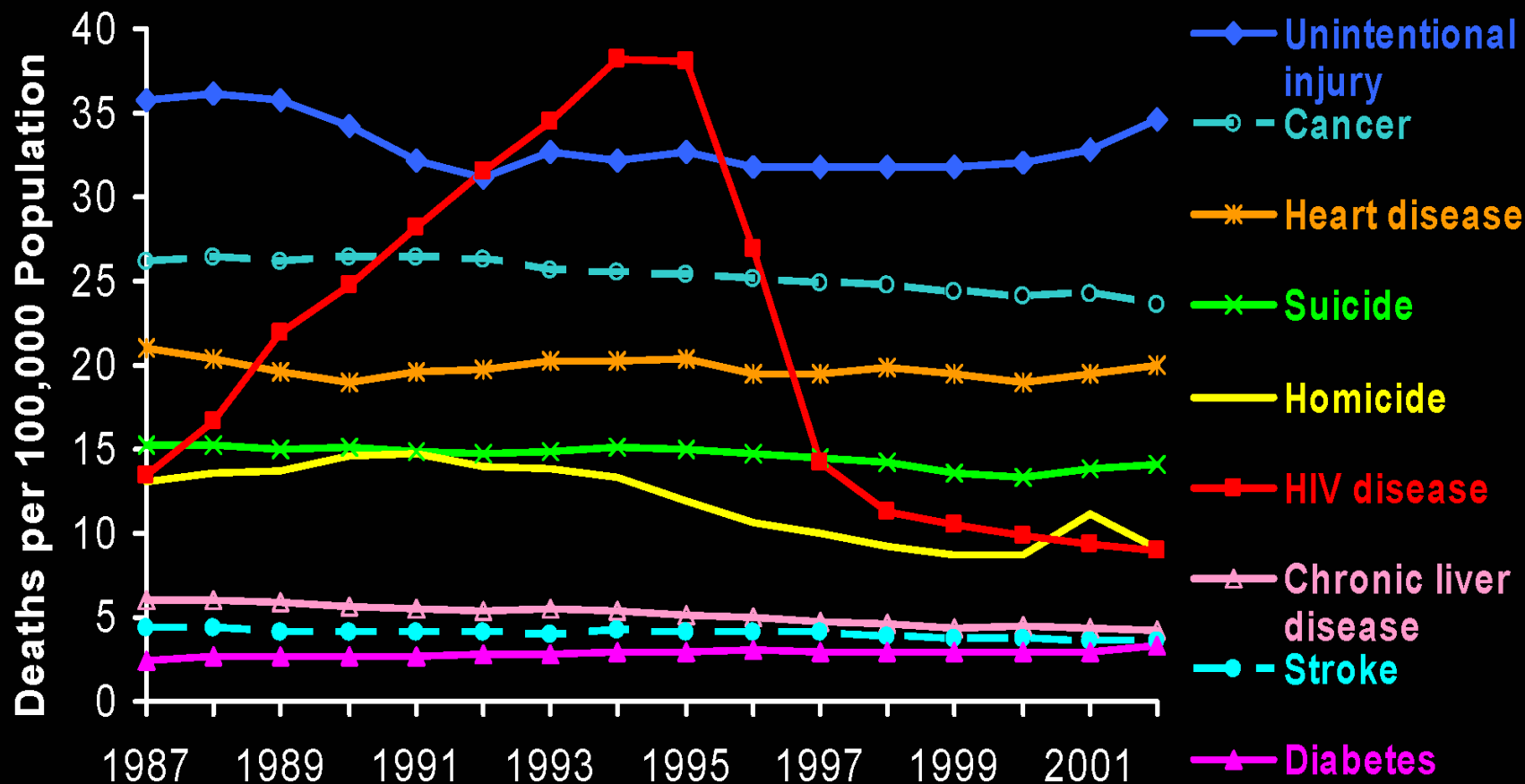
Death Rates from Leading Causes of Death in Persons Aged 25-44 Years, USA, 1982-1994



*Provisional data

SOURCE: National Vital Statistics

Trends in Annual Rates of Death due to the 9 Leading Causes among Persons 25–44 Years Old, USA, 1987–2002



Note: For comparison with data for 1999 and later years, data for 1987–1998 were modified to account for ICD-10 rules instead of ICD-9 rules.

Courtesy Michael Marco



Three Coronaviruses in Three Decades

- SARS (Severe Acute Respiratory Syndrome), 2003
- MERS-CoV, 2012 –
- SARS-CoV-2 (COVID-19), 2019 –

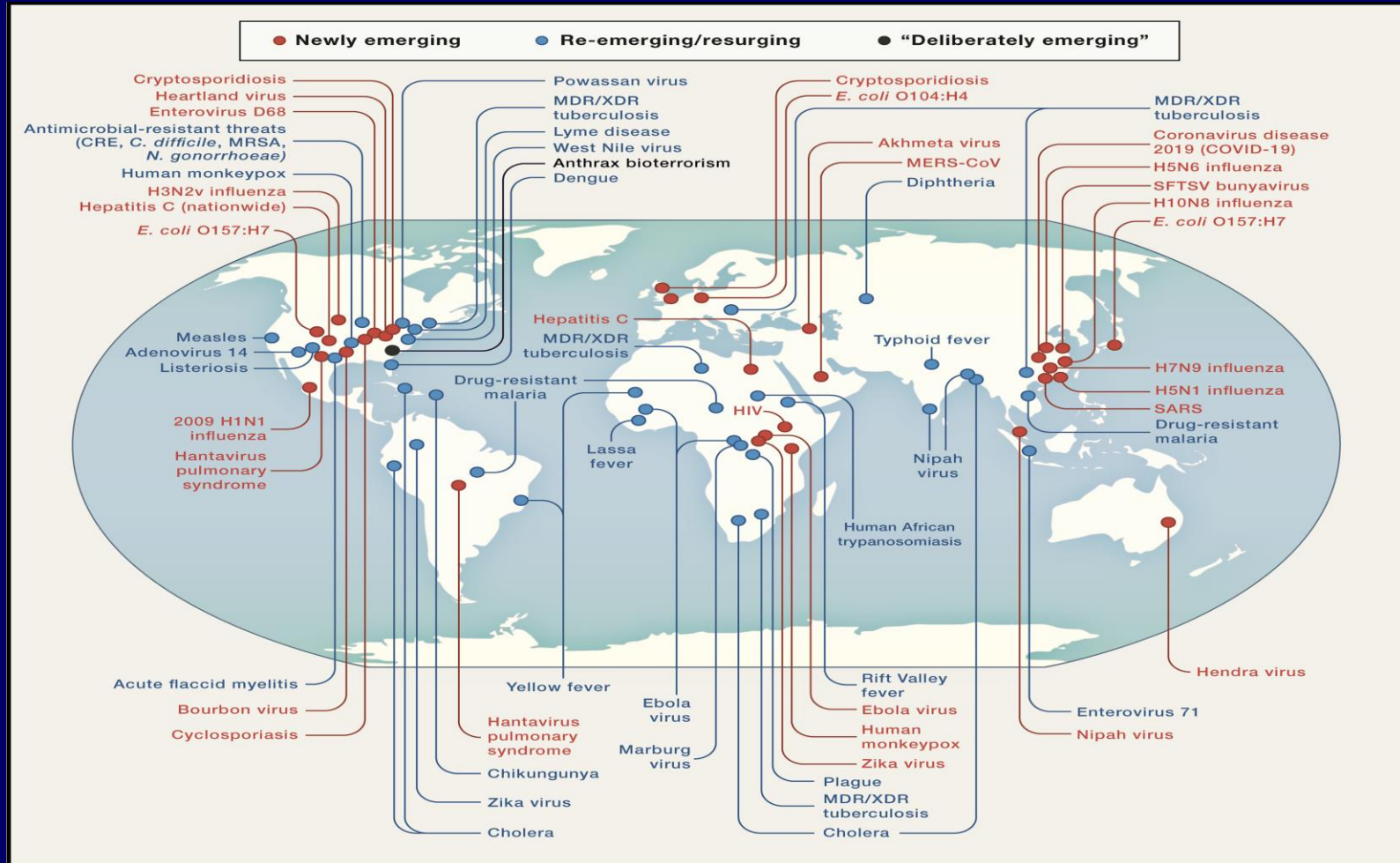
Emerging Infections

- Those rapidly increasing in incidence (number of new cases) or geographic range
- Often novel (a previously unrecognized disease)
- Anthropogenic causes often important in emergence

EMERGING INFECTIONS: SOME RECENT EXAMPLES

- Ebola, 1976 – (and West Africa 2013 –; DRC 2018, others)
- HIV/AIDS
- BSE & Variant CJD, ca. 1986 –
- Hantavirus pulmonary syndrome, 1993
- Hemolytic uremic syndrome, 1990's –
- Nipah, 1998 –
- West Nile, US, multistate, 1999 –
- SARS 2003; MERS-CoV 2012
- Influenza (including H5 in Asia 2003 –; H1N1 pandemic 2009-10; H7N9 avian flu, China, 2013 –)
- Zika
- **SARS-CoV-2 (COVID-19), 2019 –**
- **MPOX (“Monkeypox”), 2022 –**

Global Examples of Emerging and Re-Emerging Infectious Diseases



Cell 2020 1821077-1092DOI: (10.1016/j.cell.2020.08.021)

Drs. David Morens and Anthony Fauci, NIAID

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No pandemic or emerging infection has ever been predicted

--- Morse *et al.*, Lancet 380: 1956–1965 (2012)

... and we can probably now say that none has ever been stopped yet

WHO Disease Outbreak News, 23 March 2014

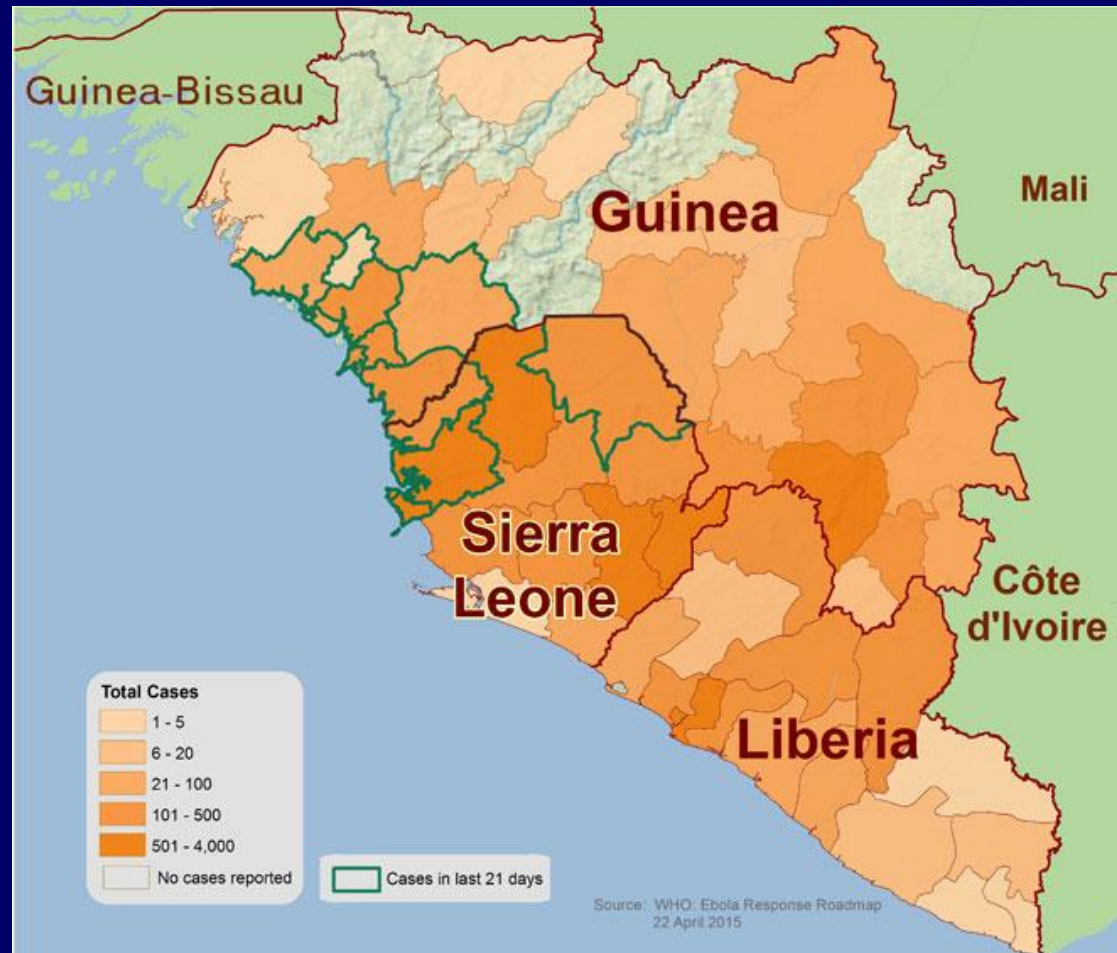
Global Alert and Response (GAR)

Ebola virus disease in Guinea

Disease Outbreak News

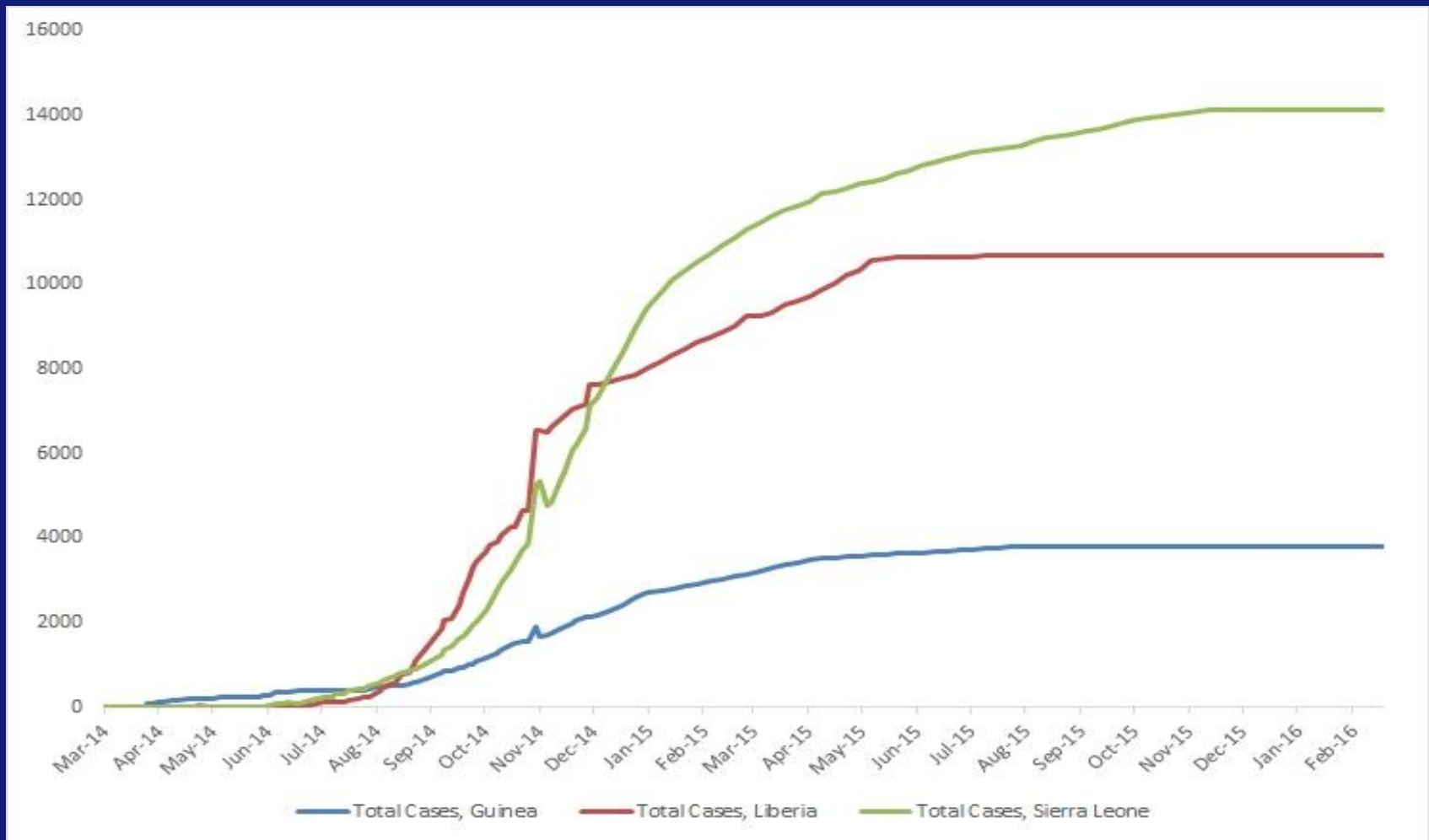
23 MARCH 2014 - The Ministry of Health (MoH) of Guinea has notified WHO of a rapidly evolving outbreak of Ebola virus disease (EVD) in forested areas of south-eastern Guinea. As of 22 March 2014, a total of 49 cases including 29 deaths (case fatality ratio: 59%) had been reported.

Ebola in West Africa (as of April 22-27, 2015)



CDC

Total suspected, probable, and confirmed cases of Ebola virus disease in Guinea, Liberia, and Sierra Leone, Mar. 25, 2014 – February 14, 2016



Source: CDC, June 2016

How Do Infections Emerge?

The Emerging Infections “Two-Step”

Step 1: Introduction

Step 2: Establishment/Dissemination

The Emerging Infections Two-Step

Step 1: Introduction

- Many are zoonotic
- The “zoonotic pool” is a rich source of potential emerging pathogens
- Changes in environment may increase contact, with greater chance or frequency of introduction
- Role of food animals as well as wildlife

Zoonoses in disease emergence

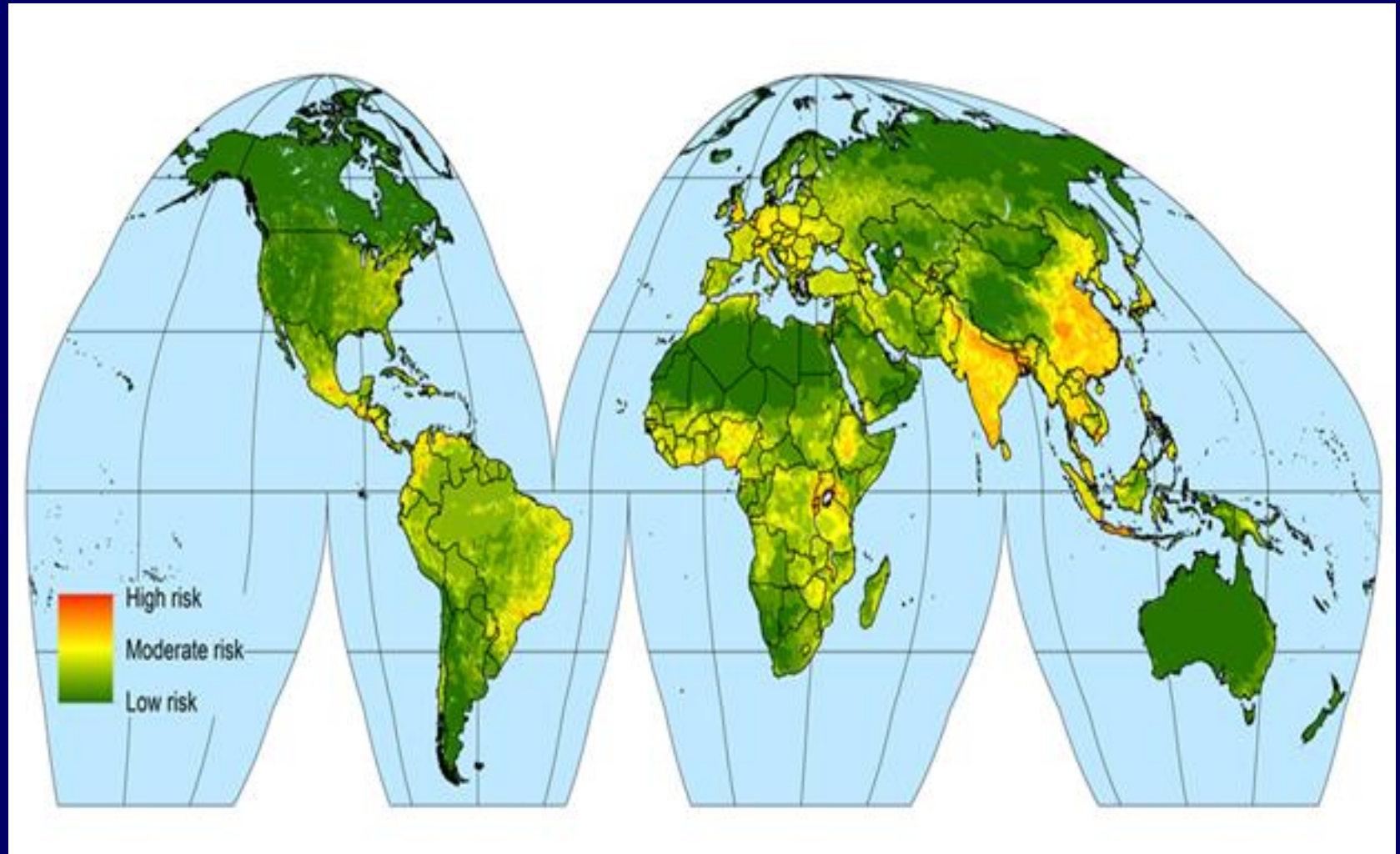
- 1407 human pathogens
- 58% are zoonotic
- 130 of the 177 recently emerged pathogens zoonotic (RR=2.0)

Woolhouse ME, Gowtage-Sequeria S.
Host range and emerging and
reemerging pathogens. *Emerg Infect
Dis* 2005; 11(12): 1842-7.

New Opportunities for Pathogens: Ecological Changes

Agriculture	Hantaan, Argentine Hemorrhagic Fever, Nipah, West Nile (Israel), possibly pandemic influenza
Food handling practices	SARS, H5N1 influenza, HIV?, Enteropathogenic <i>E. coli</i>
Dams, changes in water ecosystems	Rift Valley Fever, other vector borne diseases, Schistosomiasis
Deforestation, reforestation	Kyasanur Forest, Lyme disease
Climate changes	HPS, vector borne diseases

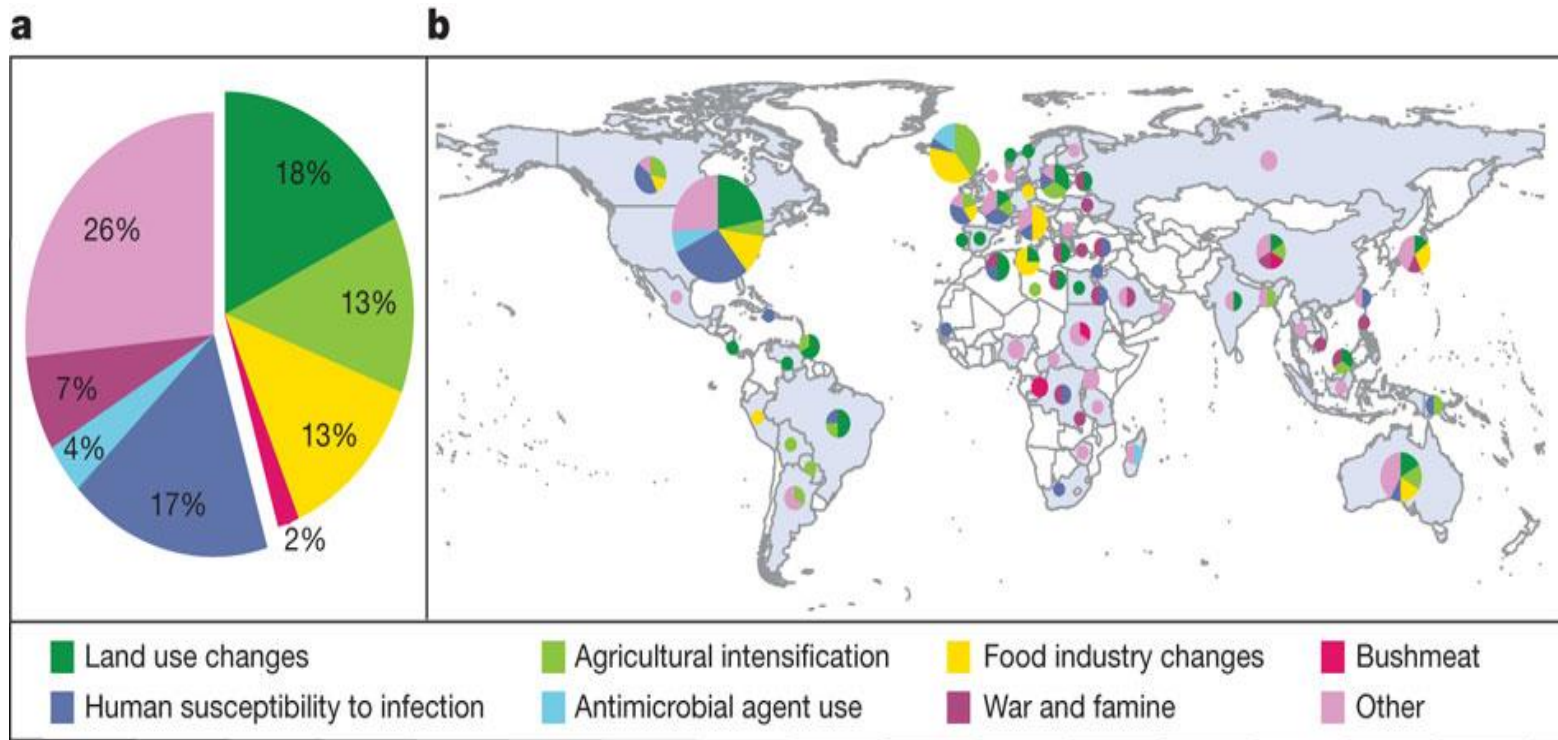
Emerging Infections “Hotspots” Today



Hotspots map at 1 km² resolution (2012)

Courtesy Daszak and Zambrana-Torrel, EcoHealth Alliance
(Morse *et al.*, Lancet 380: 1956–1965, 2012)

Drivers and locations of emergence events for zoonotic infectious diseases in humans from 1940–2005.



F Keesing *et al.* *Nature* **468**, 647-652 (2010) doi:10.1038/nature09575

Why is “One Health” Important?

- Most emerging infections are zoonotic – crossing species
- Thus, many of the emerging infections of the future can be found in other animal species
- Roles of evolution: Very interesting questions
- Humans may become infected through:
 - Changes in environment that increase contact (wildlife)
 - Handling of food animals
- Therefore, surveillance across species is essential

Common Pathways for Emerging Infections

- Wildlife contact
- Live animal markets and food handling
- Hunting
- Healthcare settings (infection control)

HOW DID HIV ENTER THE HUMAN POPULATION? (AN HYPOTHESIS)



Photograph: Karl Ammann; from Hahn *et al.*, 2000

Wildlife/livestock contact



From Duck to Pig to Human?

Scholtissek C, Naylor E. Fish farming and influenza pandemics. *Nature*. 1988 Jan 21;331(6153):215. doi: 10.1038/331215a0

A “Typical” Farm in China



Photo from Cornell Univ., College of Agriculture & Life Sciences

Markets/trade



Chicken market in Xining, Qinghai province, China
[Flickr, photo by M M (Padmanaba01), 2008]

Rhinolophus (“Horseshoe Bat”)

- Natural host of SARS Coronavirus – and a number of other related coronaviruses
- Sold in live animal markets in South China



EcoHealth Alliance

The Emerging Infections Two-Step

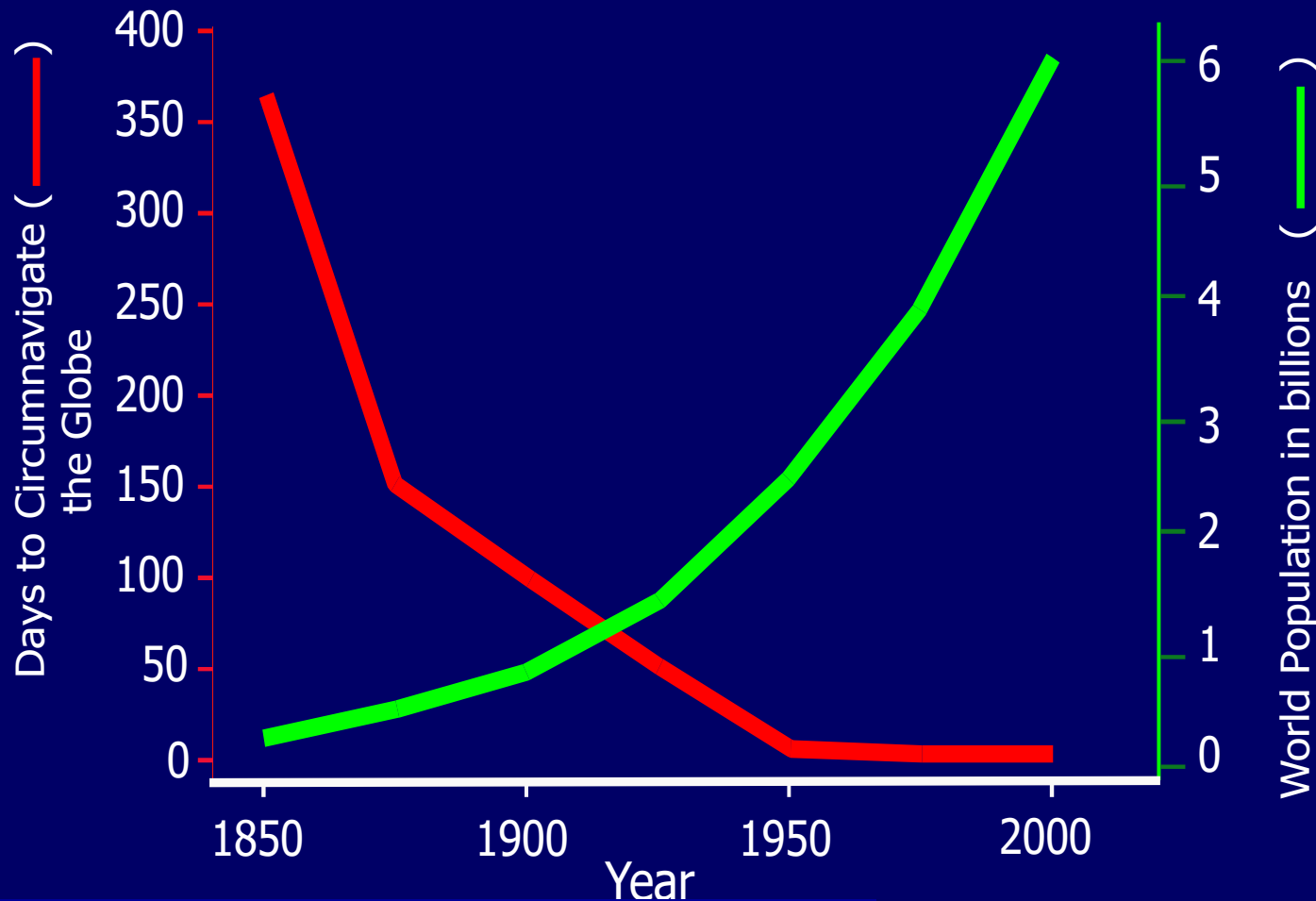
Opportunities increasing for both steps:

- Changes in land use
- Rural to urban migration
- Internal displacement
- Globalization of people and goods, travel, international migration
- Medical technologies

Step 2 (or Steps 2 & 3): Establishment & Dissemination

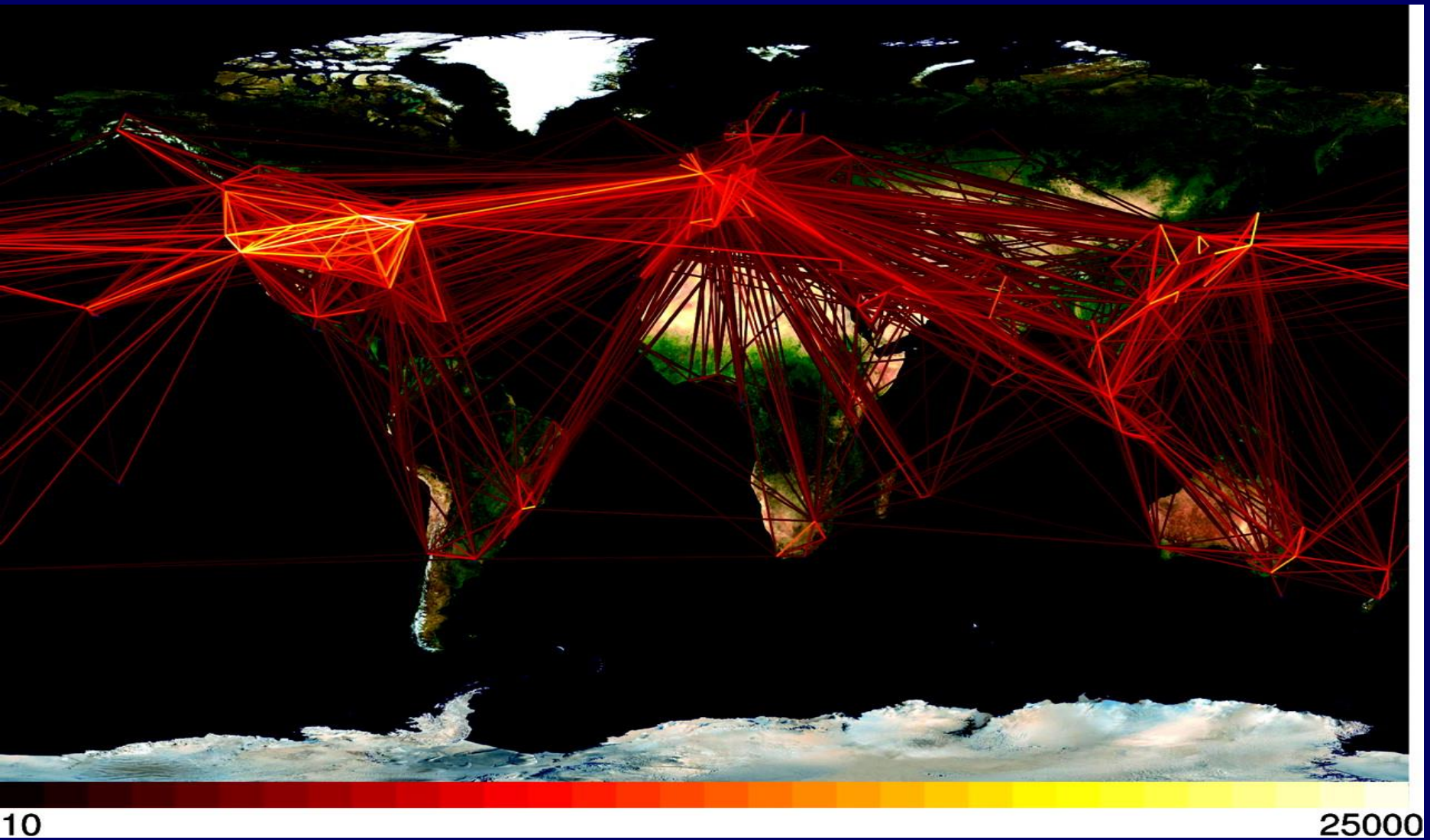
- Luckily for us, many candidates but relatively few are successful
- Human activities, including migration or travel, may disseminate a localized infection
 - Highways for “microbial traffic” to new areas
- Environmental changes may spread a natural host or vector

Speed of Global Travel in Relation to World Population Growth



Courtesy CDC. From: Murphy and Nathanson. Semin. Virol. 5, 87, 1994

Global aviation network

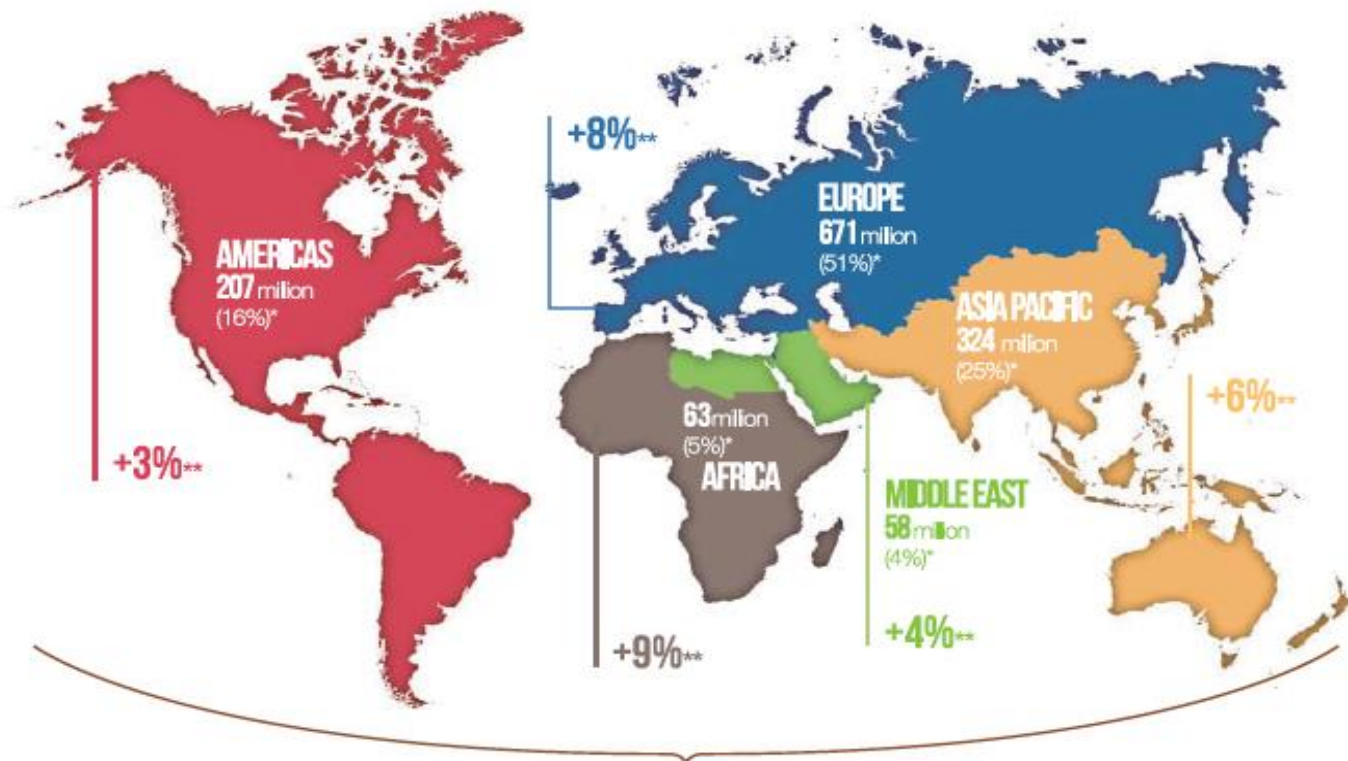


Hufnagel, L. et al. (2004) Proc. Natl. Acad. Sci. USA 101, 15124-15129

INTERNATIONAL TOURIST ARRIVALS 2017

*Share (%)

**Increase (%)



WORLD: 1,323 MILLION

Source: UN World Tourism Org. (UNWTO), 2017 Ann. Report

Transmissibility

- Essential for pathogen success
- Effects of urbanization, high density?
- Possible relation to virulence
- Genetics and evolution of transmissibility poorly understood
- Are emerging pathogens with broad host range more likely to become transmissible human-to-human ?

SARS-CoV-2/COVID-19

- This is not the first coronavirus we've seen
- But this is the first pandemic coronavirus
- This is also not the first pandemic from a respiratory virus
 - (flu: 1918, 1957, 1968, 2009)

[Home](#)[Alert and response operations](#)[Diseases](#)[Biorisk reduction](#)[Disease outbreak news](#)

Pneumonia of unknown cause – China

Disease outbreak news

5 January 2020

On 31 December 2019, the WHO China Country Office was informed of cases of pneumonia of unknown etiology (unknown cause) detected in Wuhan City, Hubei Province of China. As of 3 January 2020, a total of 44 patients with pneumonia of unknown etiology have been reported to WHO by the national authorities in China. Of the 44 cases reported, 11 are severely ill, while the remaining 33 patients are in stable condition. According to media reports, the concerned market in Wuhan was closed on 1 January 2020 for environmental sanitation and disinfection.

The causal agent has not yet been identified or confirmed. On 1 January 2020, WHO requested further information from national authorities to assess the risk.

National authorities report that all patients are isolated and receiving treatment in Wuhan medical institutions. The clinical signs and symptoms are mainly fever, with a few patients having difficulty in breathing, and chest radiographs showing invasive lesions of both lungs.

According to the authorities, some patients were operating dealers or vendors in the Huanan Seafood market. Based on the preliminary information from the Chinese investigation team, no evidence of significant human-to-human transmission and no health care worker infections have been reported.

Public Health Response

National authorities have reported the following response measures:

- One hundred and twenty-one close contacts have been identified and are under medical observation;
- The follow-up of close contacts is ongoing;
- Pathogen identification and the tracing of the cause are underway;
- Wuhan Municipal Health Commission carried out active case finding, and retrospective investigations have been completed;

WHO,
Jan. 5,
2020

Published Date: 2019-12-30 23:59:00

Subject: PRO/AH/EDR> Undiagnosed pneumonia - China (HU): RFI

Archive Number: 20191230.6864153

UNDIAGNOSED PNEUMONIA - CHINA (HUBEI): REQUEST FOR INFORMATION

A ProMED-mail post

<http://www.promedmail.org>

ProMED-mail is a program of the

International Society for Infectious Diseases

<http://www.isid.org>

[1]

Date: 30 Dec 2019

Source: Finance Sina [machine translation]

<https://finance.sina.cn/2019-12-31/detail-iihnzakh1074832.d.html?from=wap>

Wuhan unexplained pneumonia has been isolated test results will be announced [as soon as available]

On the evening of [30 Dec 2019], an "urgent notice on the treatment of pneumonia of unknown cause" was issued, which was widely distributed on the Internet by the red-headed document of the Medical Administration and Medical Administration of Wuhan Municipal Health Committee.

On the morning of [31 Dec 2019], China Business News reporter called the official hotline of Wuhan Municipal Health and Health Committee 12320 and learned that the content of the document is true.

12320 hotline staff said that what type of pneumonia of unknown cause appeared in Wuhan this time remains to be determined.

According to the above documents, according to the urgent notice from the superior, some medical institutions in Wuhan have successively appeared patients with pneumonia of unknown cause. All medical institutions should strengthen the management of outpatient and emergency departments, strictly implement the first-in-patient responsibility system, and find that patients with unknown cause of pneumonia actively adjust the power to treat them on the spot, and there should be no refusal to be pushed or pushed.

The document emphasizes that medical institutions need to strengthen multidisciplinary professional forces such as respiratory, infectious diseases, and intensive medicine in a targeted manner, open green channels, make effective connections between outpatient and emergency departments, and improve emergency plans for medical treatment.

Another piece of emergency notification, entitled "City Health and Health Commission's Report on Reporting the Treatment of Unknown Cause of Pneumonia" is also true. According to this document, according to the urgent notice from the superior, the South China Seafood Market in our city has seen patients with pneumonia of unknown cause one after another.

The so-called unexplained pneumonia cases refer to the following 4 cases of pneumonia that cannot be diagnosed at the same time: fever (greater than or equal to 38C); imaging characteristics of pneumonia or acute respiratory distress syndrome; reduced or normal white blood cells in the early stages of onset The number of lymphocytes was reduced. After treatment with antibiotics for 3 to 5 days, the condition did not improve significantly.

It is understood that the 1st patient with unexplained pneumonia that appeared in Wuhan this time came from Wuhan South China Seafood Market.

Timeline

ProMED posting: Dec. 30

-
- December 31, 2019** — Chinese Health officials inform the WHO about a cluster of 41 patients with a mysterious pneumonia. Most are connected to Huanan Seafood Wholesale Market.
 - January 1, 2020** — Huanan Seafood Wholesale Market closes.
 - January 7, 2020** — Chinese authorities identify a new type of coronavirus (called novel coronavirus or nCoV).
 - January 11, 2020** — China records its **first death**.
 - January 13, 2020** — First coronavirus case outside of China is reported in Thailand.
 - January 20, 2020** — First US case is reported: a 35-year-old man in Snohomish County, Washington.
 - January 23, 2020** — Wuhan is placed under quarantine, Hubei province follows within days.
 - January 30, 2020** — WHO declares a global public-health emergency.
 - January 31, 2020** — President Trump bans foreign nationals from entering the US if they were in China within the prior two weeks.

Mission summary: WHO Field Visit to Wuhan, China 20-21 January 2020

中文

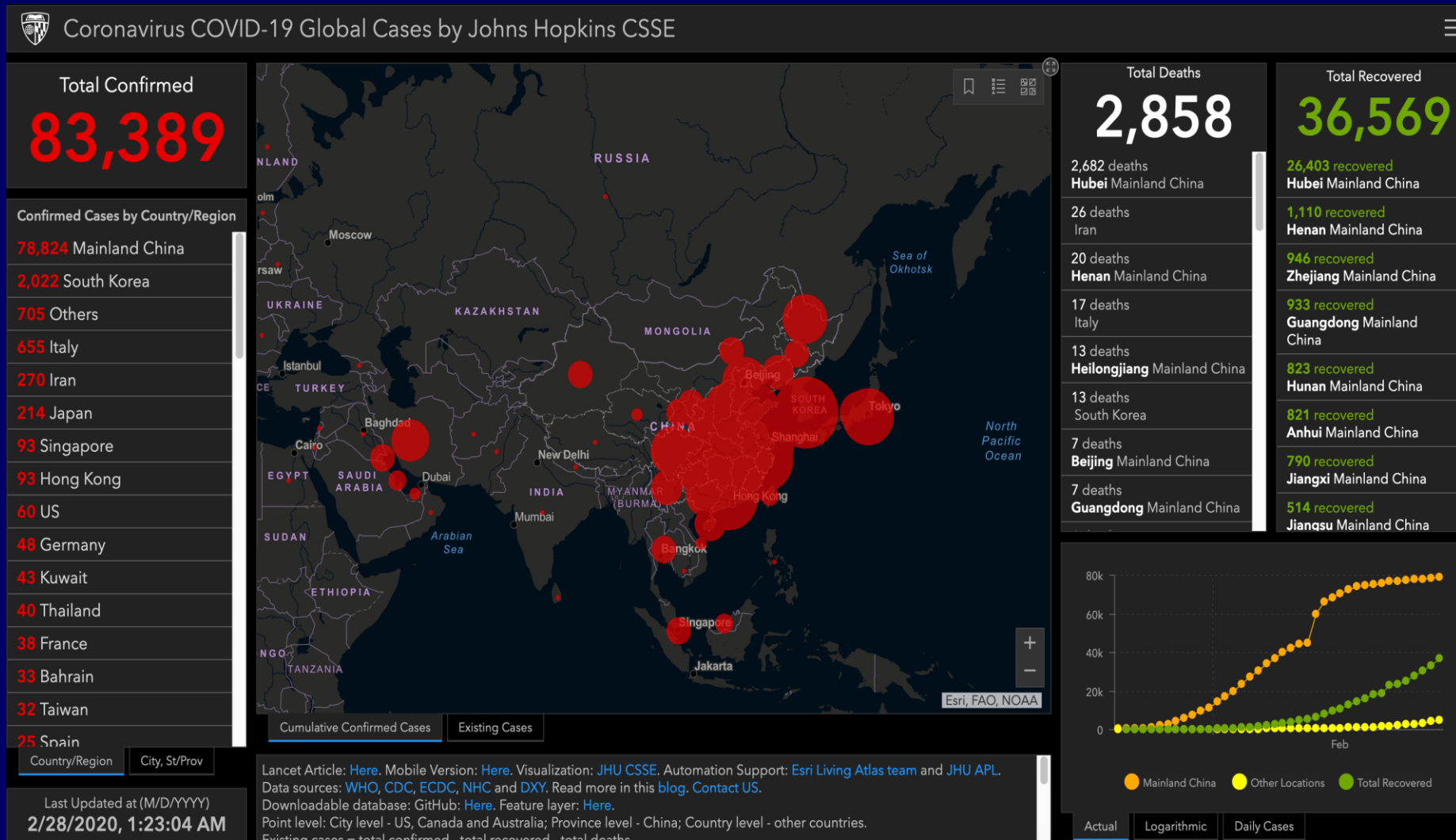
22 January 2020 | Statement

On 20-21 January 2020, a World Health Organization (WHO) delegation conducted a field visit to Wuhan to learn about the response to 2019 novel coronavirus (2019-nCoV). The mission was part of the on-going close collaboration between WHO and Chinese national, provincial, and Wuhan health authorities in responding to 2019-nCoV.

The delegation visited the Wuhan Tianhe Airport, Zhongnan hospital, Hubei provincial CDC, including the BSL3 laboratory in China's Center for Disease Control (CDC). The delegation observed and discussed active surveillance processes, temperature screening at the airport, laboratory facilities, infection prevention and control measures at the hospital and its associated fever clinics, and the deployment of the rRT-PCR test kit to detect the virus.

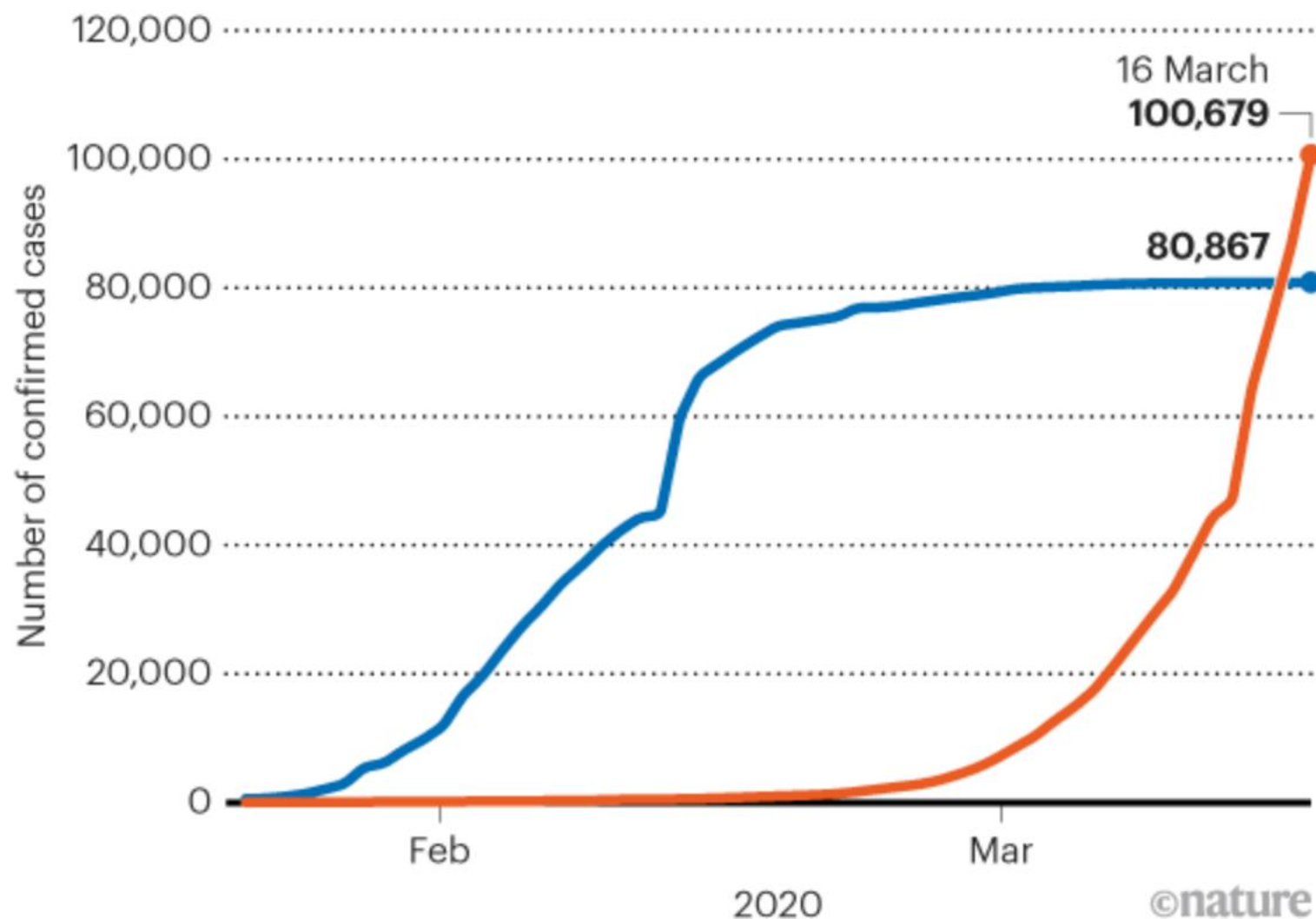
Data collected through detailed epidemiological investigation and through the deployment of the new test kit nationally suggests that human-to-human transmission is taking place in Wuhan. More analysis of the epidemiological data is needed to understand the full extent of human-to-human transmission. WHO stands ready to provide support to China to conduct further detailed analysis.

<https://gisanddata.maps.arcgis.com/apps/opsdashboard/index.html#/bda7594740fd40299423467b48e9ecf6>



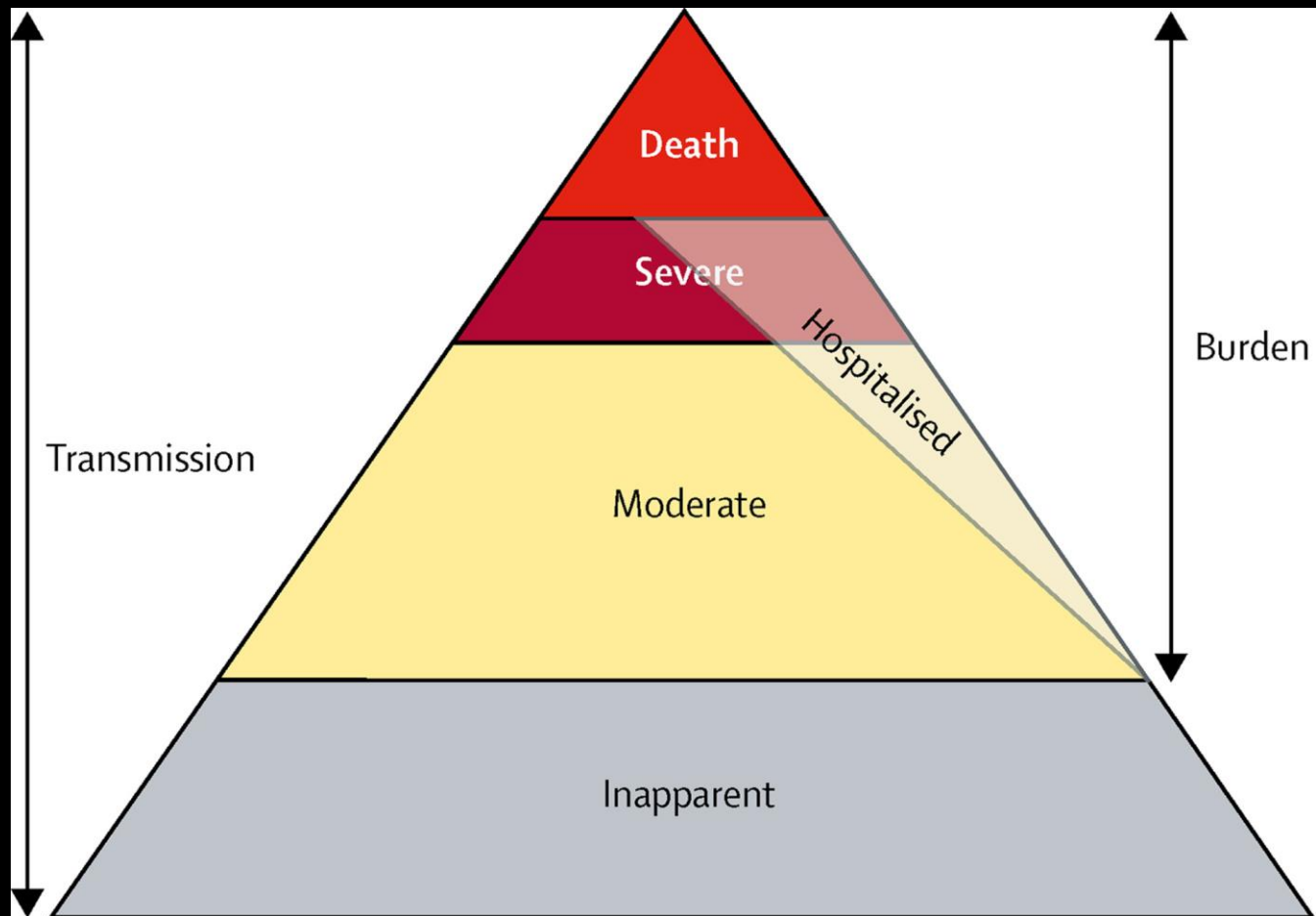
The new coronavirus has infected more than 180,000 people globally. The number of cases outside China continues to escalate.

China Other countries



Source: World Health Organization

Figure 1



International Arrivals at DFW Airport, Mar. 14, 2020



New York Times, Mar. 15, 2020



Global Cases

27,255,750

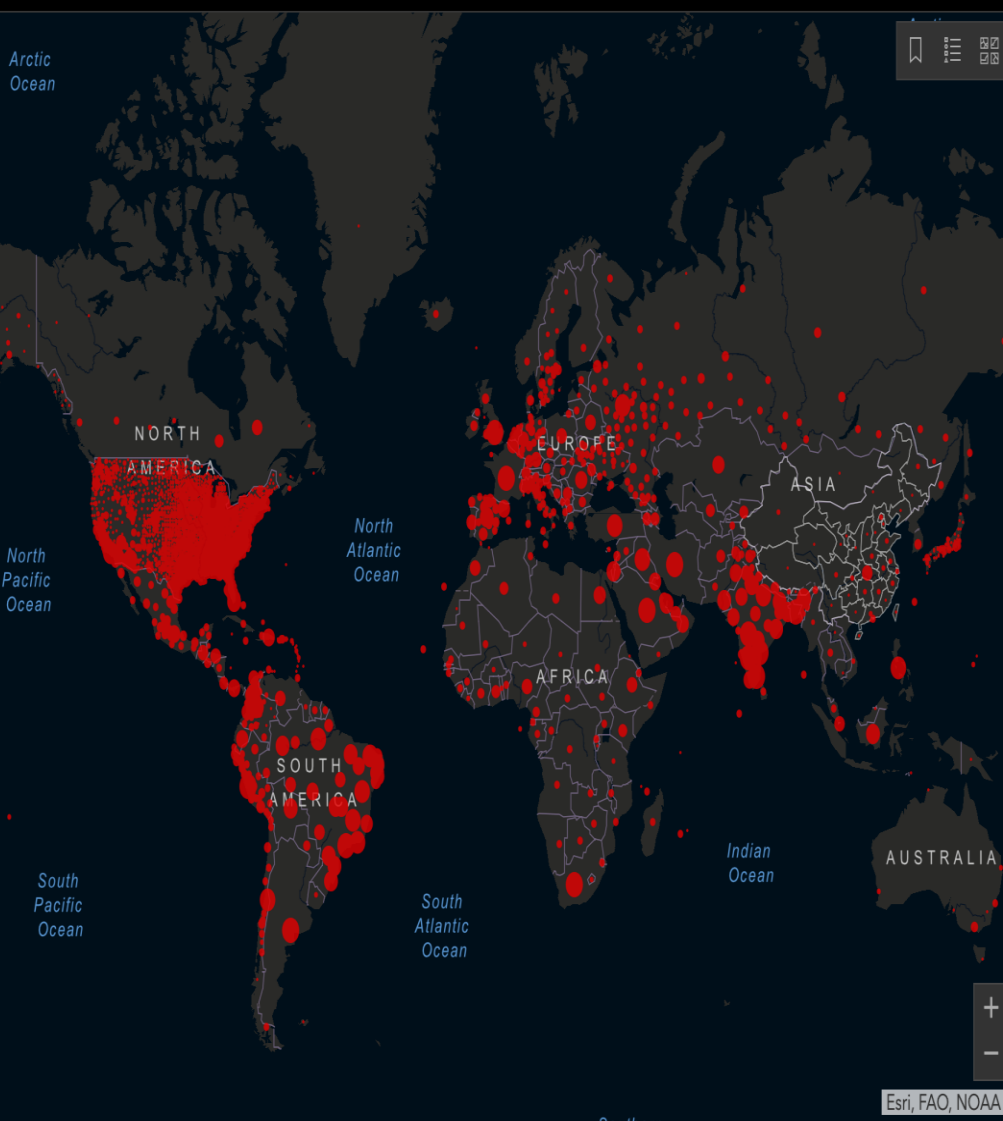
Cases by Country/Region/Sovereignty

6,300,606 US
4,204,613 India
4,147,794 Brazil
1,027,334 Russia
689,977 Peru
666,521 Colombia
639,362 South Africa
637,509 Mexico
525,549 Spain
488,007 Argentina
424,274 Chile
388,810 Iran
367,174 France
352,451 United Kingdom
327,359 Bangladesh
321,456 Saudi Arabia

Admin0 Admin1 Admin2

Last Updated at (M/D/YYYY)

9/7/2020, 11:28 PM



Cumulative Cases

Active Cases

Incidence Rate

Case-Fatality Ratio

Testing Rate

188

countries/regions

Lancet Inf Dis Article: [Here](#). Mobile Version: [Here](#). Data sources: [Full list](#). Downloadable database: [GitHub](#), [Feature Layer](#).

Lead by JHU CSSE. Technical Support: [Esri Living Atlas team](#) and [JHU APL](#). Financial Support: [JHU](#), [NSF](#), [Bloomberg Philanthropies](#) and [Stavros Niarchos Foundation](#). Resource support: [Slack](#), [Github](#) and [AWS](#). Click [here](#) to [donate](#) to the CSSE dashboard team, and other JHU COVID-19 Research Efforts. [FAQ](#). Read more in

Global Deaths

891,285

189,206 deaths
US

126,960 deaths
Brazil

71,642 deaths
India

67,781 deaths
Mexico

41,643 deaths
United Kingdom

35,553 deaths
Italy

30,732 deaths
France

29,838 deaths

Global Deaths

US State Level

Deaths, Recovered

33,002 deaths, **75,471**
recovered
New York US

15,991 deaths, **34,202**
recovered
New Jersey US

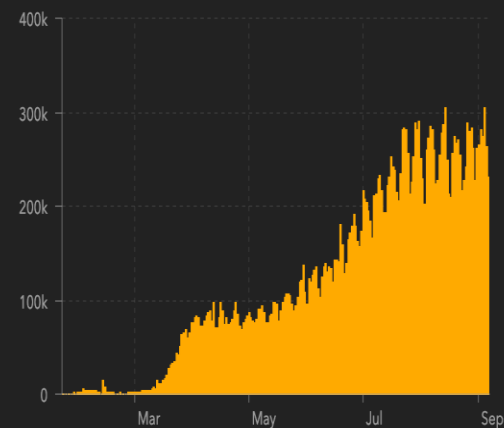
13,758 deaths, **recovered**
California US

13,697 deaths, **543,412**
recovered
Texas US

11,871 deaths, **recovered**
Florida US

9,133 deaths, **105,769**
recovered
Massachusetts US

US Deaths, Recovered



Daily Cases

METRIC

Confirmed cases



INTERVAL

7-day rolling average



Relative to Population



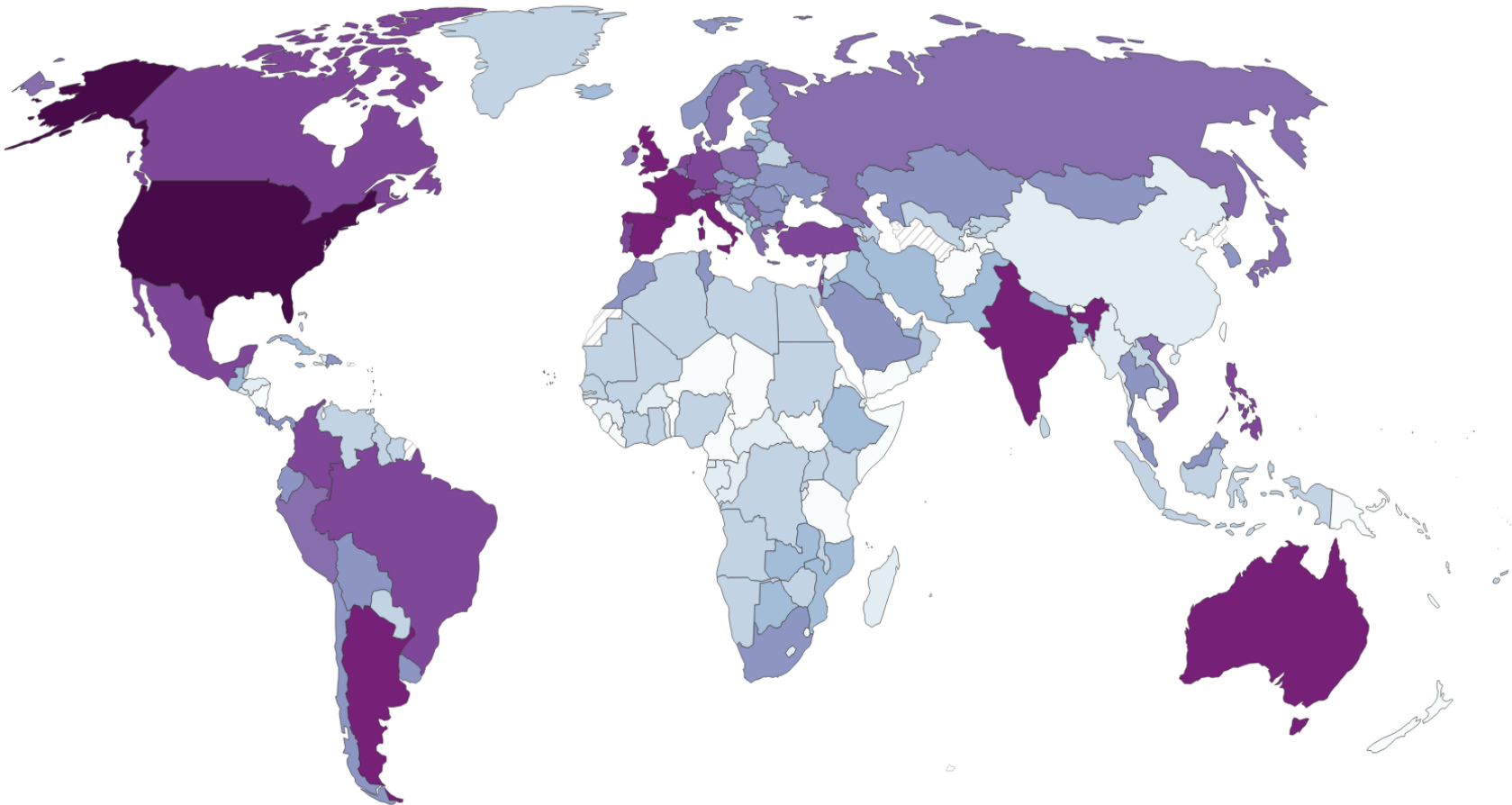
Color by test positivity

Daily new confirmed COVID-19 cases, Jan 15, 2022

7-day rolling average. Due to limited testing, the number of confirmed cases is lower than the true number of infections.



World



And then mpox (monkeypox) ...

MONKEYPOX

VISUAL EXAMPLES OF MONKEYPOX RASH



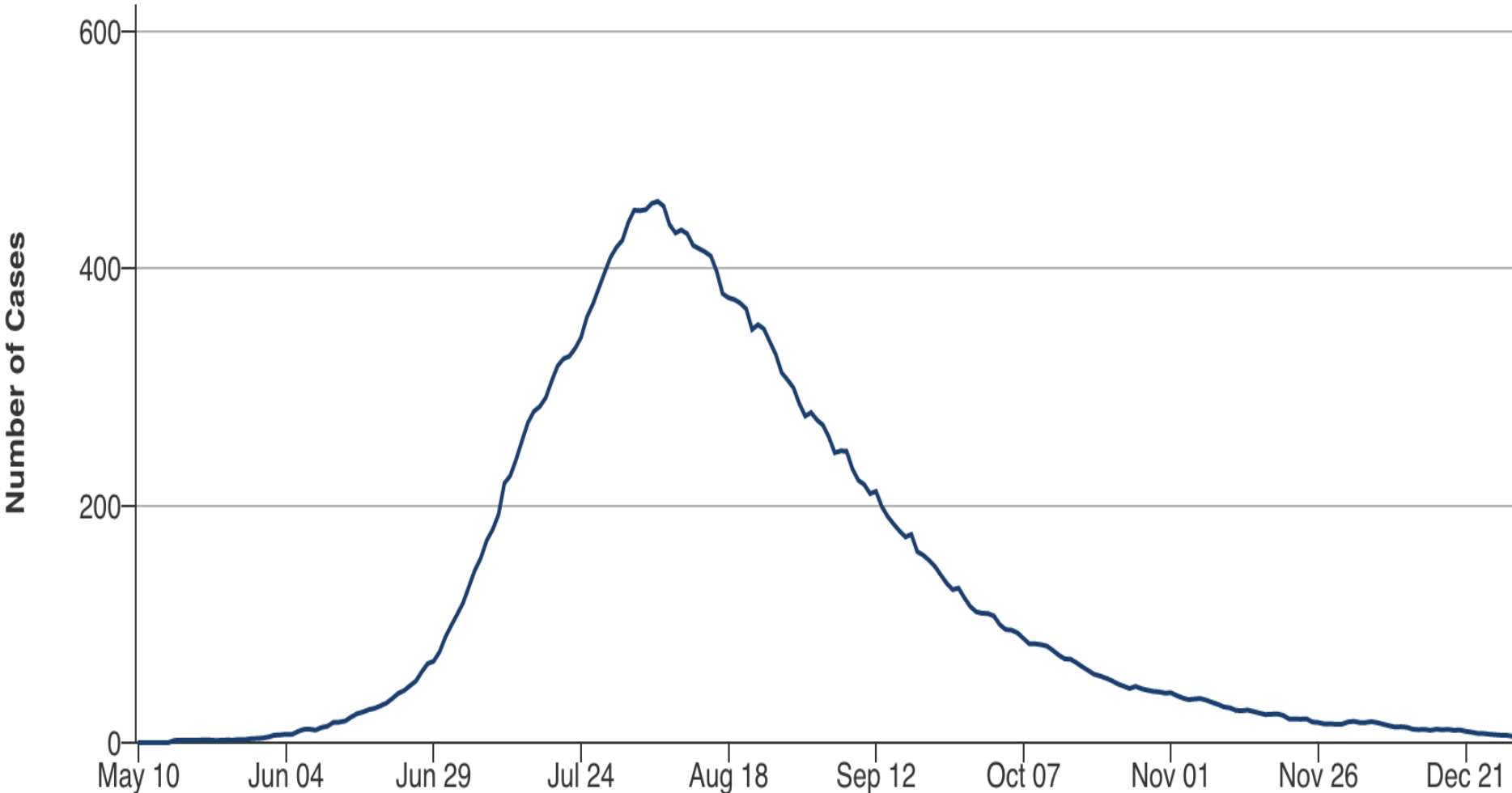
Photo Credit: NHS England High Consequence Infectious Diseases Network



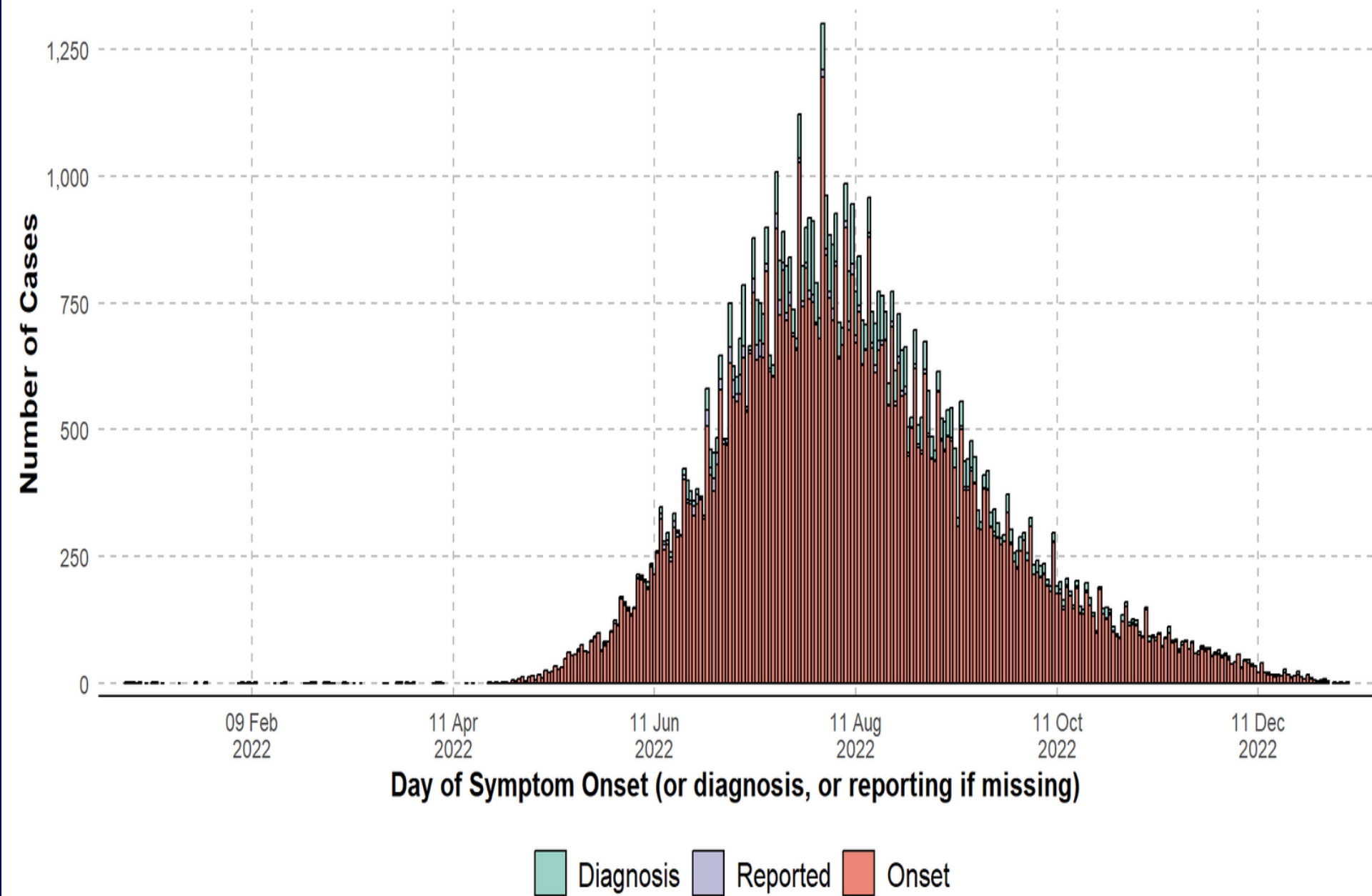
CS328947-EK

Trends of mpox cases reported to CDC during the 2022 outbreak by date*

Daily Mpox Cases and 7 Day Daily Average



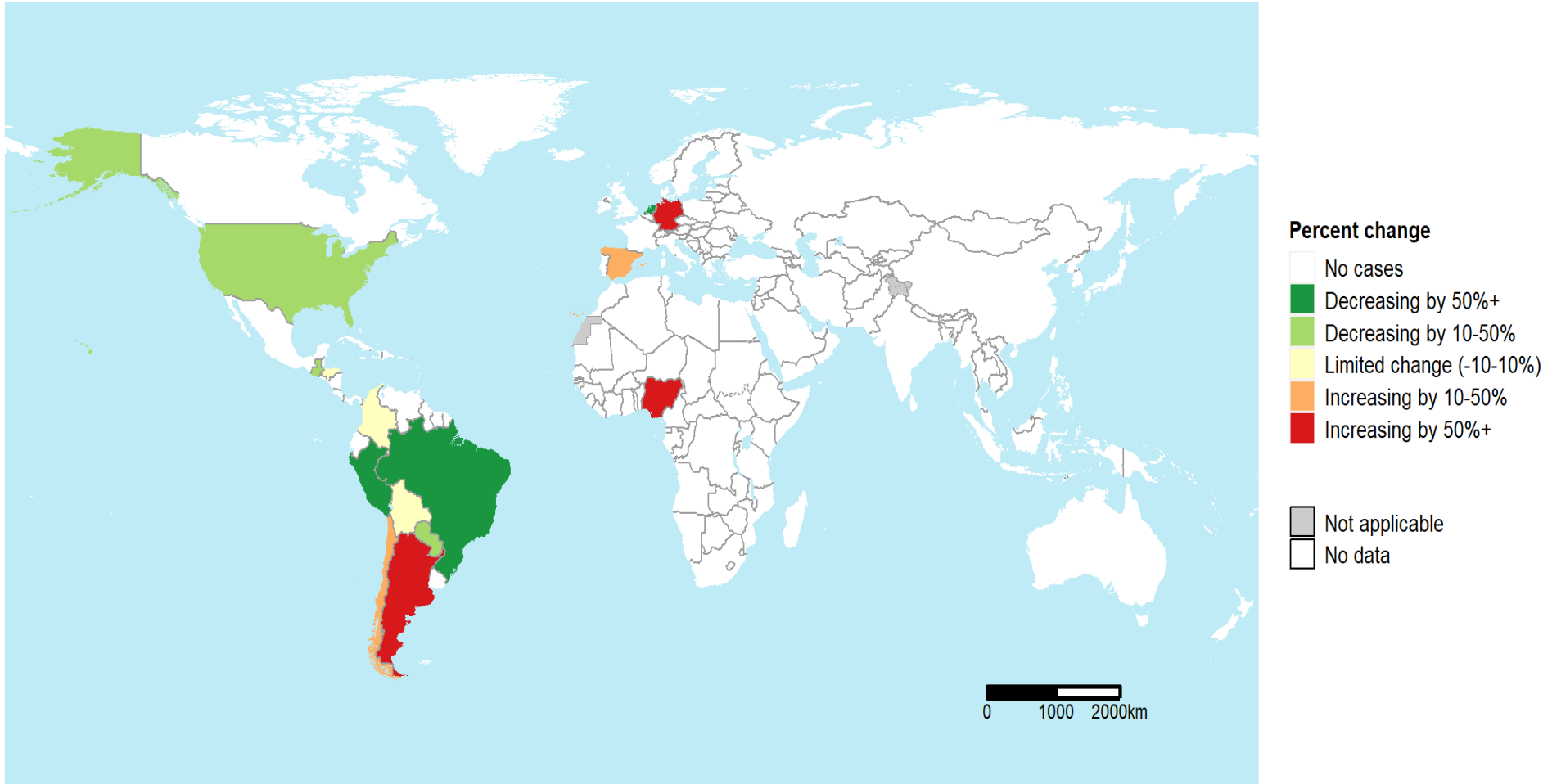
data as of January 19 2023



Source: WHO

Weekly percent change in mpox cases

from 02 Jan to 15 Jan 2023, data as of 19 Jan 23



The designations employed and the presentation of the material in this publication do not imply the expression of any opinion whatsoever on the part of WHO concerning the legal status of any country, territory, city or area or of its authorities, or concerning the delimitation of its frontiers or boundaries. Dotted and dashed lines on maps represent approximate border lines for which there may not yet be full agreement.

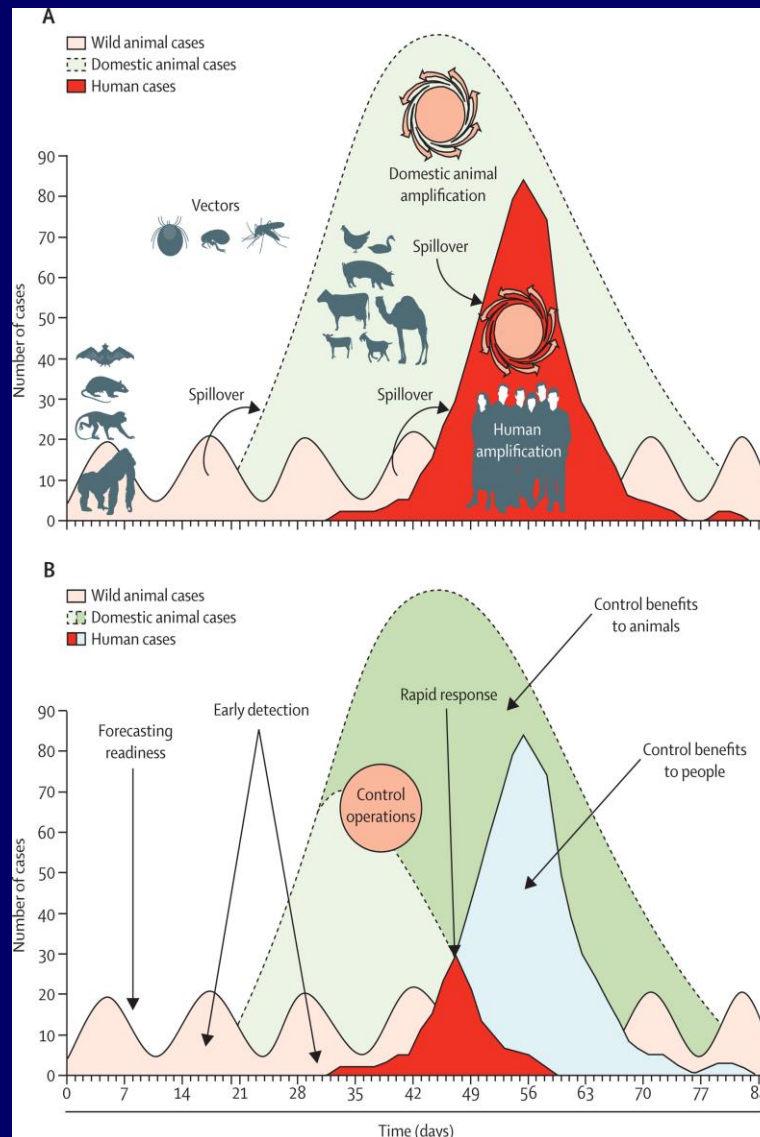
Data Source: World Health Organization
Map Production: WHO Health Emergencies Programme
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Factors (“Drivers”) in Emergence

- Ecological Changes
 - Including economic development, land use
- Human Demographics, Behavior
- International Travel and Trade
- Technology and Industry
 - Food processing
 - Health care
- Microbial Adaptation and Change
- Breakdown in Public Health Measures (“Re-Emerging Diseases”)

“People ask me to predict the future,
when all I want to do is prevent it.”
—Ray Bradbury

BENEFIT OF EARLY DETECTION



From Karesh *et al.*, Lancet 380 (9857): 1936-1945 (2012)

The Lancet 2012 3801936-1945DOI: (10.1016/S0140-6736(12)61678-X)

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ProMED-mail: A Prototype Outbreak Reporting System

ProMED-mail:
www.promedmail.org

- Moderated listserv**
- Free to all**
- Started 1994**
- Approximately 70,000 subscribers in >185 countries**

ISID IS PROUD TO BE A WINNER OF THE 2022

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ProMED-mail Português Español Русский Mekong Basin Afrique Francophone Anglophone Africa South Asia Middle East/North Africa Antimicrobial Resistance

Latest on COVID-19

Latest

Plants

Hot Topics

Errata

Latest Posts By Topic

20 Jan 2023 **Mpox update (03): worldwide, USA, DR Congo**

17 Jan 2023 **Yellow fever - Americas (01): Brazil**

12 Jan 2023 **Mpox update (02): worldwide, USA, antivirals**

12 Jan 2023 **Ebola update (01): Uganda, WHO declares outbreak over**

05 Jan 2023 **Mpox update (01): worldwide, USA**

[View printable version](#) Share this post:

Published Date: 2023-01-20 05:50:11 EST

Subject: PRO/AH/EDR> Mpox update (03): worldwide, USA, DR Congo

Archive Number: 20230120.8707842

MPOX UPDATE (03): WORLDWIDE, USA, DR CONGO

A ProMED-mail post

<http://www.promedmail.org>

ProMED-mail is a program of the
International Society for Infectious Diseases
<http://www.isid.org>

In this update:

[1] Cases around the world

[2] USA: cases by state

[3] DRC: ECHO Daily Flash

[1] Cases around the world

First Reports

- Ebola, Africa (Zaire), 1995
- Meningitis, US (multistate), UK, 1995
- VEE, Venezuela
- West Nile, 1999 –
- SARS, Feb. 10, 2003
- Avian influenza, Indonesia, Nov. 2003
- Numerous others
- About 300-500 EDR a year

ProMED ALSO HAD FIRST GLOBAL REPORTS OF SARS (AND MERS-CoV)

PNEUMONIA - CHINA (GUANGDONG): RFI

A ProMED-mail post

<<http://www.promedmail.org>>

ProMED-mail is a program of the International Society for Infectious Diseases <<http://www.isid.org>>

[1]

Date: 10 Feb 2003

From: Stephen O. Cunnion, MD, PhD, MPH <cunnion@erols.com>

This morning I received this e-mail and then searched your archives and found nothing that pertained to it. Does anyone know anything about this problem?

"Have you heard of an epidemic in Guangzhou? An acquaintance of mine from a teacher's chat room lives there and reports that the hospitals there have been closed and people are dying."

--

Stephen O. Cunnion, MD, PhD, MPH

International Consultants in Health, Inc

Member ASTM&H, ISTM

<cunnion@erols.com>

A Compliment?

"The popular ProMED-mail e-list offers a daily update on all the known disease outbreaks flaring up around the world, which surely makes it the most terrifying news source known to man."

– *Steven Johnson*

"The Ghost Map", p. 219

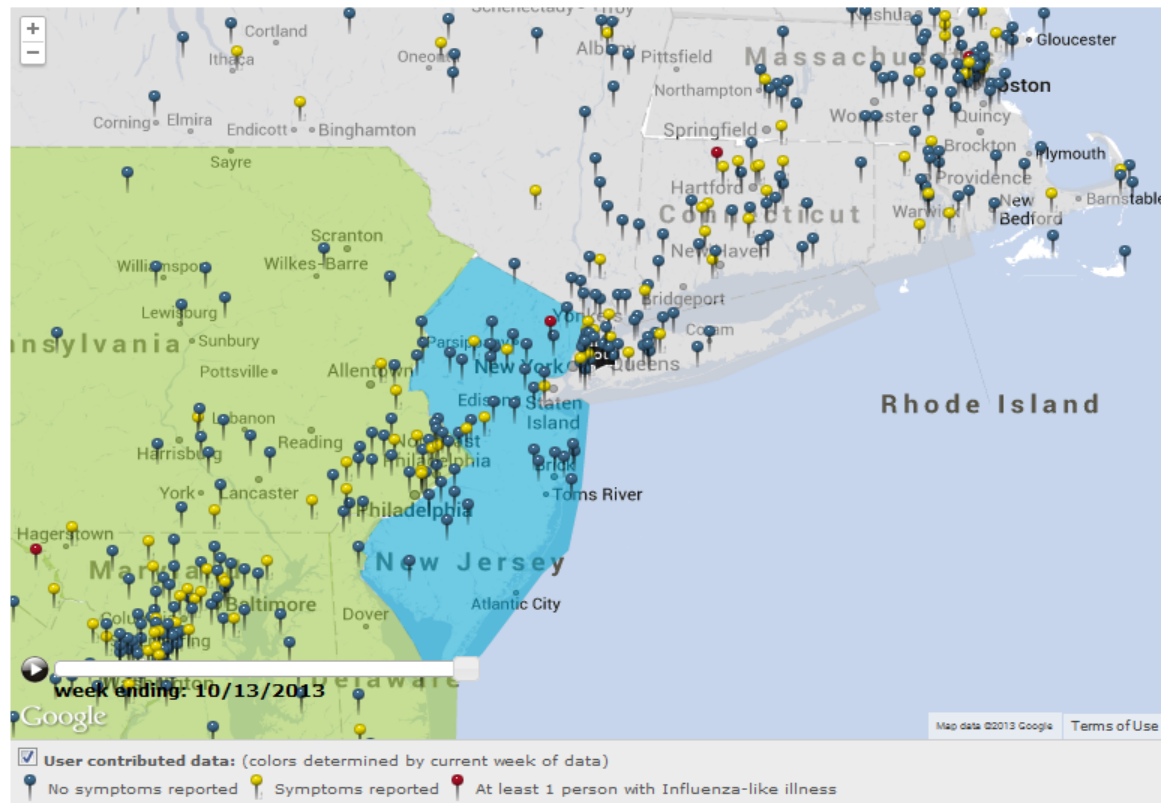
Riverhead Books/Penguin, 2006

Some Other Electronic Systems

- **GPHIN (Global Public Health Intelligence Network)**
 - Started by Canadian Government
 - Searches news sources on web
- HealthMap (partnership with ProMED-mail)
- CDC “EpiX”
- Infectious Diseases Society of America
- Clinicians Biodefense Network

Crowdsourcing Reporting and Using Social Media

- Twitter, Google, Facebook, etc. for symptom reports
- Must be used cautiously, easily misinterpreted (Zombie Apocalypse comments after zombie movie?)
- Useful: NYC DOHMH uses “Yelp” comments on restaurants



Reporting in NY

Week ending 10/13/2013

1 (0%)	Influenza-like illness
36 (18%)	Any symptoms
165 (82%)	No symptoms

Get Vaccinated

Enter your zip code below to find locations

Zip code: [Find](#)



Local Public Health Links

[New Jersey Department of Health and Senior Services](#)

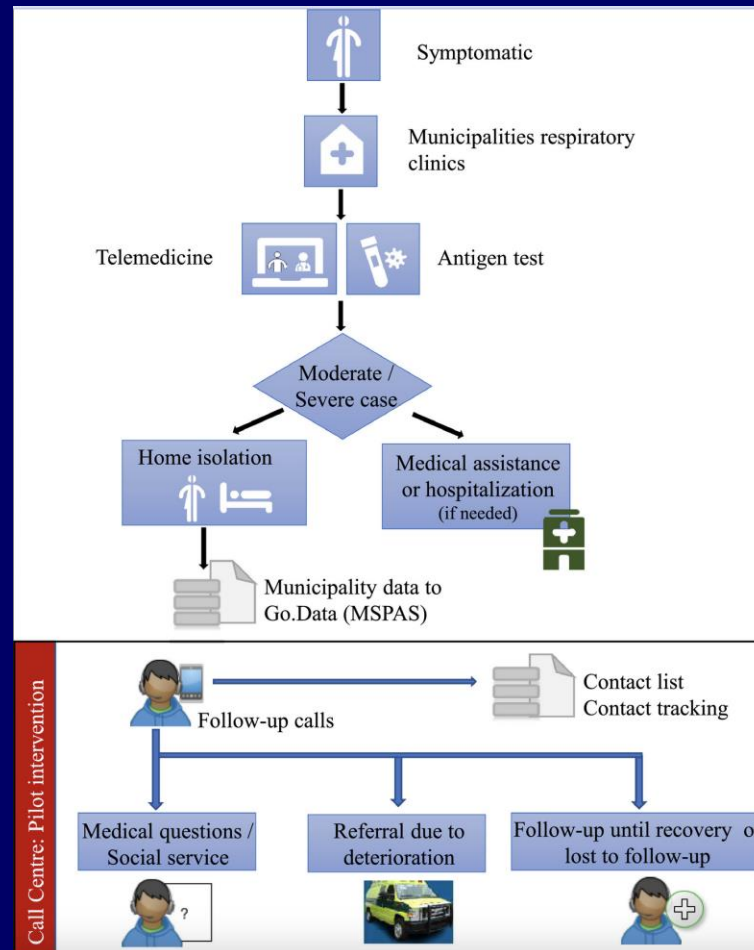
[New York State Department of Health](#)

[New York City Department of Health and Mental Hygiene](#)

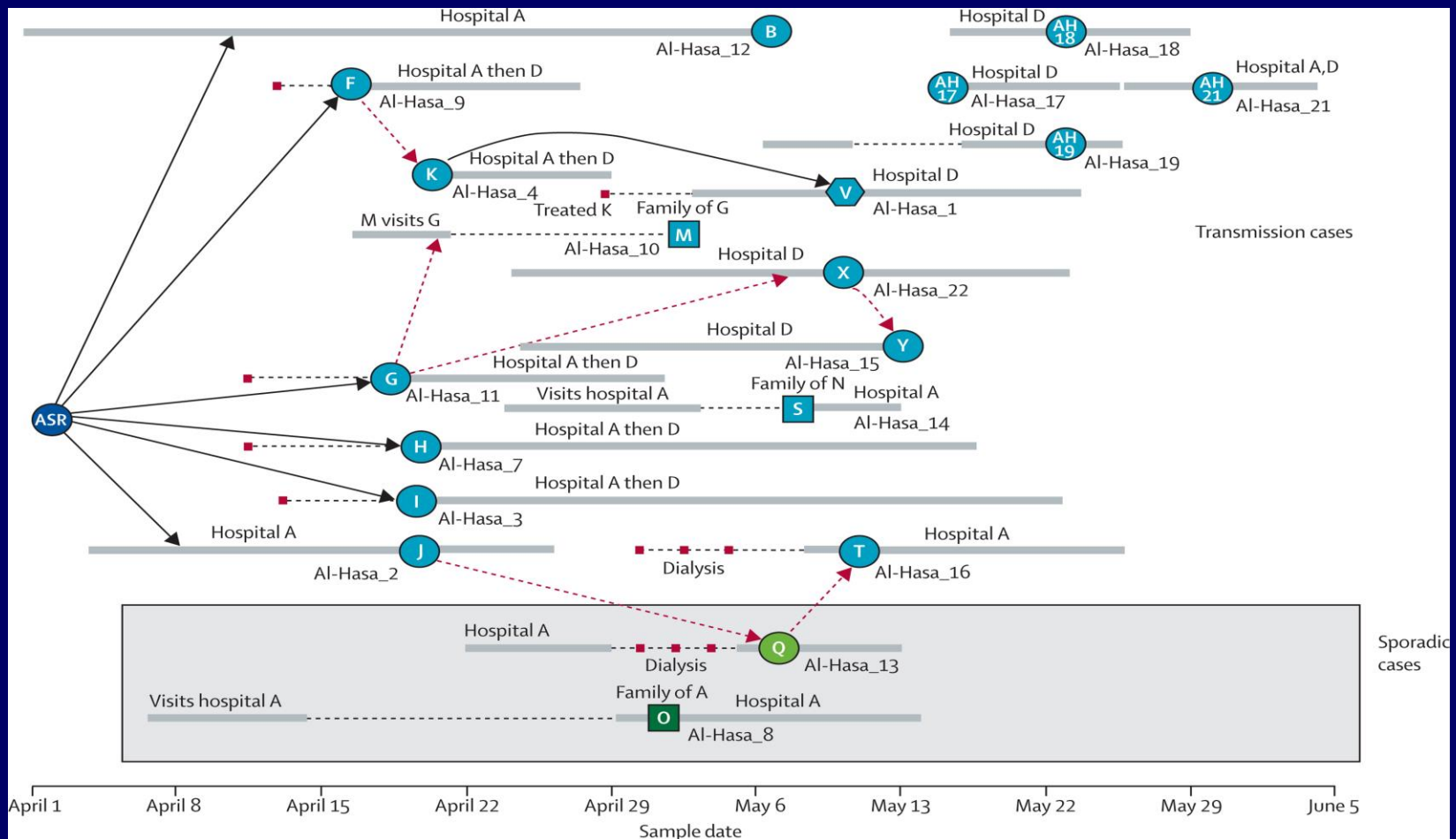
[United States Agency for Toxic Substances and Disease Registry](#)

[United States CDC Travellers' Health](#)

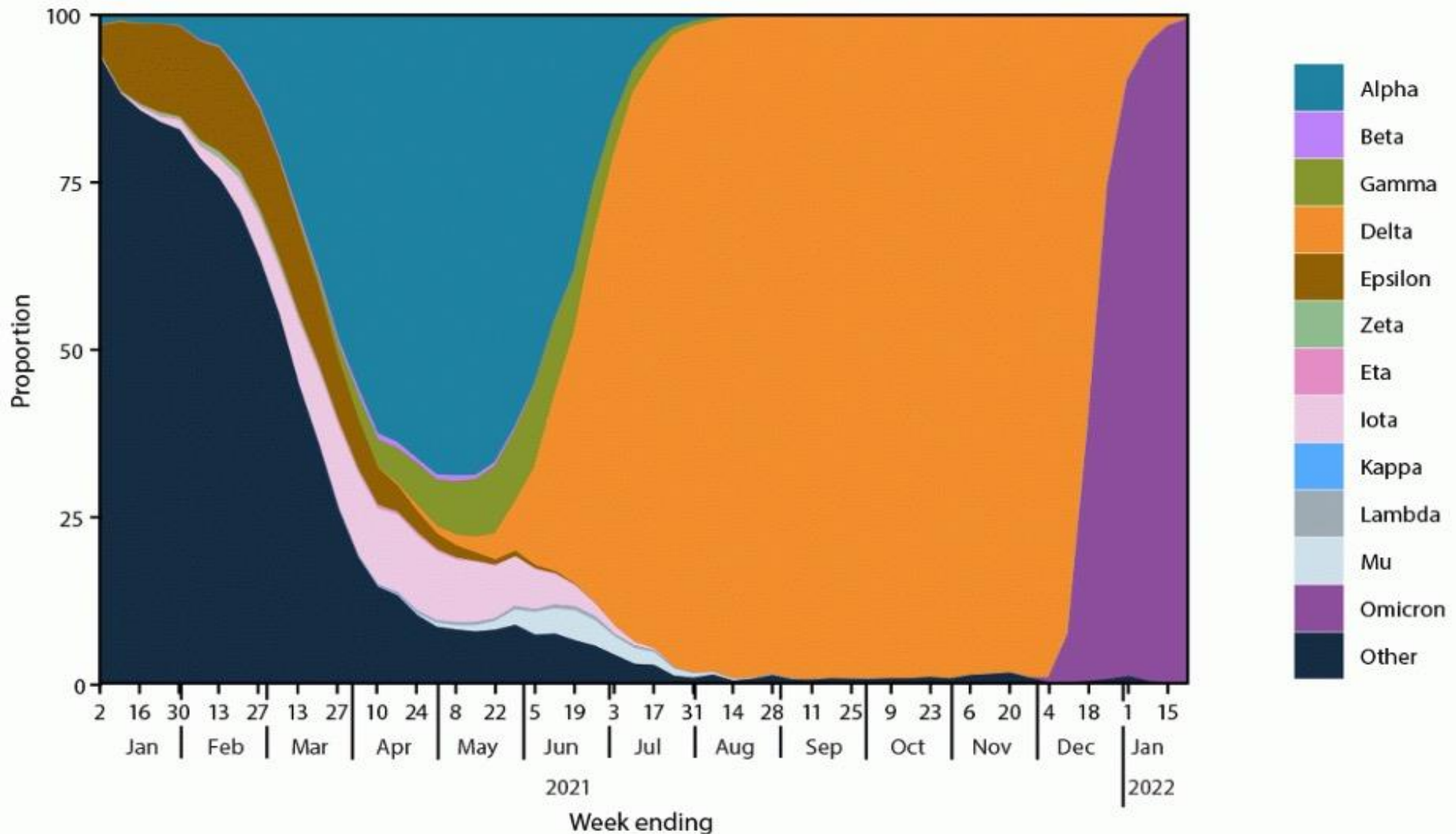
Go.Data (WHO app) for Contact Tracing



Early Example of “Genomic Epidemiology”



Genomic Surveillance for SARS-CoV-2 Variants, U.S., June 2021–January 2022



CDC. From: Lambrou et al., *MMWR*, February 11, 2022 / 71(6);206–211

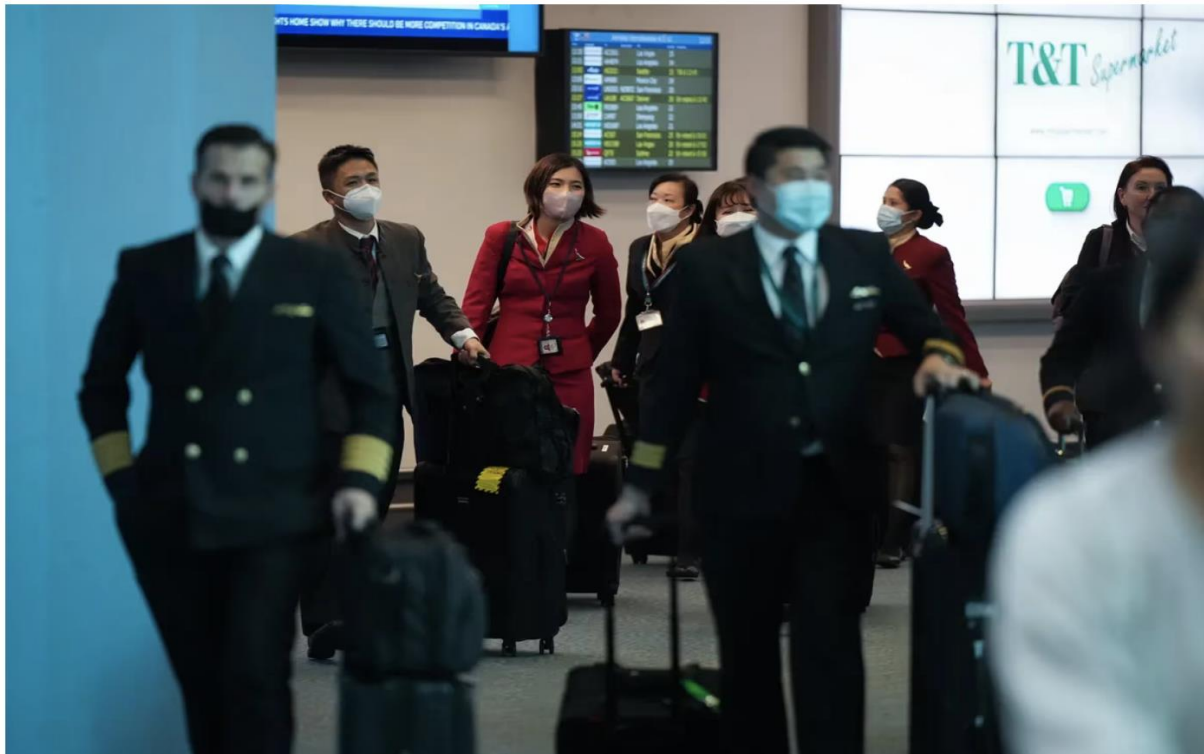
Wastewater testing to start at Vancouver, Toronto airports for flights arriving from China

MIKE HAGER >

VANCOUVER

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“Forewarned is Forearmed”?

Really?

- Surveillance for early warning is still evolving
- Also need to respond appropriately -- remains challenging
- Political will and sustainability major issues



Thank You!
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Summary of Mpox cases

As of 19 Jan 2023

	Total Cases	Total cases per 1M inhabitants	Cases in the last week ¹	Cases in the preceding week	Weekly % change in cases ¹	Days since last report	Date of first reported case
Region of the Americas							
United States of America	29,808	90	63	121	-48%	0	03 Jun 2022
Brazil	10,680	50	36	78	-54%	0	10 Jun 2022
Colombia	4,062	80	14	14	0%	0	25 Jun 2022
Peru	3,711	113	15	40	-62%	0	28 Jun 2022
Mexico	3,696	29	59	0	-	0	03 Jun 2022
Canada	1,460	39	0	0	-	0	03 Jun 2022
Chile	1,405	74	11	10	10%	0	18 Jun 2022
Argentina	1,052	23	12	7	71%	0	03 Jun 2022
Ecuador	460	26	19	0	-	0	06 Jul 2022
Guatemala	314	18	13	18	-28%	0	04 Aug 2022