

Early transmission, pandemic spread and severity of COVID-19

Basel Biometric Section - Aspects of COVID-19 pandemic, 3 June 2020

PD Dr. Christian L. Althaus, Ph.D.

Institute of Social and Preventive Medicine
University of Bern
Mittelstrasse 43
3012 Bern

Image: NIAID

u^b

b
**UNIVERSITÄT
BERN**

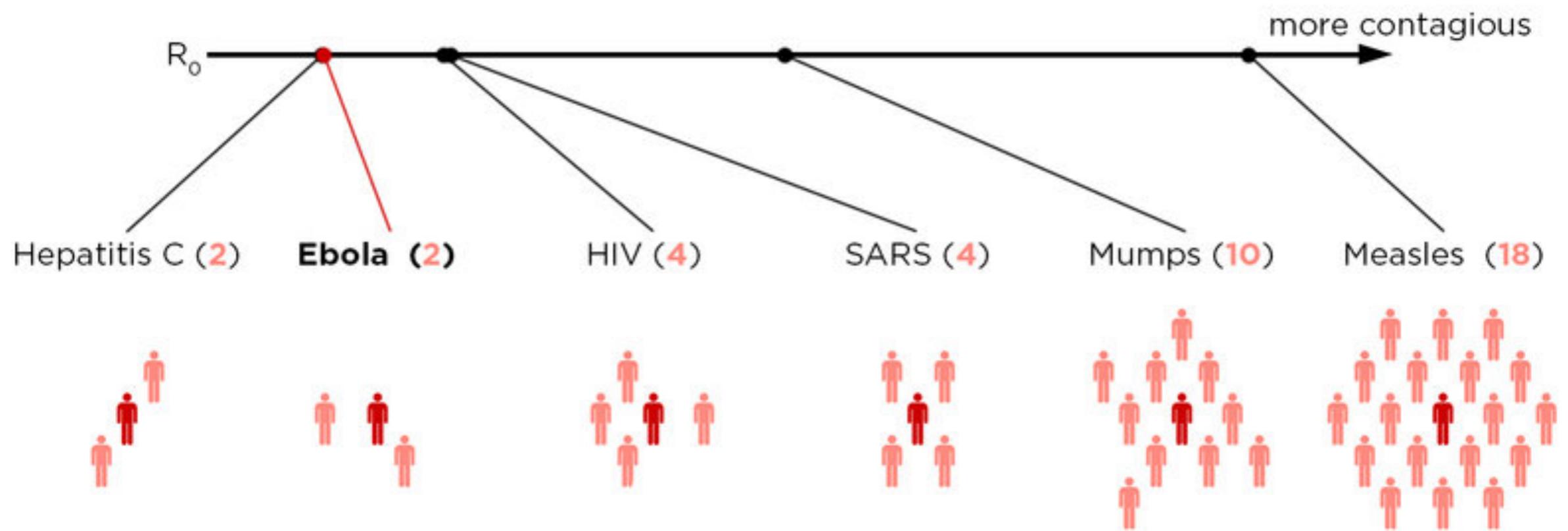
FNSNF
FONDS NATIONAL SUISSE
SCHWEIZERISCHER NATIONALFONDS
FONDO NAZIONALE SVIZZERO
SWISS NATIONAL SCIENCE FOUNDATION

Key questions for early outbreak response

1. What is the transmissibility (basic reproduction number R_0)
2. What is the disease severity (case fatality ratio)

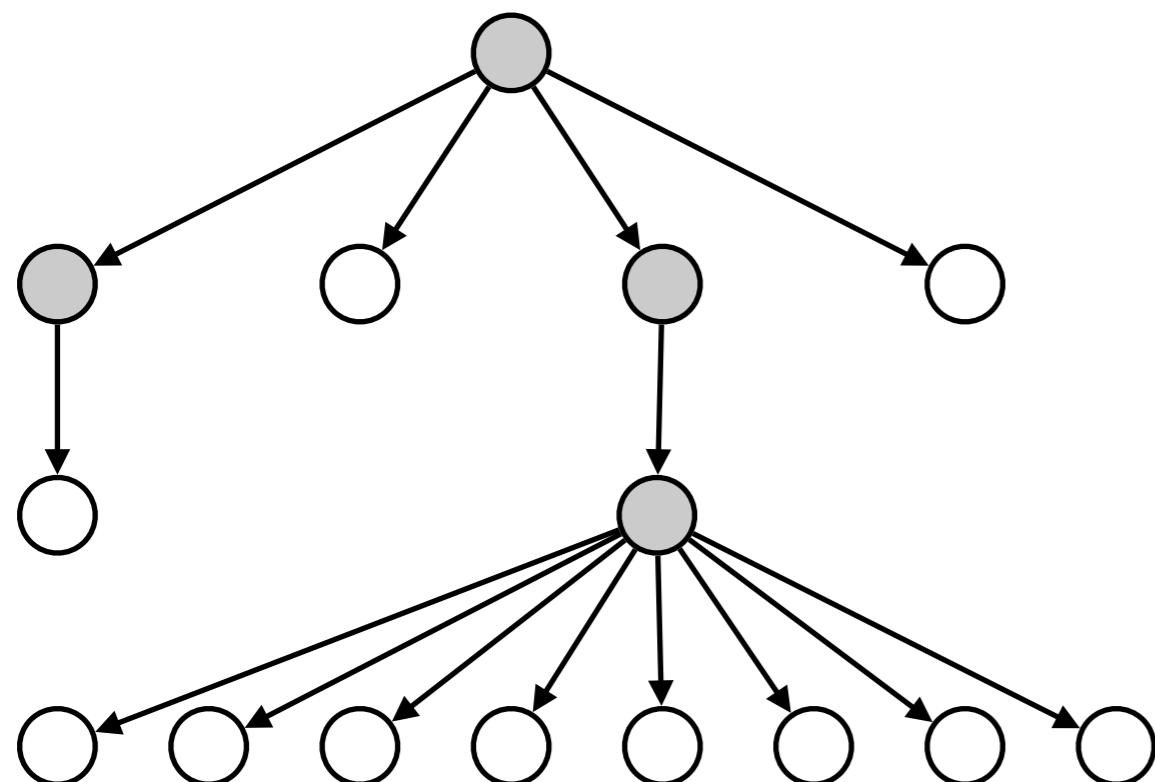
Basic reproduction number R_0

To how many people does an infected person transmit the disease on average (no control interventions, no acquired immunity, no vaccine)?

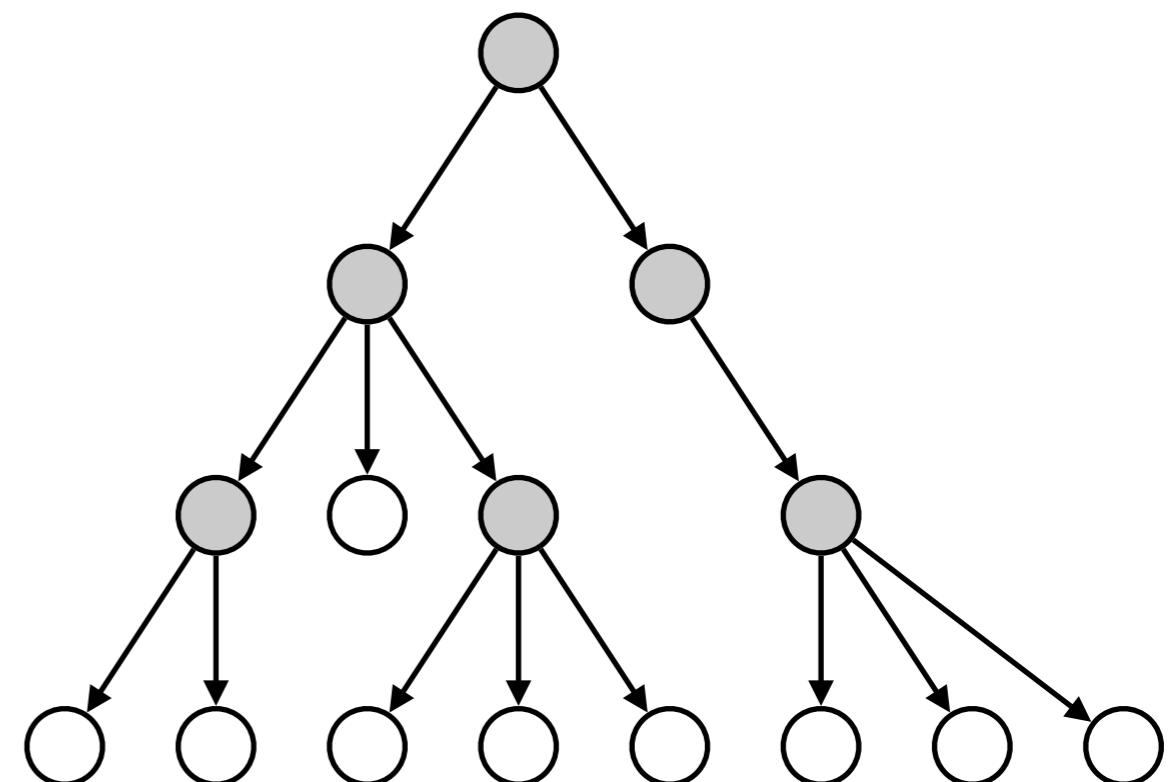


R_0 and variation in secondary cases

$$R_0 = 2$$



Superspreading events



Steady transmission chains

Overdispersion parameter k

Simulating early outbreak trajectories in China

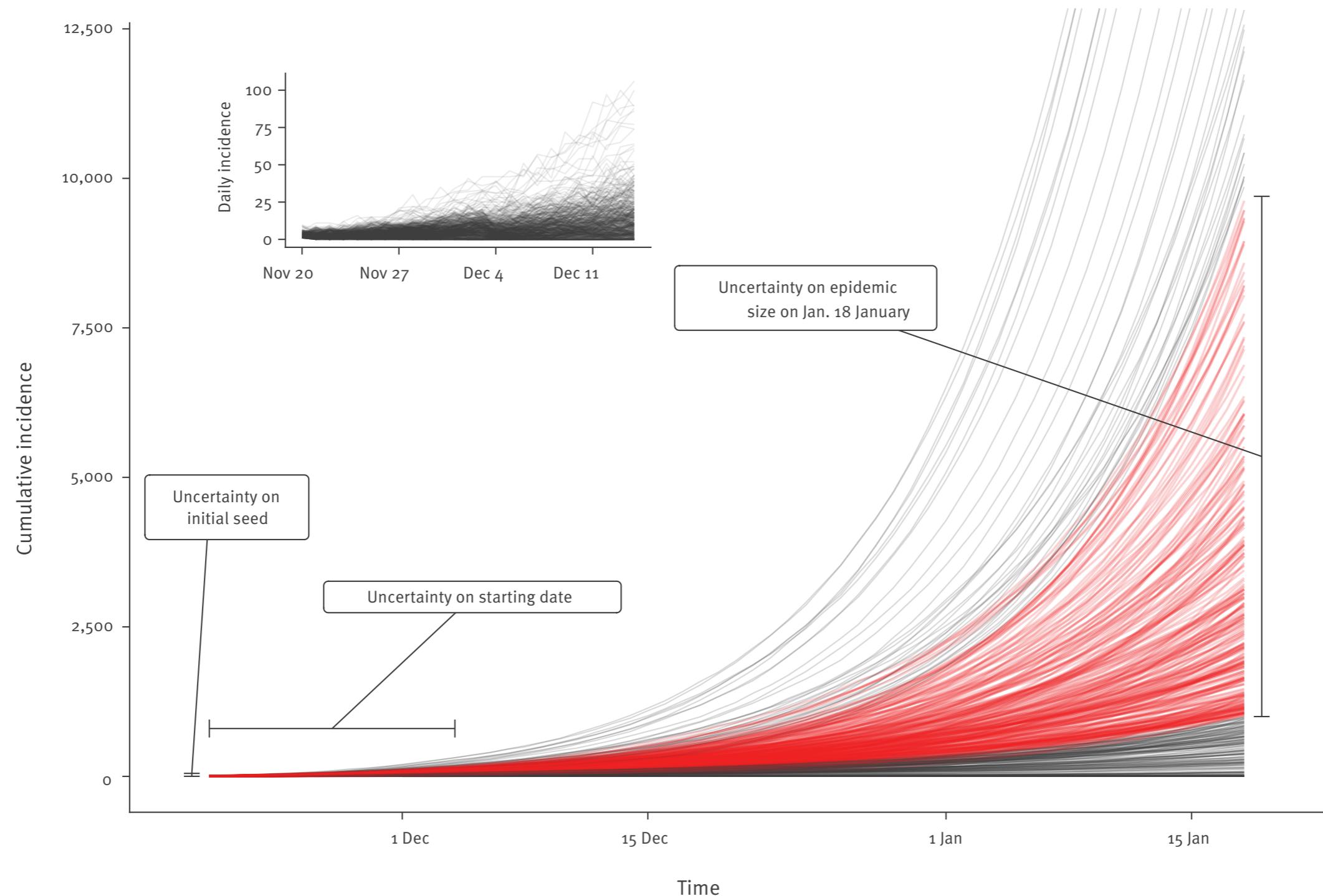


Figure: Riou & Althaus (2020, Euro Surveill)

Estimated epidemiological parameters

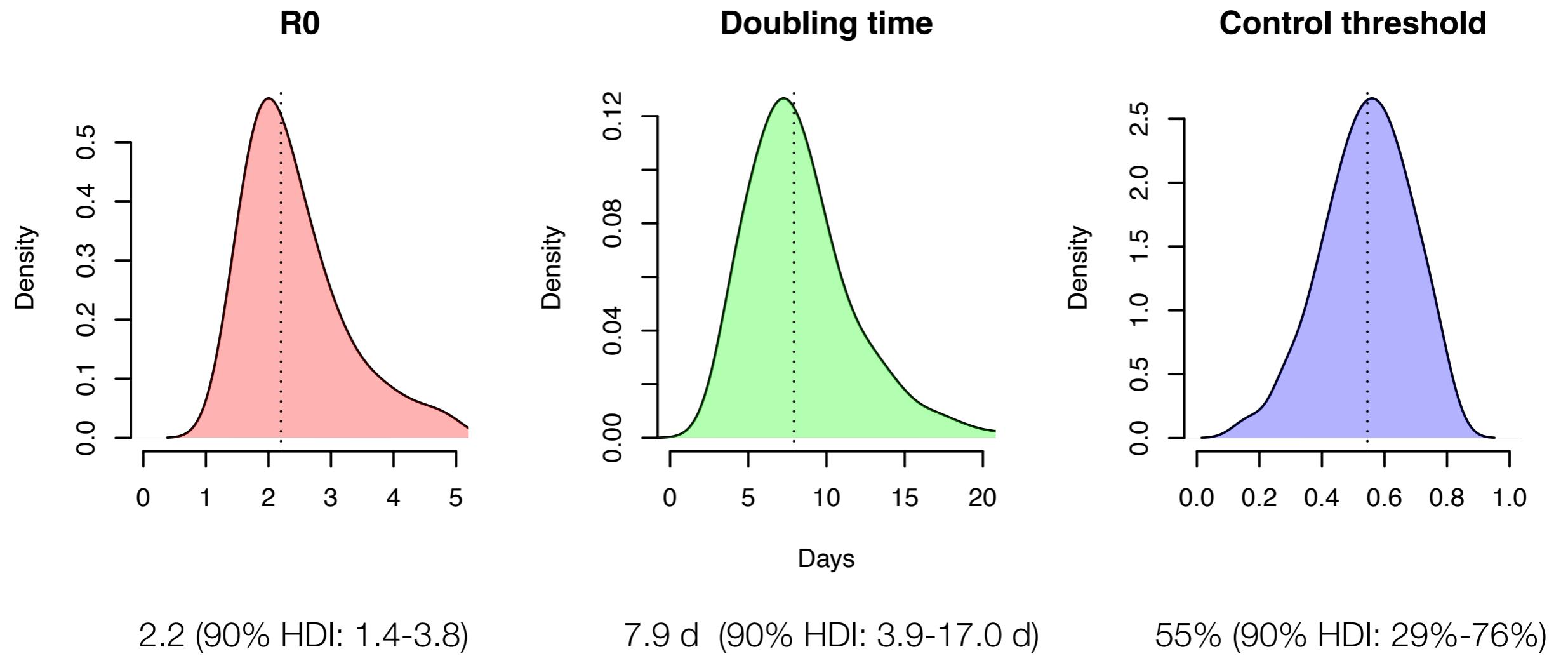


Figure based on: Riou & Althaus (2020, Euro Surveill)

Comparison to MERS, SARS and influenza

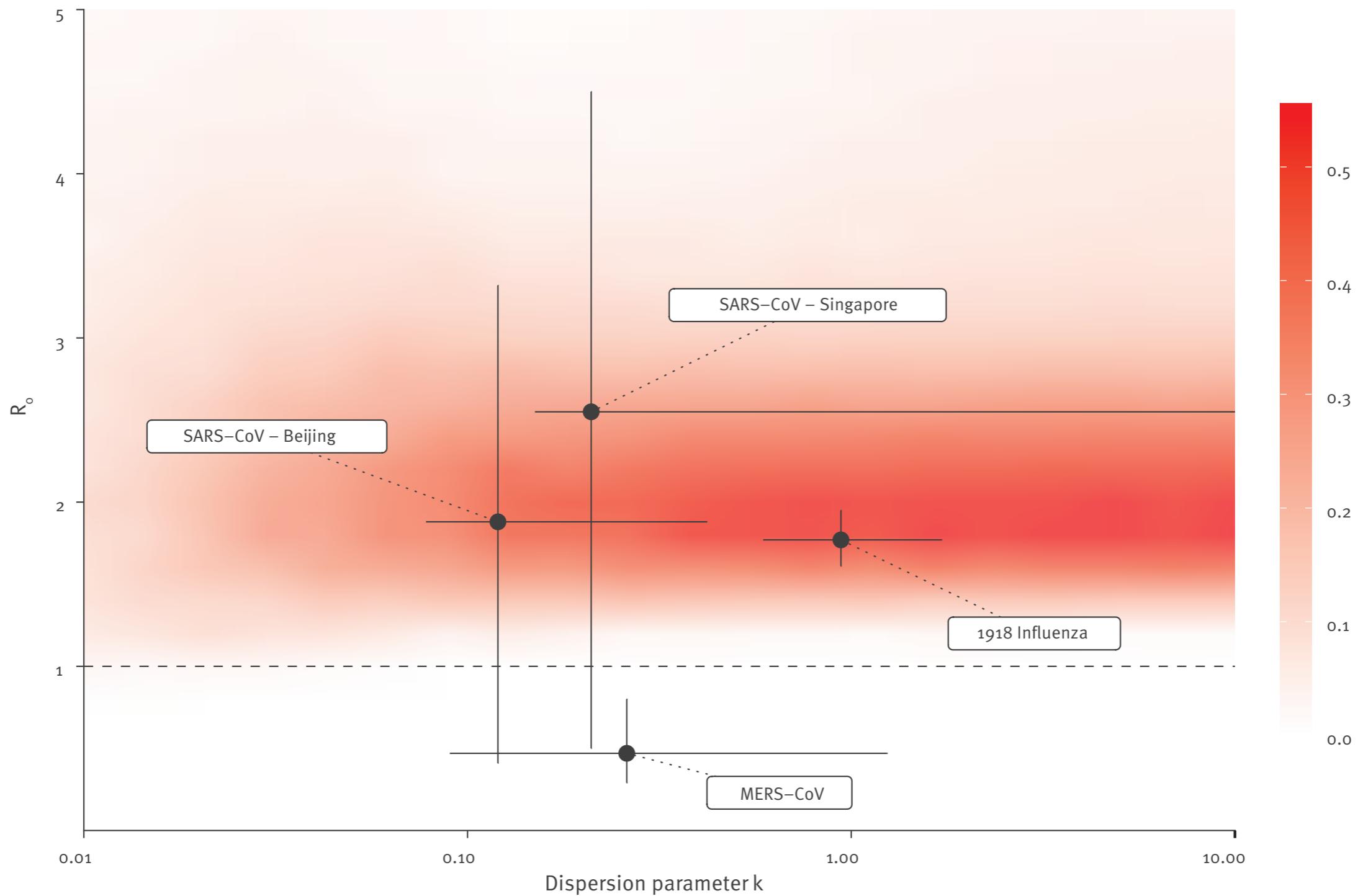


Figure: Riou & Althaus (2020, Euro Surveill)

“We have therefore made the assessment that COVID-19 can be characterized as a pandemic.”

-WHO Director-General, 11 March 2020

Early-stage importation risk to Europe

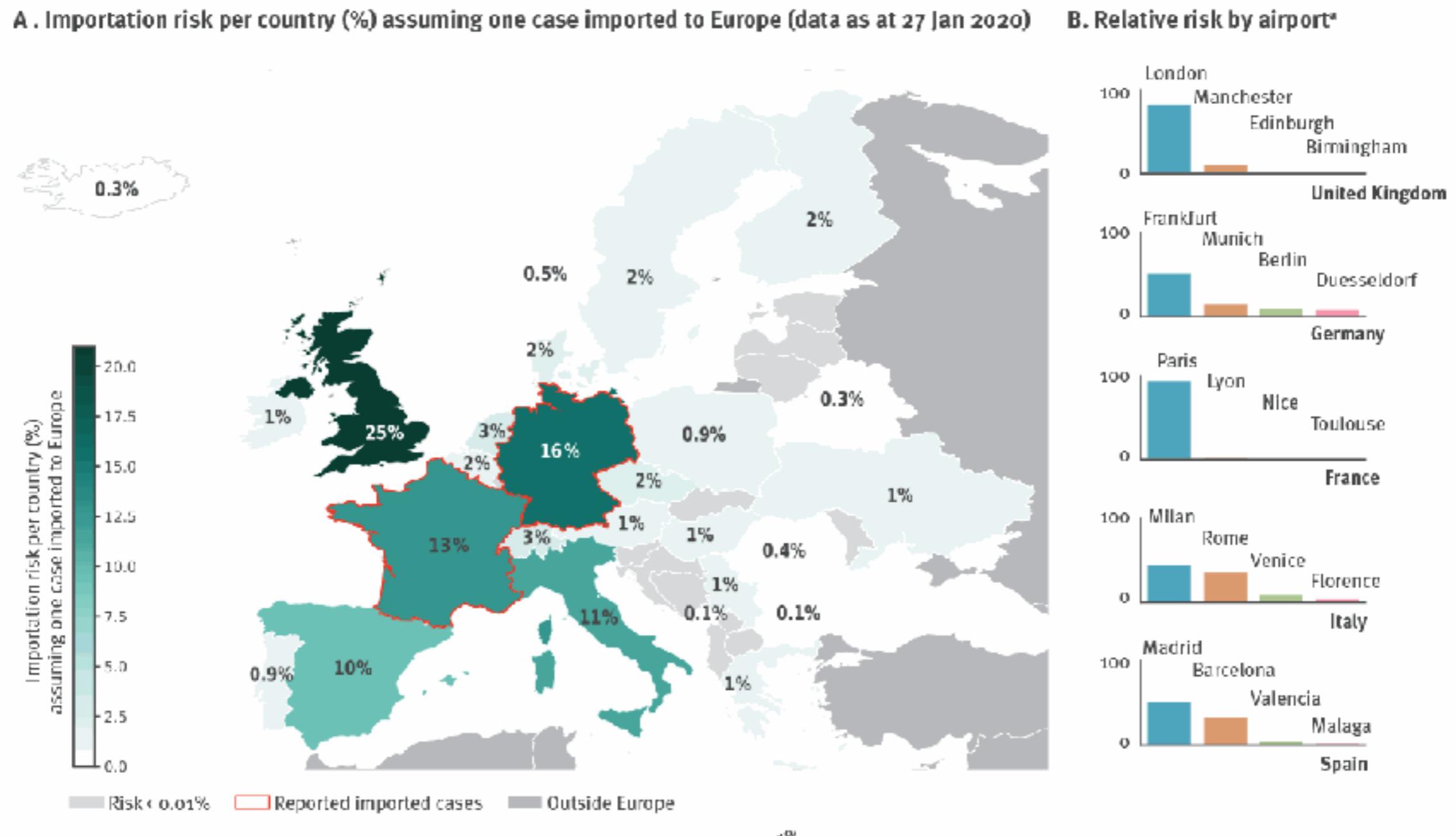


Figure: Pullano et al. (2020, Euro Surveill)

Outbreak control by isolating cases and contacts

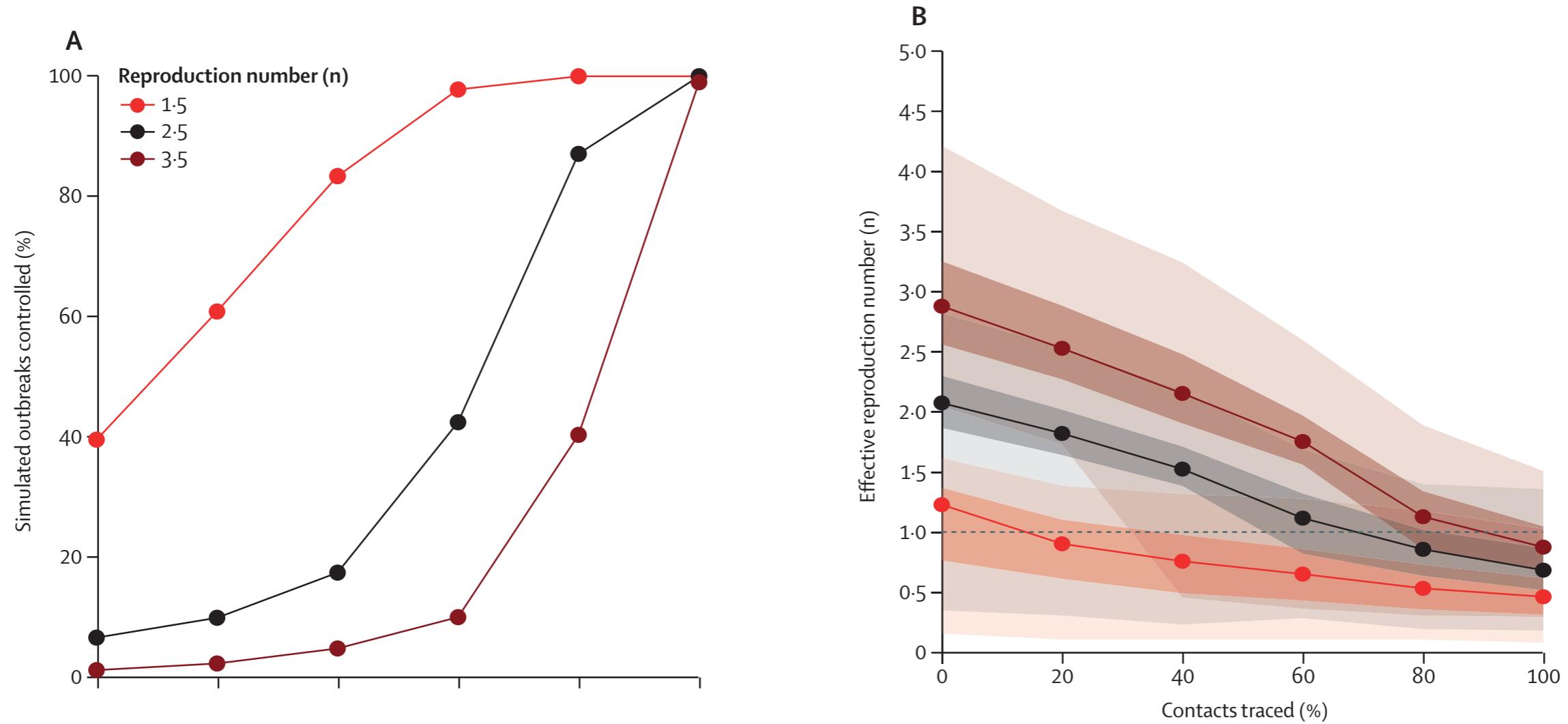


Figure: Hellewell et al. (2020, Lancet Glob Health)

“It’s just like the flu.”

-Several ‘experts’

Case fatality in mainland China

TABLE 1. Patients, deaths, and case fatality rates, as well as observed time and mortality for n=44,672 confirmed COVID-19 cases in Mainland China as of February 11, 2020.

Baseline Characteristics	Confirmed Cases, N (%)	Deaths, N (%)	Case Fatality Rate, %	Observed Time, PD	Mortality, per 10 PD
Overall	44,672	1,023	2.3	661,609	0.015
Age, years					
0–9	416 (0.9)	–	–	4,383	–
10–19	549 (1.2)	1 (0.1)	0.2	6,625	0.002
20–29	3,619 (8.1)	7 (0.7)	0.2	53,953	0.001
30–39	7,600 (17.0)	18 (1.8)	0.2	114,550	0.002
40–49	8,571 (19.2)	38 (3.7)	0.4	128,448	0.003
50–59	10,008 (22.4)	130 (12.7)	1.3	151,059	0.009
60–69	8,583 (19.2)	309 (30.2)	3.6	128,088	0.024
70–79	3,918 (8.8)	312 (30.5)	8.0	55,832	0.056
≥80	1,408 (3.2)	208 (20.3)	14.8	18,671	0.111
Sex					
Male	22,981 (51.4)	653 (63.8)	2.8	342,063	0.019
Female	21,691 (48.6)	370 (36.2)	1.7	319,546	0.012
Occupation					
Service industry	3,449 (7.7)	23 (2.2)	0.7	54,484	0.004
Farmer/laborer	9,811 (22.0)	139 (13.6)	1.4	137,992	0.010
Health worker	1,716 (3.8)	5 (0.5)	0.3	28,069	0.002
Retiree	9,193 (20.6)	472 (46.1)	5.1	137,118	0.034
Other/none	20,503 (45.9)	384 (37.5)	1.9	303,946	0.013

Challenges in assessing case fatality ratio

1. Under-ascertainment of mild cases \Rightarrow leads to overestimation
2. Right-censoring of cases with respect to delay from illness onset to death
 \Rightarrow leads to underestimation

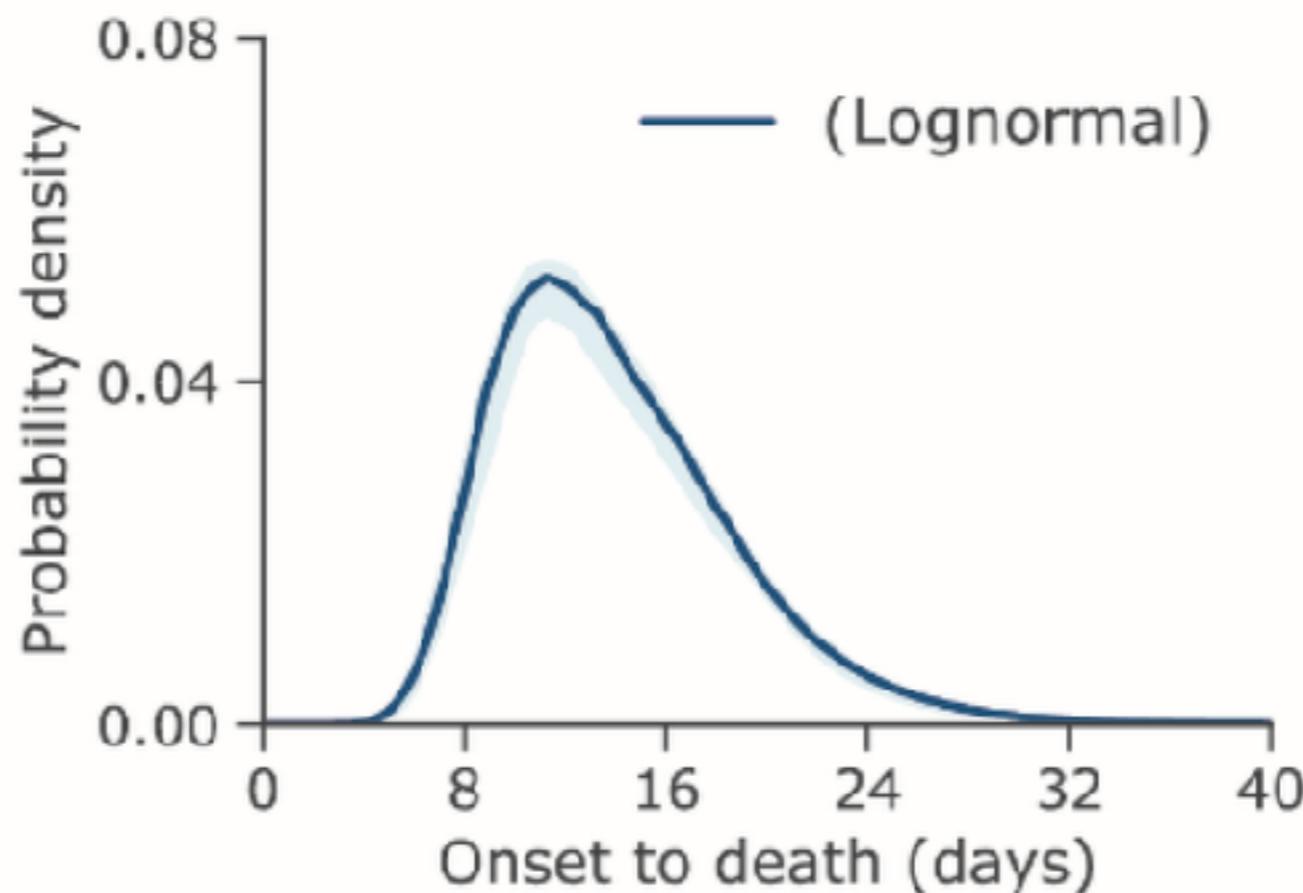


Figure: Linton et al. (2020, J Clin Med)

Compartmental COVID-19 transmission model

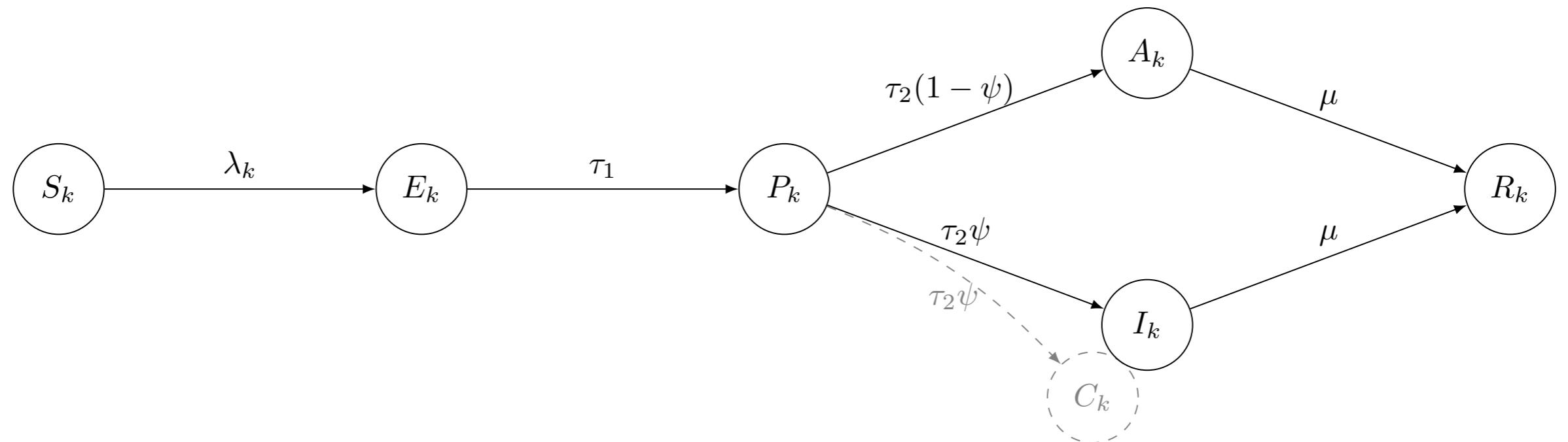


Figure: Hauser et al. (2020, PLOS Med, in print)

COVID-19 epidemic in Switzerland

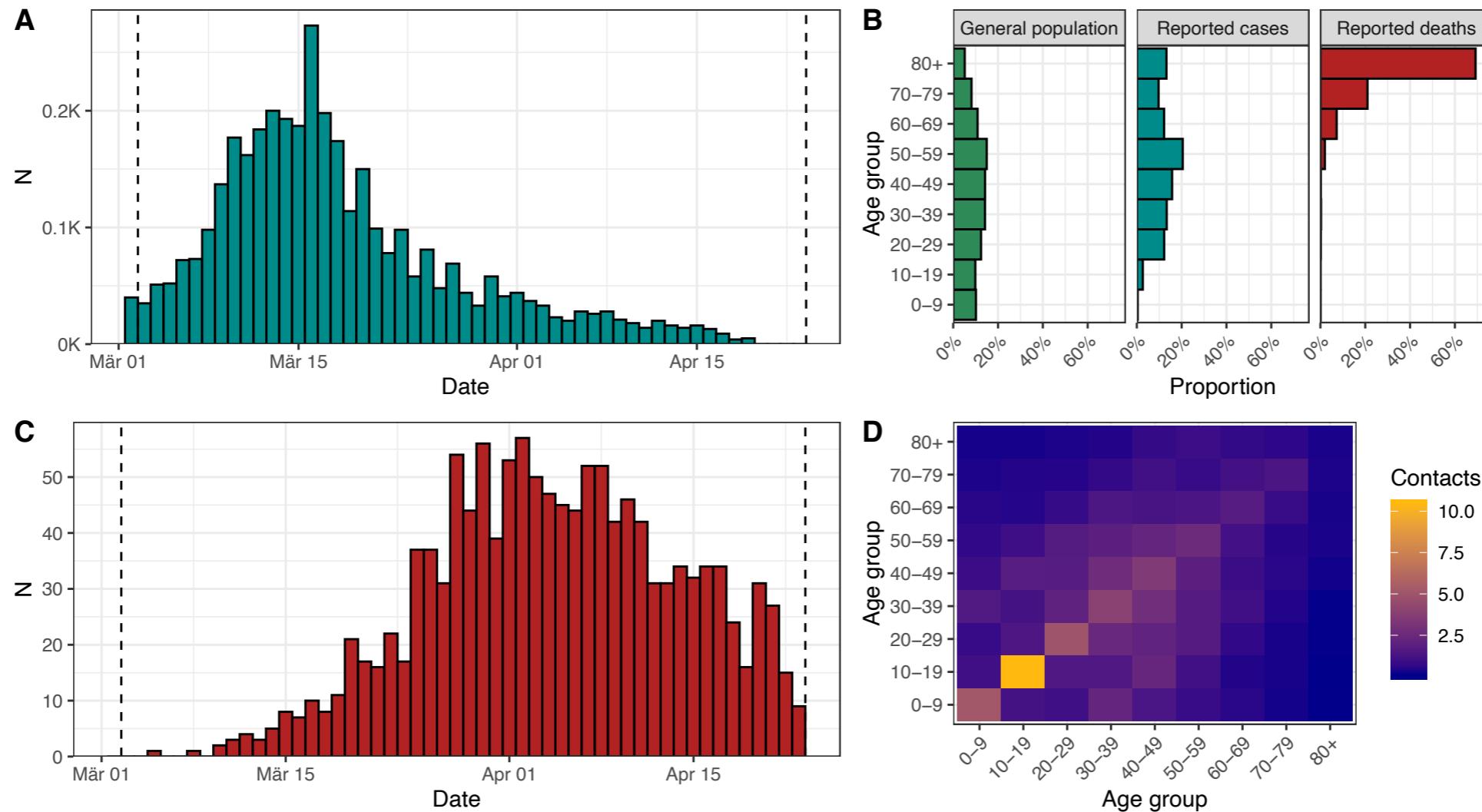


Figure S7: Data used to fit the model in Switzerland. (A) Reported confirmed cases of COVID-19. (B) Age distribution of the Chinese population compared to that of confirmed cases and of deaths due to COVID-19. (C) Reported deaths (D) Matrix representing the average number of daily contacts between each age class in Europe (POLYMOD)

Model fit to COVID-19 epidemic in Hubei, China

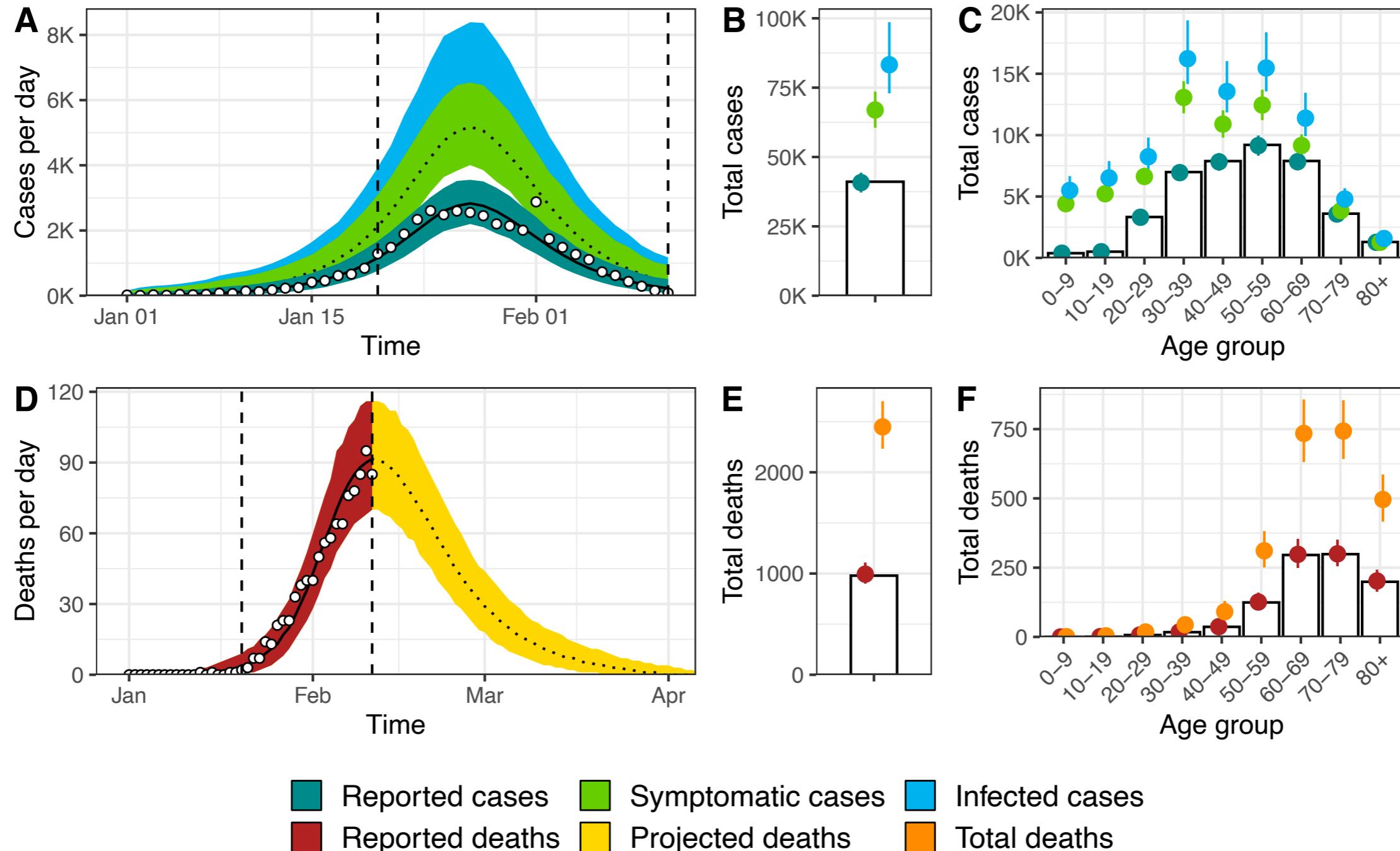


Figure: Hauser et al. (2020, PLOS Med, in print)

Adjusted infection fatality ratios in Hubei, China and six areas of Europe

Table 1: Model estimates of total infections of SARS-CoV-2 infection, total deaths, crude case fatality rate (CFR), symptomatic fatality rate (SFR) and infection fatality rate (IFR) by area.

Area (limit date)	Estimated total infections	Estimated total deaths	CFR	SFR	IFR
Hubei, China (11 February)					
- <i>Baseline</i>	83,300 (73,000-98,600)	2,450 (2,230-2,700)	2.4% (2.1-2.8)	3.7% (3.2-4.2)	2.9% (2.4-3.5)
- <i>After correction</i>	138,000 (120,000-162,000)	3,430 (3,120-3,760)	2.1% (1.8-2.4)	3.1% (2.7-3.5)	2.5% (2.1-2.9)
- <i>With lower susceptibility of children</i>	74,100 (63,600-86,700)	2,440 (2,230-2,710)	2.4% (2.1-2.8)	4.1% (3.6-4.7)	3.3% (2.7-4.0)
Austria (14 April)	69,100 (56,500-82,700)	731 (623-867)	3.0% (2.4-3.7)	1.3% (1.1-1.6)	1.1% (0.8-1.3)
Baden-Württemberg, Germany (16 April)	212,000 (188,000-247,000)	1,580 (1,060-2,710)	3.3% (2.1-5.7)	0.9% (0.6-1.6)	0.7% (0.5-1.3)
Bavaria, Germany (16 April)	257,000 (228,000-296,000)	1,940 (1,420-2,720)	3.3% (2.4-4.9)	0.9% (0.7-1.3)	0.8% (0.5-1.1)
Lombardy, Italy (25 April)	1,150,000 (1,010,000-1,350,000)	15,700 (13,900-17,600)	18.2% (15.7-21.0)	1.7% (1.5-2.0)	1.4% (1.1-1.6)
Spain (16 April)	2,650,000 (2,360,000-3,090,000)	27,800 (25,400-30,500)	11.1% (9.9-12.5)	1.3% (1.2-1.5)	1.0% (0.9-1.2)
Switzerland (23 April)	308,000 (248,000-383,000)	1,520 (1,380-1,690)	4.1% (3.4-5.1)	0.6% (0.5-0.8)	0.5% (0.4-0.6)

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

MRC Centre for Global Infectious Disease Analysis

Abdul Latif Jameel Institute for Disease and Emergency Analytics

Imperial College London

*Correspondence: neil.ferguson@imperial.ac.uk ¹ See full list at end of document. *These two authors contributed equally.

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>

Summary

- Transmission: R_0 around 2 - 3
- Variation in secondary cases: Between SARS and influenza
- Control: More than 75% of cases need to be isolated for successful control
- Severity: Infection fatality ratio of 0.5%-1.5% in different areas of Europe
- Open questions: Seasonality, immunity, endemicity