

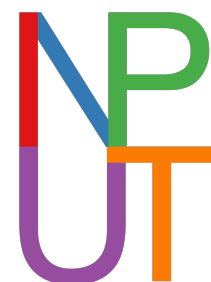


How to prepare for the next pandemic?

Swiss Public Health Conference, Bern, 26 August 2021

PD Dr. Christian L. Althaus

Interfaculty Platform for Data and Computational Science (INPUT)
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u^b

^b
**UNIVERSITÄT
BERN**

Image: Nextstrain

“It's tough to make predictions,
especially about the future.”

-Yogi Berra

Emerging (and re-emerging) infectious diseases

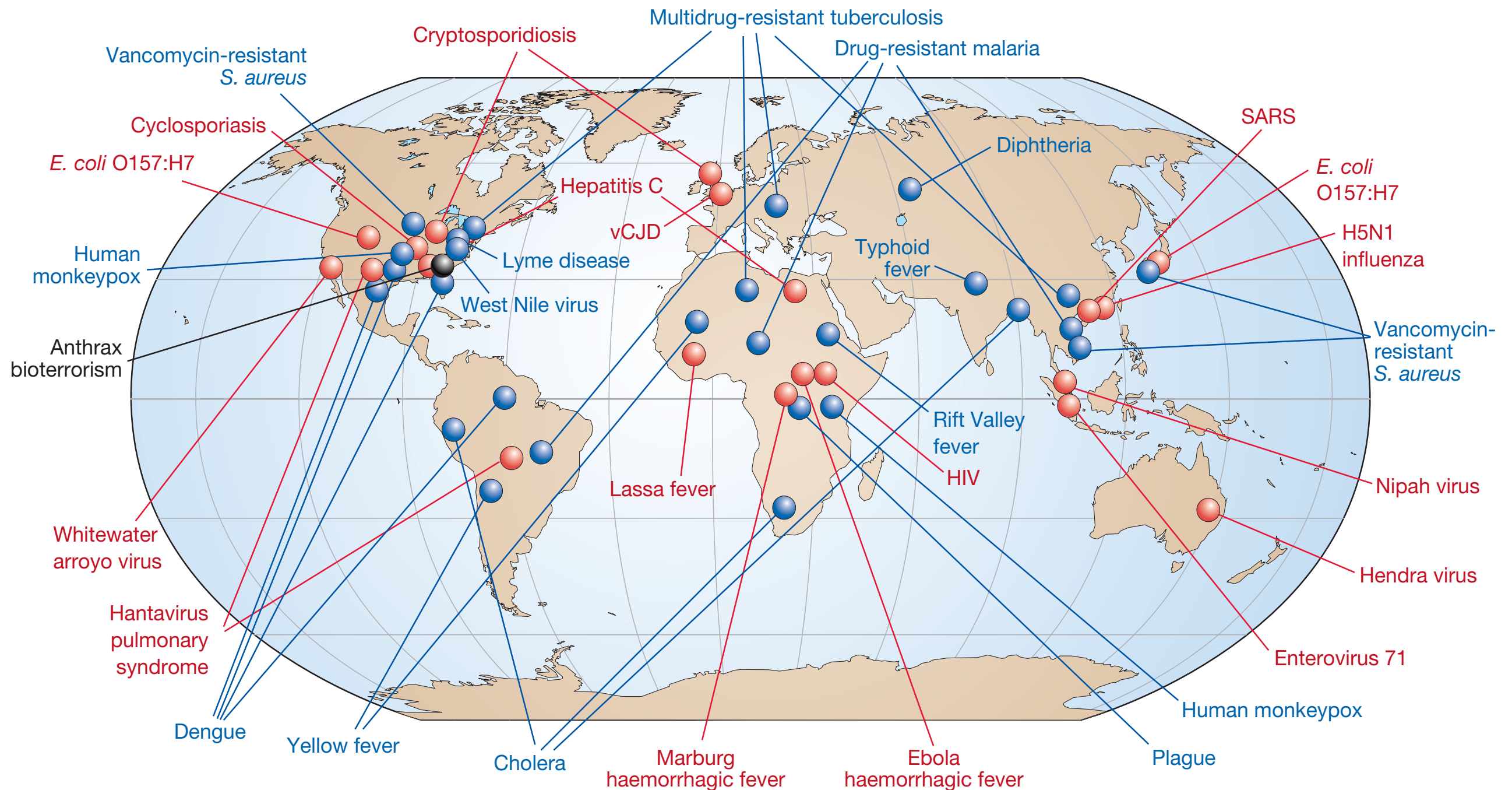


Figure: Morens et al. (2004, Nature)

LEGEND

Epidemic

Pandemic

MAJOR EPIDEMIC THREATS SINCE 2000



INTERNATIONAL COLLABORATION EFFORTS TO FIGHT EPIDEMIC THREATS

GAVI

Gavi, the Vaccine Alliance, is an international organisation that was created in 2000 to improve access to new and underused vaccines for children living in the world's poorest countries.

GOARN

The **Global Outbreak Alert and Response Network (GOARN)** is a technical collaboration of existing institutions and networks who pool human and technical resources for the rapid identification, confirmation and response to outbreaks of international importance.

IHR
(2005)

The **International Health Regulations (2005)** or IHR (2005) are an international law which helps countries work together to save lives and livelihoods caused by the international spread of diseases and other health risks. The IHR (2005) aim to prevent, protect against, control and respond to the international spread of disease while avoiding unnecessary interference with international traffic and trade.

PIP
Framework

The **Pandemic Influenza Preparedness (PIP) Framework** brings together Member States, industry, other stakeholders and WHO to implement a global approach to pandemic influenza preparedness and response. Its key goals include:

- to improve and strengthen the sharing of influenza viruses with human pandemic potential; and
- to increase the access of developing countries to vaccines and other pandemic related supplies.

R&D
Blueprint

R&D Blueprint is a global strategy and preparedness plan that allows the rapid activation of research and development activities during epidemics. Its aim is to fast-track the availability of effective tests, vaccines and medicines that can be used to save lives and avert large scale crises.

PIP
Review

IHR
Review

Access to COVID-19
Tools (ACT) Accelerator

is a global collaboration to accelerate the development, production and equitable access to new COVID-19 diagnostics, therapeutics and vaccines.

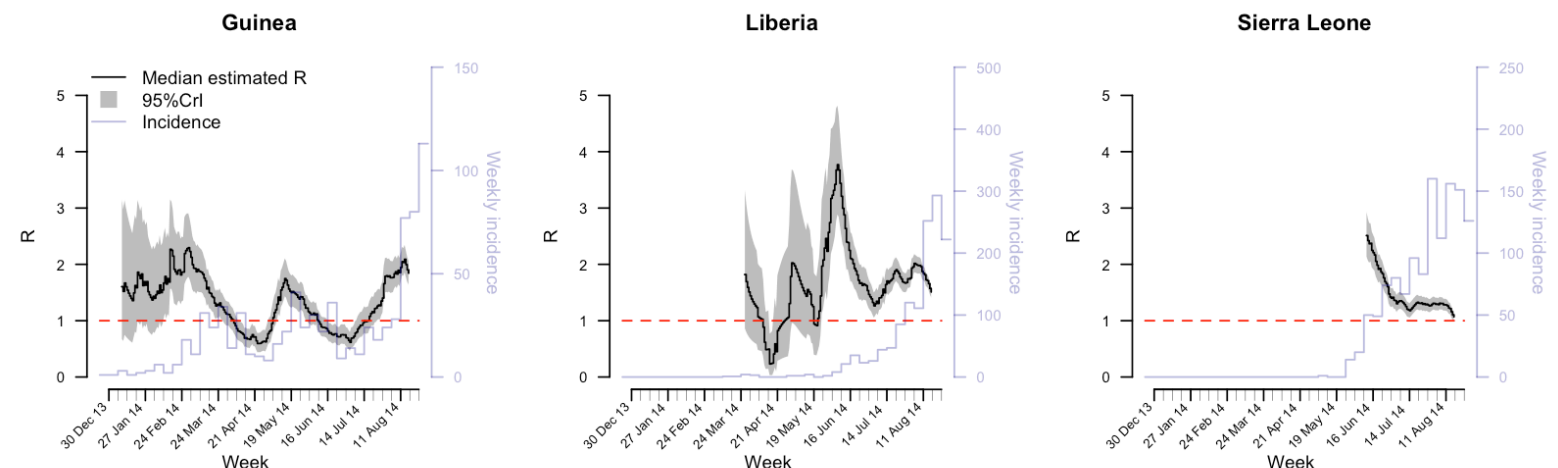
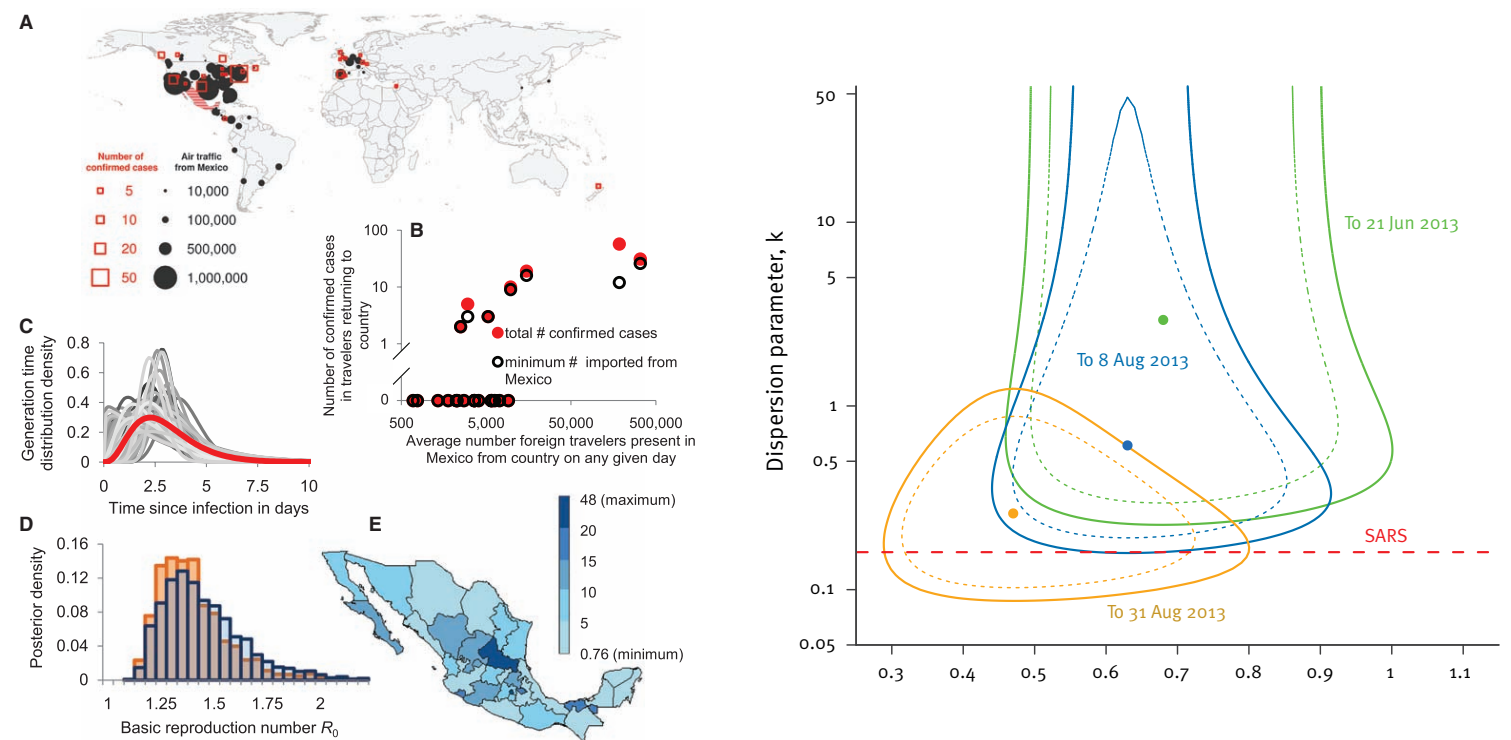
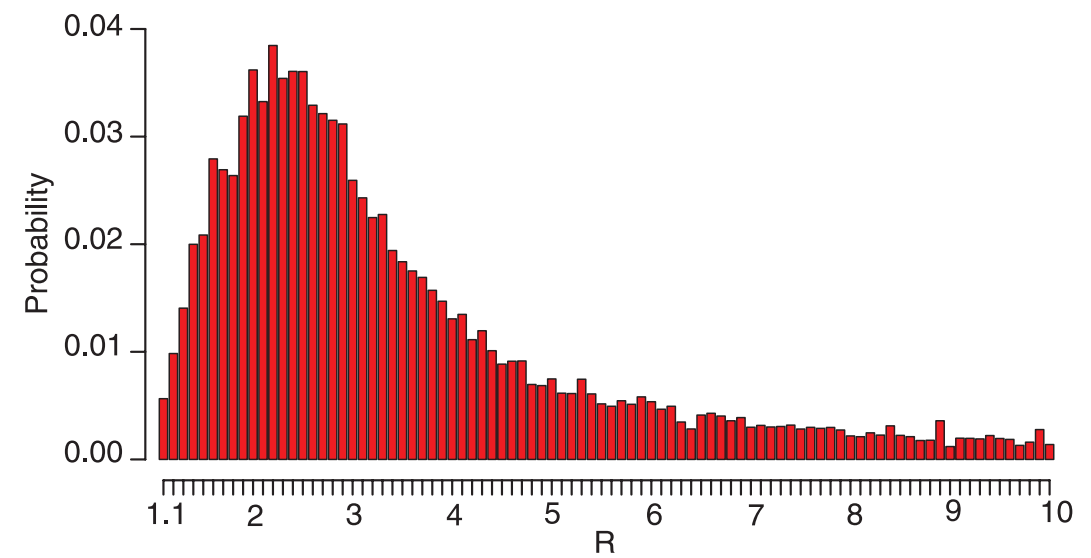
ACT
Accelerator

Timeline

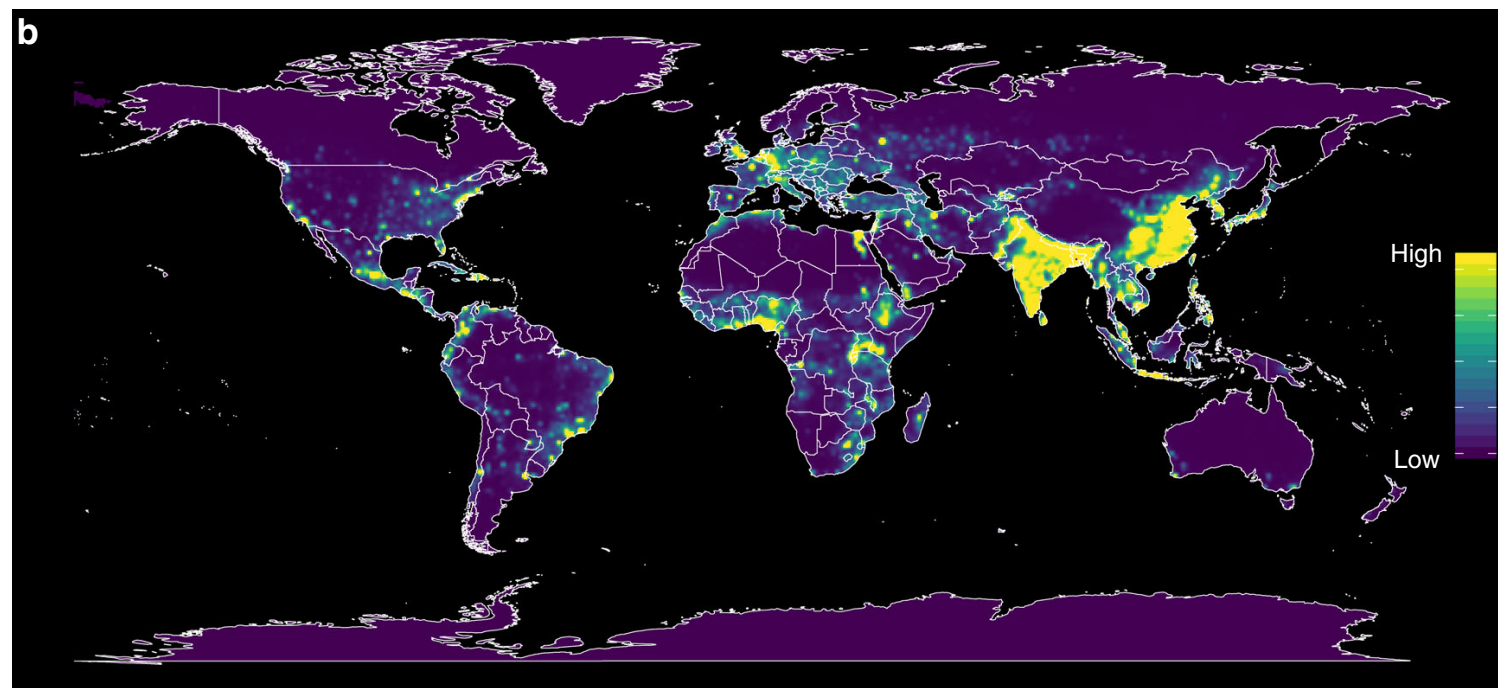
Major infectious threats in the 21st Century & collaboration mechanisms to fight against them

Outbreak analysis

- **SARS** (*Lipsitch et al., 2003, Science*)
- **H1N1** (*Fraser et al., 2009, Science*)
- **Ebola** (*WHO Ebola Response Team, 2014, N Engl J Med*)
- **MERS** (*Kucharski & Althaus, 2015, Euro Surveill*)

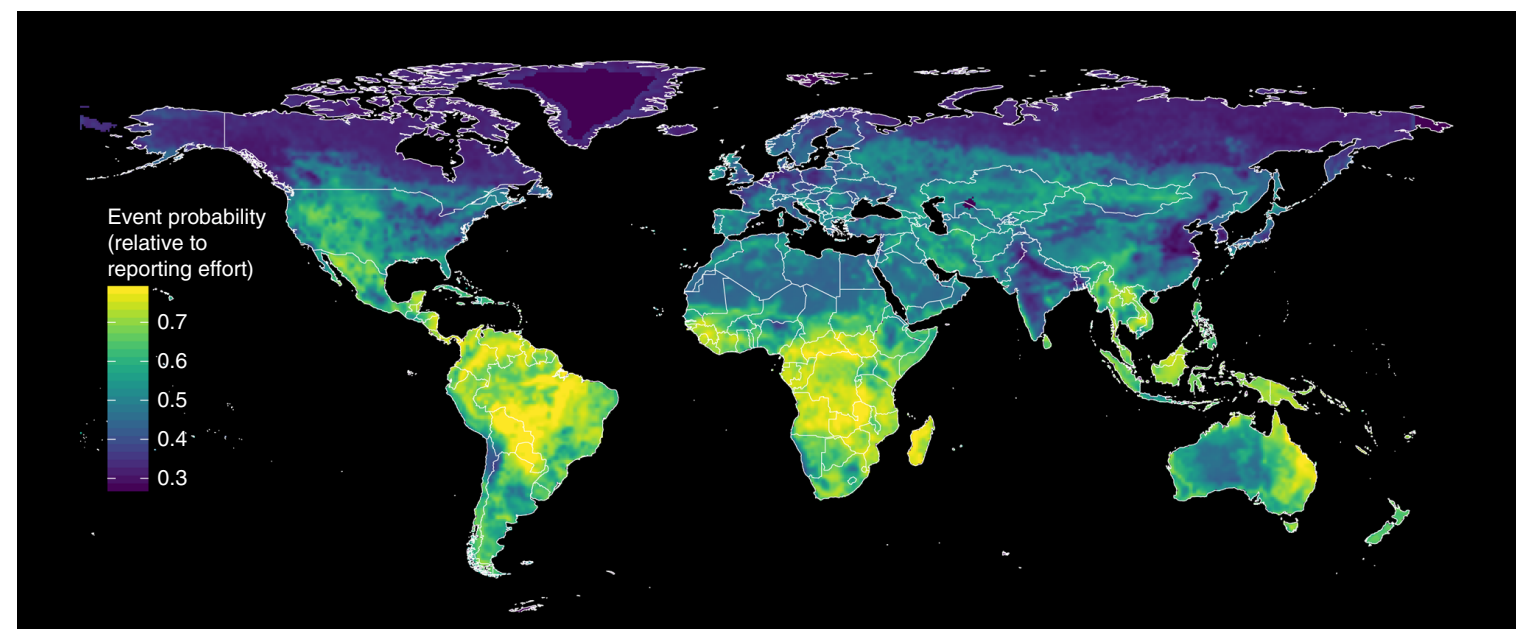


Global hotspots of emerging zoonotic diseases



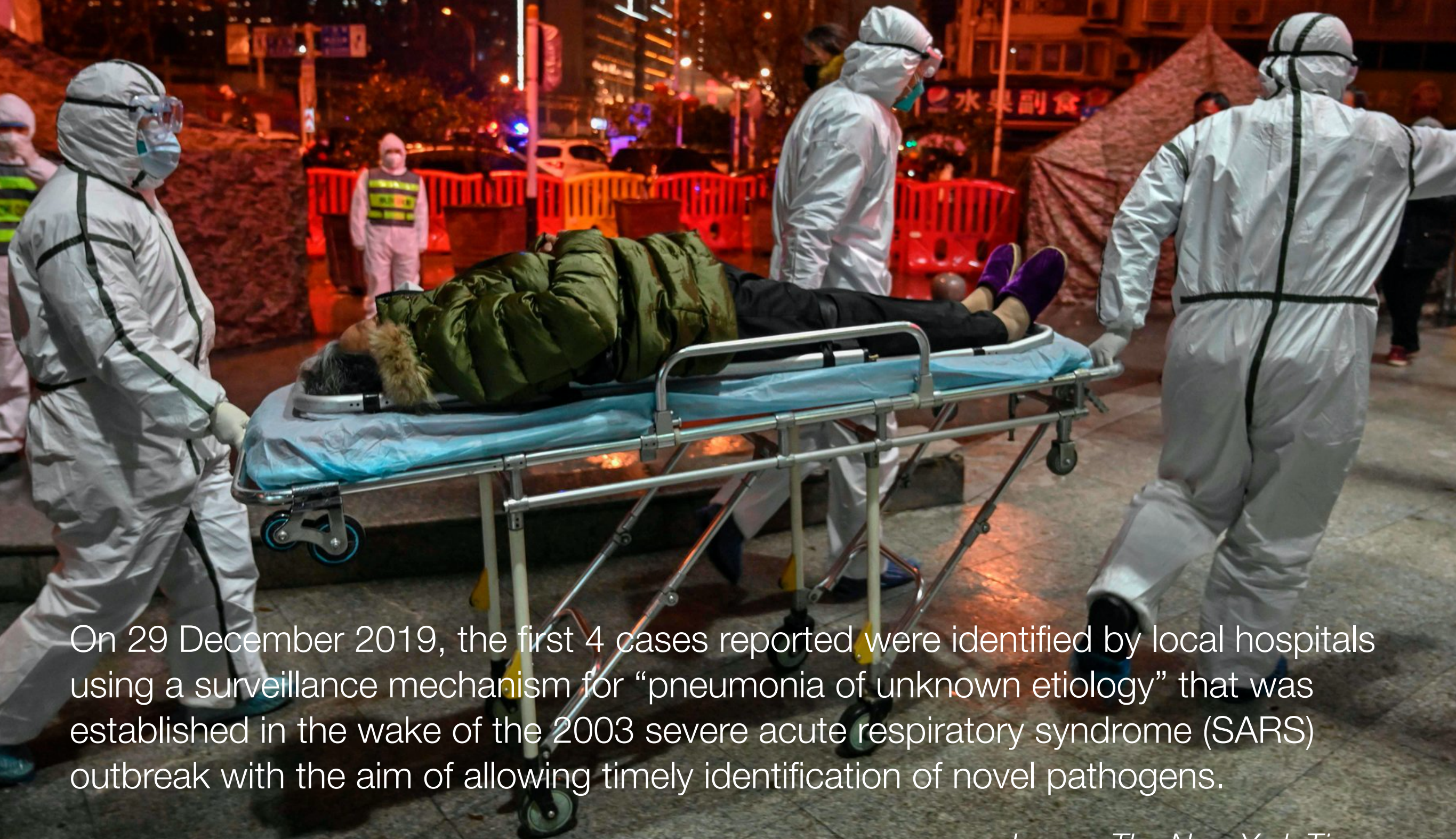
Predicted relative risk
of zoonotic EID events

EID risk relative to
reporting effort



Figures: Allen et al. (2017, Nat Commun)

Early January 2020



On 29 December 2019, the first 4 cases reported were identified by local hospitals using a surveillance mechanism for “pneumonia of unknown etiology” that was established in the wake of the 2003 severe acute respiratory syndrome (SARS) outbreak with the aim of allowing timely identification of novel pathogens.

Image: The New York Times

Key questions for early outbreak response



1. What are the transmission characteristics (R_0 and superspreading)?
2. What is the severity of the disease (infection fatality ratio)?

Image: <https://plug-in-digital.itch.io/pandemicio>

Early publications on SARS-CoV-2 transmission

29 January 2020

30 January 2020

31 January 2020

ORIGINAL ARTICLE

Early Transmission Dynamics in Wuhan, China, of Novel Coronavirus–Infected Pneumonia

Qun Li, M.Med., Xuhua Guan, Ph.D., Peng Wu, Ph.D., Xiaoye Wang, M.P.H., Lei Zhou, M.Med., Yeqing Tong, Ph.D., Ruiqi Ren, M.Med., Kathy S.M. Leung, Ph.D., Eric H.Y. Lau, Ph.D., Jessica Y. Wong, Ph.D., Xuesen Xing, Ph.D., Nijuan Xiang, M.Med., Yang Wu, M.Sc., Chao Li, M.P.H., Qi Chen, M.Sc., Dan Li, M.P.H., Tian Liu, B.Med., Jing Zhao, M.Sc., Man Liu, M.Sc., Wenxiao Tu, M.Med., Chuding Chen, M.Sc., Lianmei Jin, M.Med., Rui Yang, M.Med., Qi Wang, M.P.H., Suhua Zhou, M.Med., Rui Wang, M.D., Hui Liu, M.Med., Yingbo Luo, M.Sc., Yuan Liu, M.Med., Ge Shao, B.Med., Huan Li, M.P.H., Zhongfa Tao, M.P.H., Yang Yang, M.Med., Zhiqiang Deng, M.Med., Boxi Liu, M.P.H., Zhitao Ma, M.Med., Yanping Zhang, M.Med., Guoqing Shi, M.P.H., Tommy T.Y. Lam, Ph.D., Joseph T. Wu, Ph.D., George F. Gao, D.Phil., Benjamin J. Cowling, Ph.D., Bo Yang, M.Sc., Gabriel M. Leung, M.D., and Zijian Feng, M.Med.

ABSTRACT

BACKGROUND The initial cases of novel coronavirus (2019-nCoV)–infected pneumonia (NCIP) occurred in Wuhan, Hubei Province, China, in December 2019 and January 2020. We analyzed data on the first 425 confirmed cases in Wuhan to determine the epidemiologic characteristics of NCIP.

METHODS We collected information on demographic characteristics, exposure history, and illness timelines of laboratory-confirmed cases of NCIP that had been reported by January 22, 2020. We described characteristics of the cases and estimated the key epidemiologic time-delay distributions. In the early period of exponential growth, we estimated the epidemic doubling time and the basic reproductive number.

RESULTS Among the first 425 patients with confirmed NCIP, the median age was 59 years and 56% were male. The majority of cases (55%) with onset before January 1, 2020, were linked to the Huanan Seafood Wholesale Market, as compared with 8.6% of the subsequent cases. The mean incubation period was 5.2 days (95% confidence interval [CI], 4.1 to 7.0), with the 95th percentile of the distribution at 12.5 days. In its early stages, the epidemic doubled in size every 7.4 days. With a mean serial interval of 7.5 days (95% CI, 5.3 to 19), the basic reproductive number was estimated to be 2.2 (95% CI, 1.4 to 3.9).

CONCLUSIONS On the basis of this information, there is evidence that human-to-human transmission has occurred among close contacts since the middle of December 2019. Considerable efforts to reduce transmission will be required to control outbreaks if similar dynamics apply elsewhere. Measures to prevent or reduce transmission should be implemented in populations at risk. (Funded by the Ministry of Science and Technology of China and others.)

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RAPID COMMUNICATION

Pattern of early human-to-human transmission of Wuhan 2019 novel coronavirus (2019-nCoV), December 2019 to January 2020

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Citation style for this article:
Riou Julien, Althaus Christian L. . Pattern of early human-to-human transmission of Wuhan 2019 novel coronavirus (2019-nCoV), December 2019 to January 2020. Euro Surveill. 2020;25(4):pii=2000058. https://doi.org/10.2807/1560-7917.ES.2020.25.4.2000058

Article submitted on 24 Jan 2020 / accepted on 30 Jan 2020 / published on 30 Jan 2020

Since December 2019, China has been experiencing a large outbreak of a novel coronavirus (2019-nCoV) which can cause respiratory disease and severe pneumonia. We estimated the basic reproduction number R_0 of 2019-nCoV to be around 2.2 (90% high density interval: 1.4–3.8), indicating the potential for sustained human-to-human transmission. Transmission characteristics appear to be of similar magnitude to severe acute respiratory syndrome-related coronavirus (SARS-CoV) and pandemic influenza, indicating a risk of global spread.

On 31 December 2019, the World Health Organization (WHO) was alerted about a cluster of pneumonia of unknown aetiology in the city of Wuhan, China [1,2]. Only a few days later, Chinese authorities identified and characterised a novel coronavirus (2019-nCoV) as the causative agent of the outbreak [3]. The outbreak appears to have started from a single or multiple zoonotic transmission events at a wet market in Wuhan where game animals and meat were sold [4] and has resulted in 5,997 confirmed cases in China and 68 confirmed cases in several other countries by 29 January 2020 [5]. Based on the number of exported cases identified in other countries, the actual size of the epidemic in Wuhan has been estimated to be much larger [6]. At this early stage of the outbreak, it is important to gain understanding of the transmission pattern and the potential for sustained human-to-human transmission of 2019-nCoV. Information on the transmission characteristics will help coordinate current screening and containment strategies, support decision making on whether the outbreak constitutes a public health emergency of international concern (PHEIC), and is key for anticipating the risk of pandemic spread of 2019-nCoV. In order to better understand the early transmission pattern of 2019-nCoV, we performed stochastic simulations of early outbreak trajectories that are consistent with the epidemiological findings to date.

Epidemic parameters

Two key properties will determine further spread of 2019-nCoV. Firstly, the basic reproduction number R_0 describes the average number of secondary cases generated by an infectious index case in a fully susceptible population, as was the case during the early phase of the outbreak. If R_0 is above the critical threshold of 1, continuous human-to-human transmission with sustained transmission chains will occur. Secondly, the individual variation in the number of secondary cases provides further information about the expected outbreak dynamics and the potential for superspreading events [7–9]. If the dispersion of the number of secondary cases is high, a small number of cases may be responsible for a disproportionate number of secondary cases, while a large number of cases will not transmit the pathogen at all. While superspreading always remain a rare event, it can result in a large and explosive transmission event and have a lot of impact on the course of an epidemic. Conversely, low dispersion would lead to a steadier growth of the epidemic, with more homogeneity in the number of secondary cases per index case. This has important implications for control efforts.

Simulating early outbreak trajectories

In a first step, we initialised simulations with one index case. For each primary case, we generated secondary cases according to a negative-binomial offspring distribution with mean R_0 and dispersion k [7,8]. The dispersion parameter k quantifies the variability in the number of secondary cases, and can be interpreted as a measure of the impact of superspreading events (the lower the value of k , the higher the impact of superspreading). The generation time interval D was assumed to be gamma-distributed with a shape parameter of 2, and a mean that varied between 7 and 14 days. We explored a wide range of parameter combinations (Table) and ran 1,000 stochastic simulations for each individual combination. This corresponds to

Articles

Nowcasting and forecasting the potential domestic and international spread of the 2019-nCoV outbreak originating in Wuhan, China: a modelling study

Joseph T Wu*, Kathy Leung*, Gabriel M Leung

Summary
Background Since Dec 31, 2019, the Chinese city of Wuhan has reported an outbreak of atypical pneumonia caused by the 2019 novel coronavirus (2019-nCoV). Cases have been exported to other Chinese cities, as well as internationally, threatening to trigger a global outbreak. Here, we provide an estimate of the size of the epidemic in Wuhan on the basis of the number of cases exported from Wuhan to cities outside mainland China and forecast the extent of the domestic and global public health risks of epidemics, accounting for social and non-pharmaceutical prevention interventions.

Methods We used data from Dec 31, 2019, to Jan 28, 2020, on the number of cases exported from Wuhan internationally (known days of symptom onset from Dec 25, 2019, to Jan 19, 2020) to infer the number of infections in Wuhan from Dec 1, 2019, to Jan 25, 2020. Cases exported domestically were then estimated. We forecasted the national and global spread of 2019-nCoV, accounting for the effect of the metropolitan-wide quarantine of Wuhan and surrounding cities, which began Jan 23–24, 2020. We used data on monthly flight bookings from the Official Aviation Guide and data on human mobility across more than 300 prefecture-level cities in mainland China from the Tencent database. Data on confirmed cases were obtained from the reports published by the Chinese Center for Disease Control and Prevention. Serial interval estimates were based on previous studies of severe acute respiratory syndrome coronavirus (SARS-CoV). A susceptible-exposed-infectious-recovered metapopulation model was used to simulate the epidemics across all major cities in China. The basic reproductive number was estimated using Markov Chain Monte Carlo methods and presented using the resulting posterior mean and 95% credible interval (CrI).

Findings In our baseline scenario, we estimated that the basic reproductive number for 2019-nCoV was 2.68 (95% CrI 2.47–2.86) and that 75,815 individuals (95% CrI 37,304–130,330) have been infected in Wuhan as of Jan 25, 2020. The epidemic doubling time was 6.4 days (95% CrI 5.8–7.1). We estimated that in the baseline scenario, Chongqing, Beijing, Shanghai, Guangzhou, and Shenzhen had imported 461 (95% CrI 227–805), 113 (57–193), 98 (49–168), 111 (56–191), and 80 (40–139) infections from Wuhan, respectively. If the transmissibility of 2019-nCoV were similar everywhere domestically and over time, we inferred that epidemics are already growing exponentially in multiple major cities of China with a lag time behind the Wuhan outbreak of about 1–2 weeks.

Interpretation Given that 2019-nCoV is no longer contained within Wuhan, other major Chinese cities are probably sustaining localised outbreaks. Large cities overseas with close transport links to China could also become outbreak epicentres, unless substantial public health interventions at both the population and personal levels are implemented immediately. Independent self-sustaining outbreaks in major cities globally could become inevitable because of substantial exportation of presymptomatic cases and in the absence of large-scale public health interventions. Preparedness plans and mitigation interventions should be readied for quick deployment globally.

Funding Health and Medical Research Fund (Hong Kong, China).

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Introduction
Wuhan, the capital of Hubei province in China, is investigating an outbreak of atypical pneumonia caused by the zoonotic 2019 novel coronavirus (2019-nCoV). As of Jan 29, 2020 (1100 h Hong Kong time), there have been 5993 cases of 2019-nCoV infections confirmed in mainland China (figure 1), including 132 deaths. As of Jan 28, 2020 (1830 h Hong Kong time), there have been 78 exported cases from Wuhan to areas outside mainland China (appendix p 2–4). The National Health Commission of China has developed a case-definition system to facilitate the classification of patients (panel). To mitigate the spread of the virus, the Chinese Government has progressively implemented metropolitan-wide quarantine of Wuhan and several nearby cities since Jan 23–24, 2020. Numerous domestic

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See Online for appendix

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1

Conclusions: Basic reproduction number $R_0 \sim 2 - 3$, potential for superspreading, high risk of global spread.

Comparison to MERS, SARS and influenza

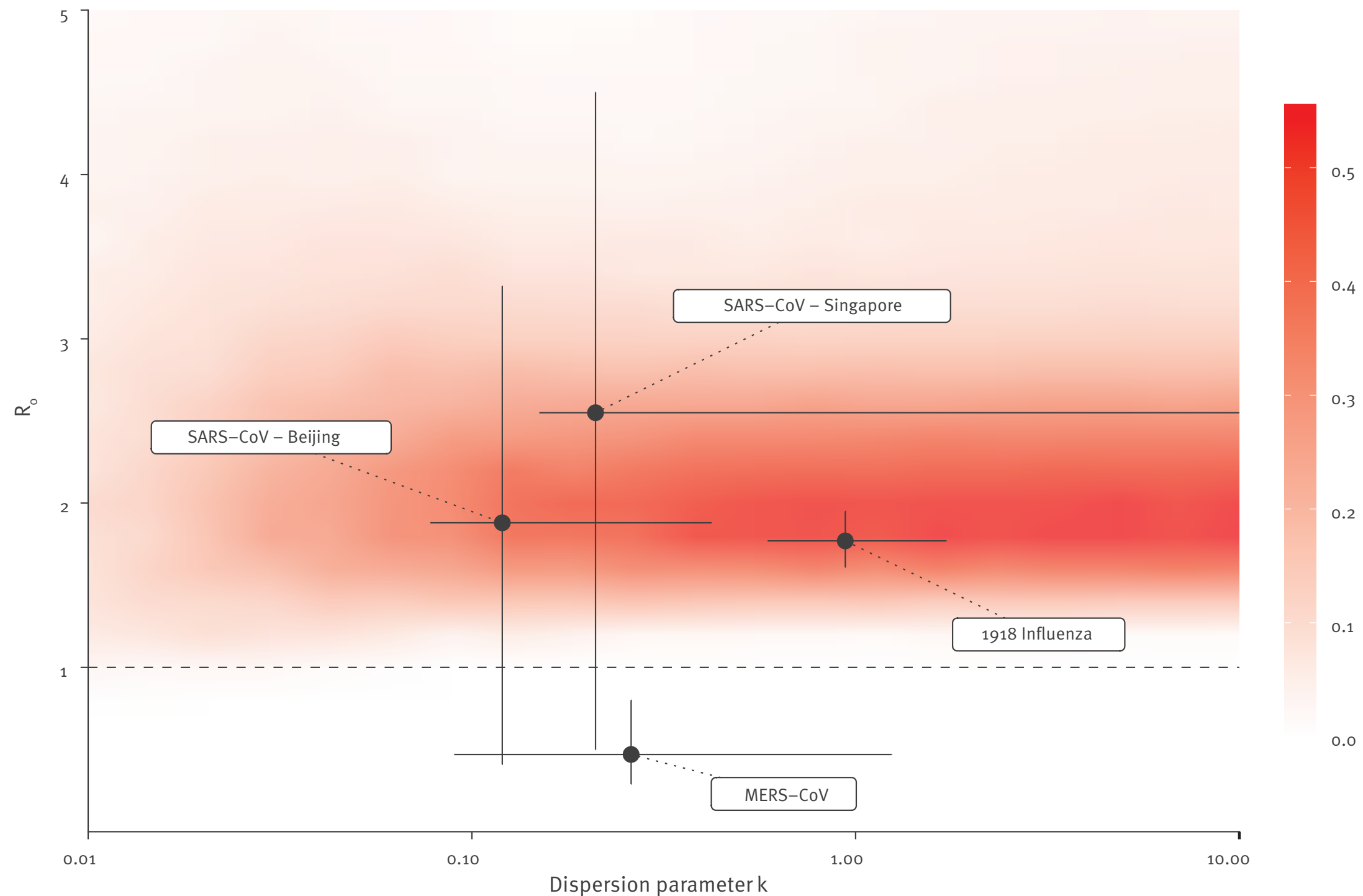


Figure: Riou & Althaus (2020, Euro Surveill)



The World Health Organization (WHO) declares the novel coronavirus outbreak a public health emergency of international concern (PHEIC) on 30 January 2020.

Report 4: Severity of 2019-novel coronavirus (nCoV)

[\(Download Report 4\)](#)

Ilaria Dorigatti⁺, Lucy Okell⁺, Anne Cori, Natsuko Imai, Marc Baguelin, Sangeeta Bhatia, Adhiratha Boonyasiri, Zulma Cucunubá, Gina Cuomo-Dannenburg, Rich FitzJohn, Han Fu, Katy Gaythorpe, Arran Hamlet, Wes Hinsley, Nan Hong, Min Kwun, Daniel Laydon, Gemma Nedjati-Gilani, Steven Riley, Sabine van Elsland, Erik Volz, Haowei Wang, Yuanrong (Raymond) Wang, Caroline Walters, Xiaoyue Xi, Christl Donnelly, Azra Ghani, Neil Ferguson^{*}. With support from other volunteers from the MRC Centre.¹

WHO Collaborating Centre for Infectious Disease Modelling

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Summary Report 4

We present case fatality ratio (CFR) estimates for three strata of COVID-19 (previously termed 2019-nCoV) infections. For cases detected in Hubei, we estimate the CFR to be 18% (95% credible interval: 11%-81%). For cases detected in travellers outside mainland China, we obtain central estimates of the CFR in the range 1.2-5.6% depending on the statistical methods, with substantial uncertainty around these central values. Using estimates of underlying infection prevalence in Wuhan at the end of January derived from testing of passengers on repatriation flights to Japan and Germany, we adjusted the estimates of CFR from either the early epidemic in Hubei Province, or from cases reported outside mainland China, to obtain estimates of the overall CFR in all infections (asymptomatic or symptomatic) of approximately 1% (95% confidence interval 0.5%-4%). It is important to note that the differences in these estimates does not reflect underlying differences in disease severity between countries. CFRs seen in individual countries will vary depending on the sensitivity of different surveillance systems to detect cases of differing levels of severity and the clinical care offered to severely ill cases. All CFR estimates should be viewed cautiously at the current time as the sensitivity of surveillance of both deaths and cases in mainland China is unclear. Furthermore, all estimates rely on limited data on the typical time intervals from symptom onset to death or recovery which influences the CFR estimates.

Source: <https://www.imperial.ac.uk/mrc-global-infectious-disease-analysis>

Modeling scenarios

- Imperial College COVID-19 Response Team (Report 9, 16 March 2020)
- CI: Case Isolation
HQ: Voluntary home quarantine
SD: Social distancing
PC: Closure of schools and universities
- UK reported deaths: ~ 130k
UK excess mortality: ~ 110k

R ₀	On Trigger	Total deaths			
		Do nothing	CI_HQ_SD	PC_CI_SD	PC_CI_HQ_SD
2	60	410,000	47,000	6,400	5,600
	100	410,000	47,000	9,900	8,300
	200	410,000	46,000	17,000	14,000
	300	410,000	45,000	24,000	21,000
	400	410,000	44,000	30,000	26,000
2.2	60	460,000	62,000	9,700	6,900
	100	460,000	61,000	13,000	10,000
	200	460,000	64,000	23,000	17,000
	300	460,000	65,000	32,000	26,000
	400	460,000	68,000	39,000	31,000
2.4	60	510,000	85,000	12,000	8,700
	100	510,000	87,000	19,000	13,000
	200	510,000	90,000	30,000	24,000
	300	510,000	94,000	43,000	34,000
	400	510,000	98,000	53,000	39,000
2.6	60	550,000	110,000	20,000	12,000
	100	550,000	110,000	26,000	16,000
	200	550,000	120,000	39,000	30,000
	300	550,000	120,000	56,000	40,000
	400	550,000	120,000	71,000	48,000

Table: <https://www.imperial.ac.uk/mrc-global-infectious-disease-analysis/covid-19/report-9-impact-of-npis-on-covid-19/>

Pandemic risk assessment

- **WHO, 11 February 2020:** *“It can create havoc, politically, economically and socially. (...) That’s a window of opportunity so I’m reminding; there is time, the time is ticking and time is of the essence in this outbreak.” (Director-General)*
- **Federal Department of Defence, Civil Protection and Sport (DDPS), 3 February 2020:**
“Aus Sicht des Oberfeldarztes ist die Verbreitung des 2019-nCoV nicht zu verhindern, sondern allenfalls zu verzögern. (...) Schwere Fälle werden das Spitalwesen belasten.” (A. Stettbacher)
- **Federal Office of Public Health (FOPH), 24 February 2020:**
“Virus wird nicht so leicht übertragen wie Grippevirus, darum gute Aussichten, die Situation unter Kontrolle zu bringen.” (D. Koch)

How to prepare for the next pandemic?

Identifying regions with ‘missing zoonoses’

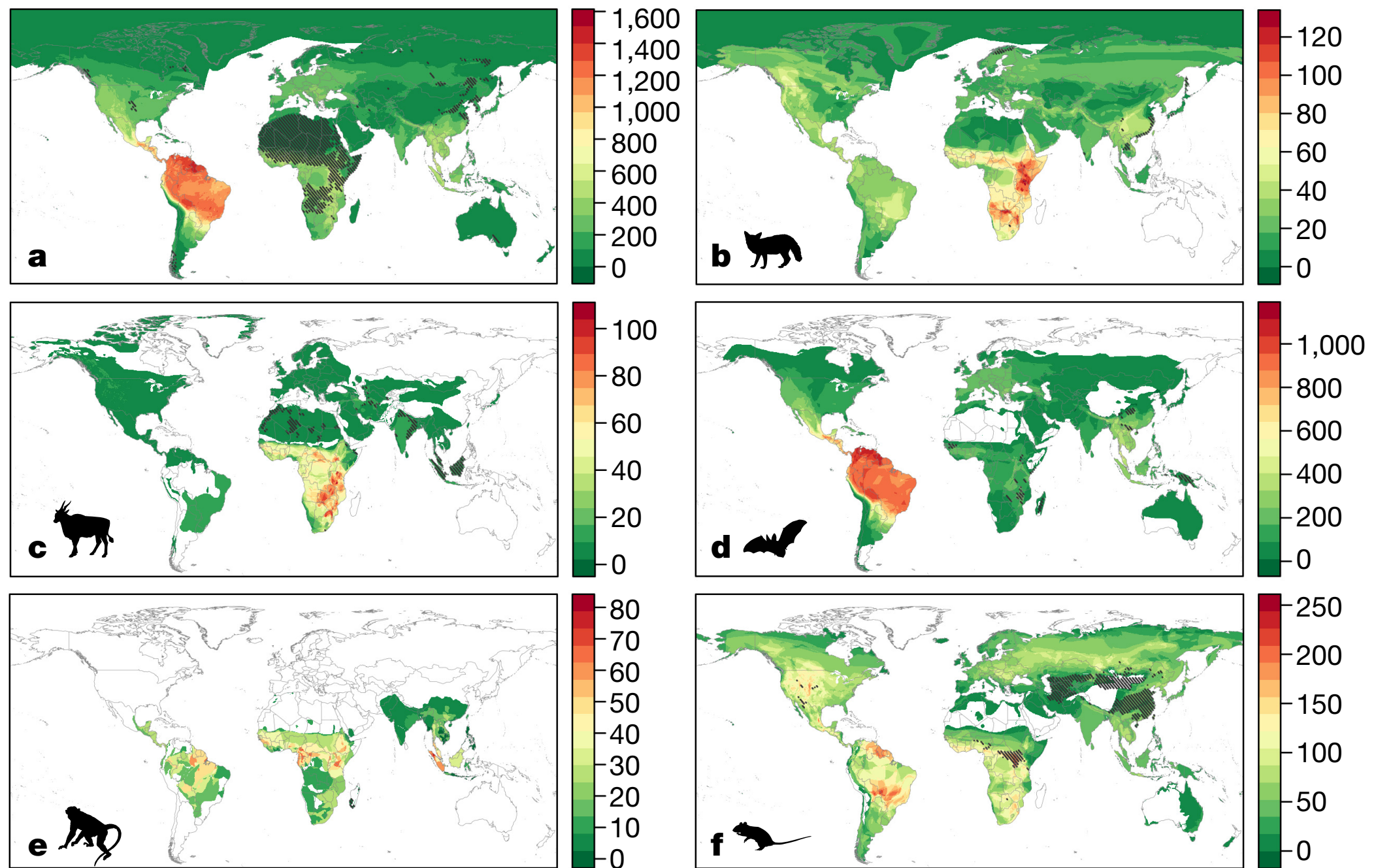
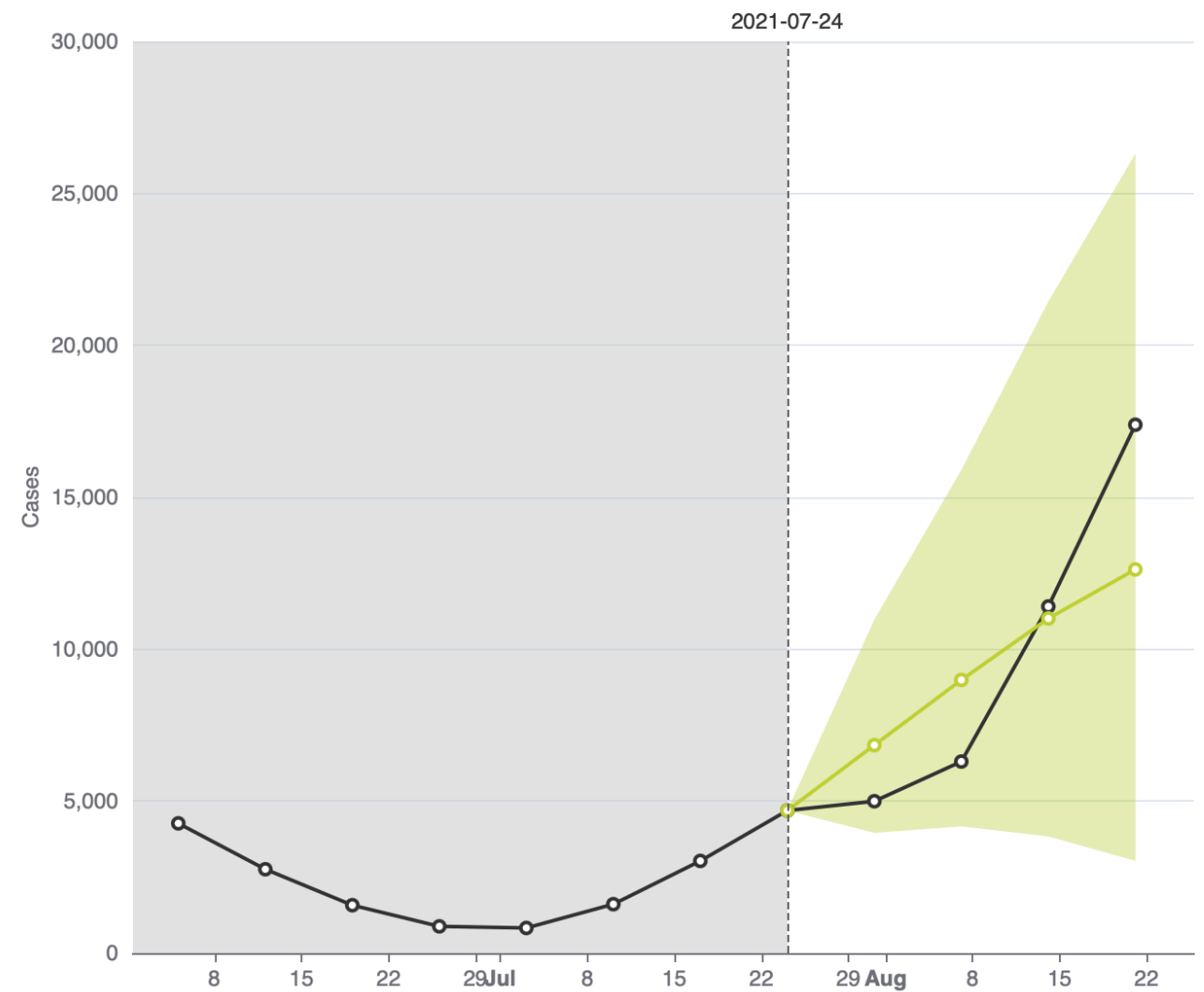


Figure: Olival et al. (2017, Nature)

Early detection for early action

- Hospital surveillance systems (globally)
- Further development of real-time modeling and disease monitoring systems
- Systematic evaluation of short-term forecasting systems (European Covid-19 Forecast Hub)

Forecasts · Cases, Switzerland · issued on Jul 26, 2021

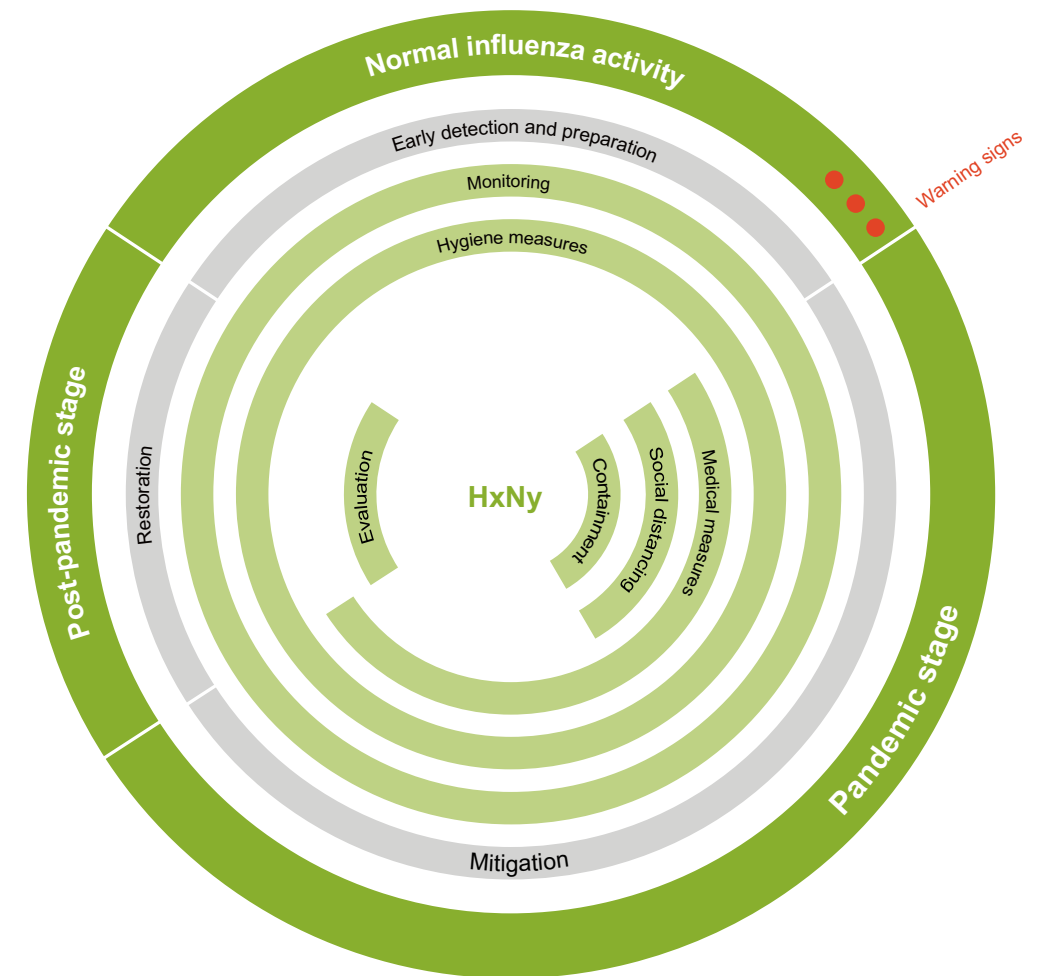


National pandemic plans

- Improve diagnostic capacities
- Stockpiling of personal protective equipment, PPE (e.g., masks)
- Early education of the general public on the disease and their role in preventing its spread
- Test-Trace-Isolate-Quarantine (TTIQ)
- Consider targeted use of NPIs (e.g., physical distancing)

Swiss Influenza Pandemic Plan

Strategies and measures to prepare for an influenza pandemic



Schweizerische Eidgenossenschaft
Confédération suisse
Confederazione Svizzera
Confederaziun svizra

Swiss Confederation

Federal Department of Home Affairs FDHA
Federal Office of Public Health FOPH

5th edition 2018

Dialogue between politics and science

Kritik von oberster Stelle: Politik hört zu wenig auf Wissenschaft

Covid Bundeskanzler Walter Thurnherr, der die Regierung eng begleitet, zieht in deren Auftrag Lehren aus der Pandemie.

Raphaela Birrer
und **Philipp Loser**

Regierung und Wissenschaft arbeiten in der Schweiz zu schlecht zusammen. Zu diesem Schluss kommt Bundeskanzler Walter Thurnherr in seiner grossen Bilanz zur Corona-Krise. So habe der Bundesrat in der Pandemie die Covid-Taskforce der Wissenschaft erst am 30. März 2020 eingesetzt – «das war eindeutig zu spät», urteilt Thurnherr im Interview mit dieser Zeitung.

Der Bundeskanzler erkennt darin ein grundsätzliches Malaise. Das Verhältnis zwischen Politik und Wissenschaft sei in der Schweiz generell «zu wenig geklärt, zum Teil angespannt». Kontakte zwischen Vertretern beider Sphären seien «rar». Die Schweizer Politik funktioniere «im We-

sentlichen mehrheits-, nicht evidenzbasiert». Konkret habe die Politik bisher nur auf die Wissenschaft zurückgegriffen, wenn deren Argumente die eigene Position gestützt hätten. «Dass die Wissenschaft der Politik widersprechen könnte, war hingegen eher weniger vorgesehen.»

Sorge um die Debattenkultur

Thurnherr, selber studierter Physiker, will diese Zusammenarbeit nun verbessern. Denn die nächste Krise komme bestimmt. Der Austausch zwischen Politik und Wissenschaft müsse darum «intensiver und institutionalisierter werden».

Als Bundeskanzler nimmt Thurnherr an jeder Bundesrats-sitzung teil und hat so die Entscheide in der Corona-Pandemie hautnah miterlebt und mitge-

prägt. Er ist nun vom Gesamtbundesrat beauftragt worden, das ganze Krisenmanagement einer umfassenden Evaluation zu unterziehen. Diese solle mehrere Jahre dauern, sagt Thurnherr. Bereits jetzt sei aber klar, dass die Zusammenarbeit von Wissenschaft und Politik ein zentraler Punkt sei.

Besorgt äussert sich der Bundeskanzler zur Debattenkultur in der Schweiz. Er zieht dabei sogar eine Parallele zu den USA unter Donald Trump. Worte von Politikern könnten schlimme Folgen haben – «das gilt nicht nur in den USA, sondern auch in unseren Breitengraden», sagt er in Bezug auf die Diktatur-Rhetorik der SVP. Das Gespräch mit Thurnherr ist das erste einer Reihe von Interviews zur Frage, was die Pandemie verändert. **Seite 2, 3**

Bottom line

Make efficient use of available tools and ensure an all-of-government and all-of-society approach to limit the health, economic and societal impact of future pandemics.

⇒ “Public Health”