Novel Coronavirus: The science, what we can learn from past pandemics, and comments on the future
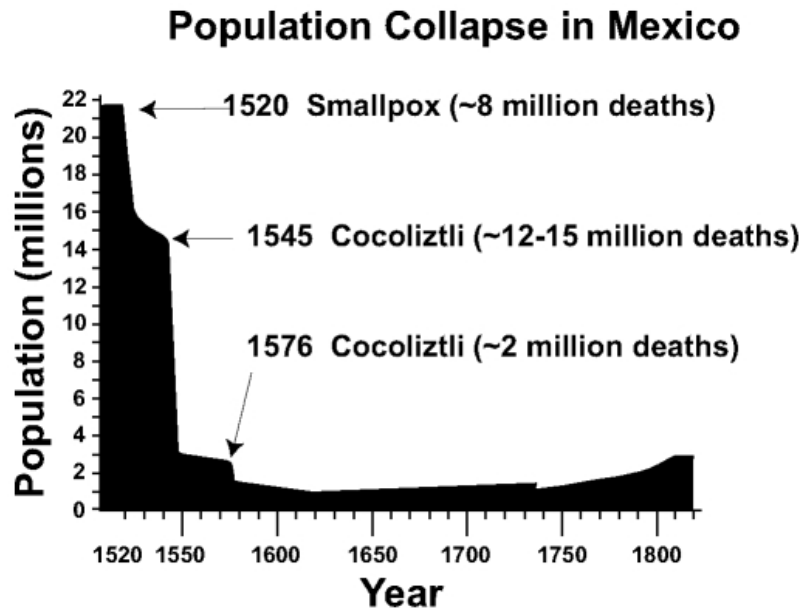
Jason Ballengee

April 28th

Disclaimer 1: The views expressed are solely my own and do not reflect the position of any organization I am associated with.

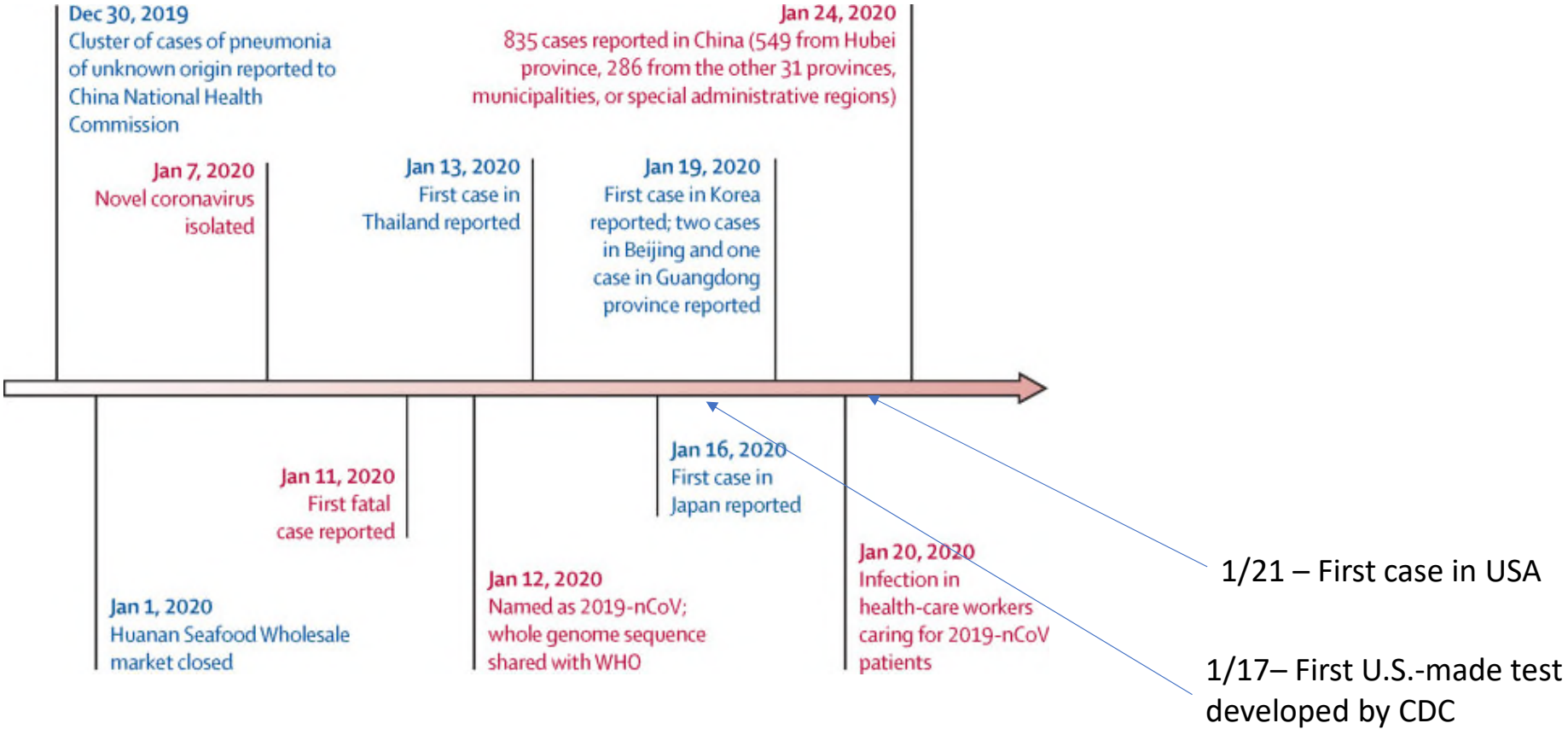**Disclaimer 2: I have incorporated minimal new content into this deck since April 20th**

Disease has always touched the course of history...for example, clearing the path for the creation of the USA

Population Collapse in Mexico

- 1520 Smallpox (~8 million deaths)
- 1545 Cocoliztli (~12-15 million deaths)
- 1576 Cocoliztli (~2 million deaths)

Population (millions) vs Year

THREE LIONS/HULTON ARCHIVE/GETTY IMAGES

This talk will proceed in 3 waves

- Science-based background

- Historian-based background of past pandemics

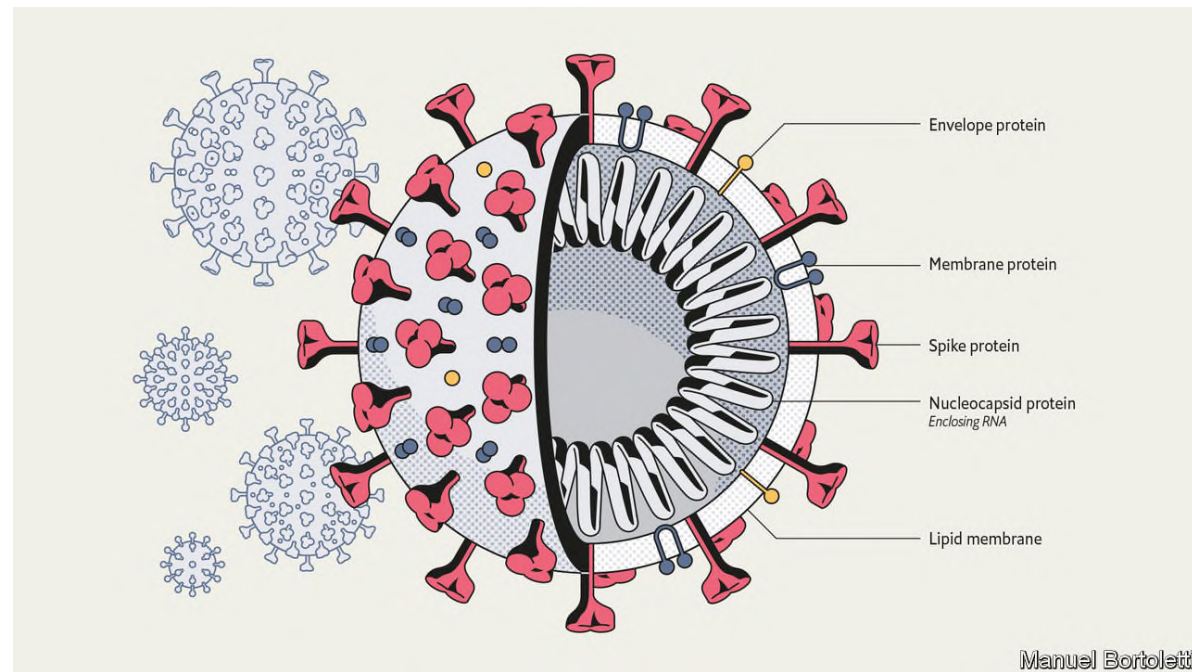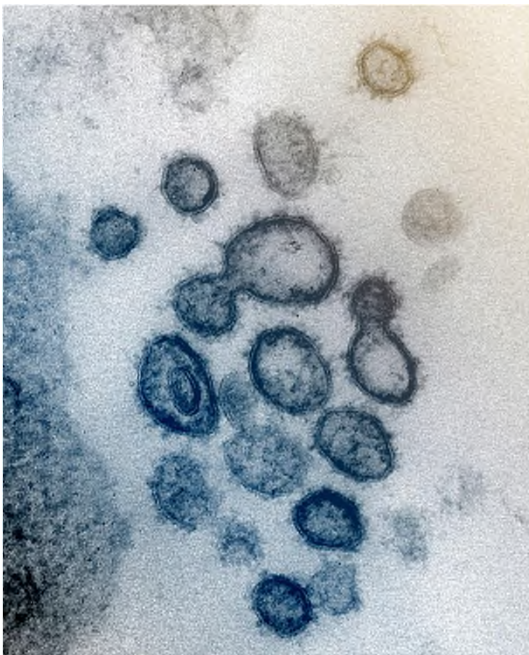- What the above *might* mean for the months and years ahead

The novel coronavirus has likely been circulating since at least November, with warning signals becoming detectable in late December

Dec 30, 2019
Cluster of cases of pneumonia of unknown origin reported to China National Health Commission

Jan 7, 2020
Novel coronavirus isolated

Jan 13, 2020
First case in Thailand reported

Jan 19, 2020
First case in Korea reported; two cases in Beijing and one case in Guangdong province reported

Jan 24, 2020
835 cases reported in China (549 from Hubei province, 286 from the other 31 provinces, municipalities, or special administrative regions)

Jan 1, 2020
Huanan Seafood Wholesale market closed

Jan 11, 2020
First fatal case reported

Jan 12, 2020
Named as 2019-nCoV; whole genome sequence shared with WHO

Jan 16, 2020
First case in Japan reported

Jan 20, 2020
Infection in health-care workers caring for 2019-nCoV patients

1/21 – First case in USA

1/17– First U.S.-made test developed by CDC

https://www.thelancet.com/journals/lancet/article/PIIS0140-6736(20)30185-9/fulltext   https://www.sciencedirect.com/science/article/pii/S0896841120300469

SARS-CoV-2 is a virus

Envelope protein

Membrane protein

Spike protein

Nucleocapsid protein
Enclosing RNA

Lipid membrane

Manuel Bortoletti

COVID-19 is a <u>disease</u> caused by a novel coronavirus
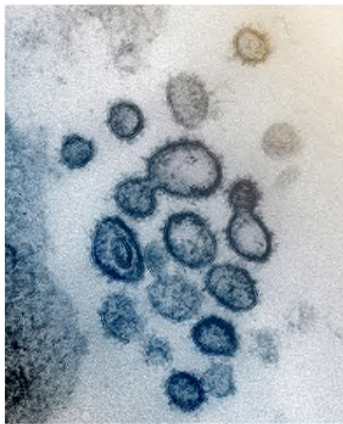
severe acute respiratory syndrome corona<u>virus</u> 2
(SARS-CoV-2).
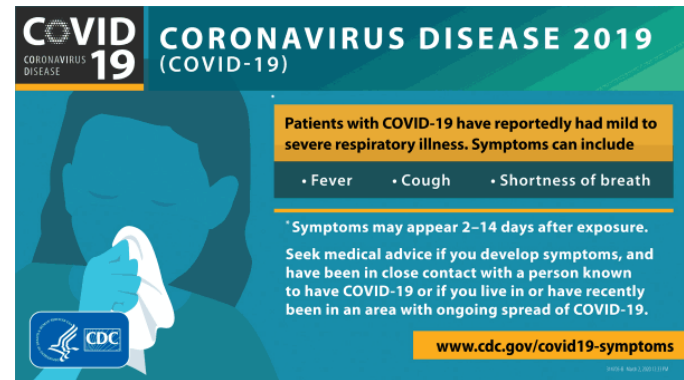
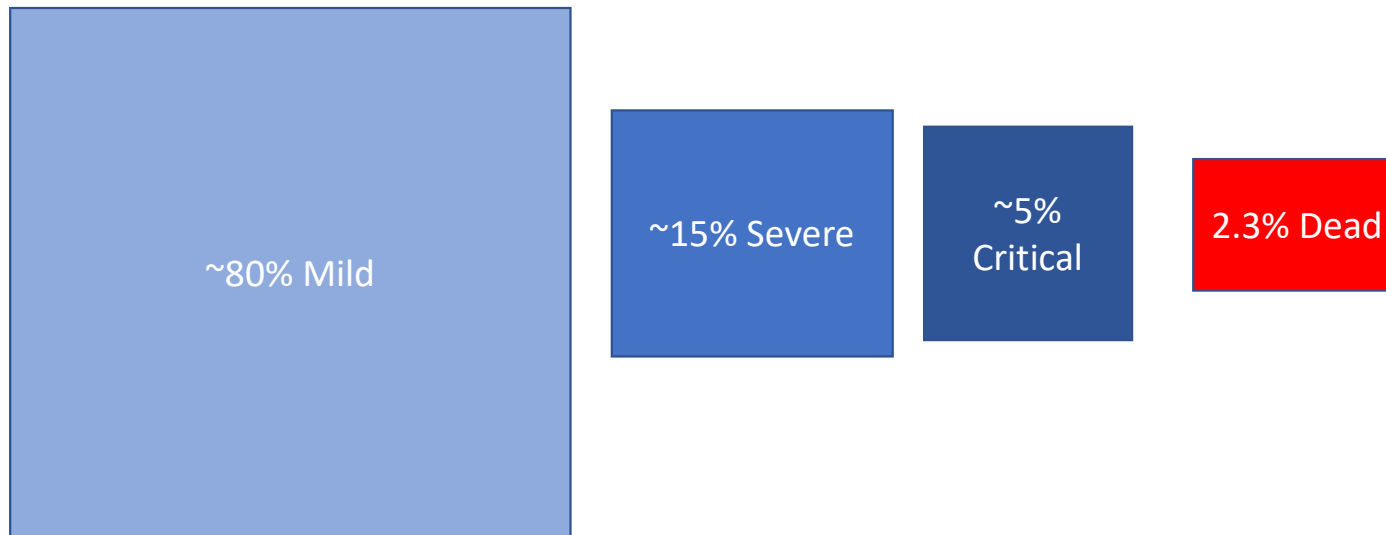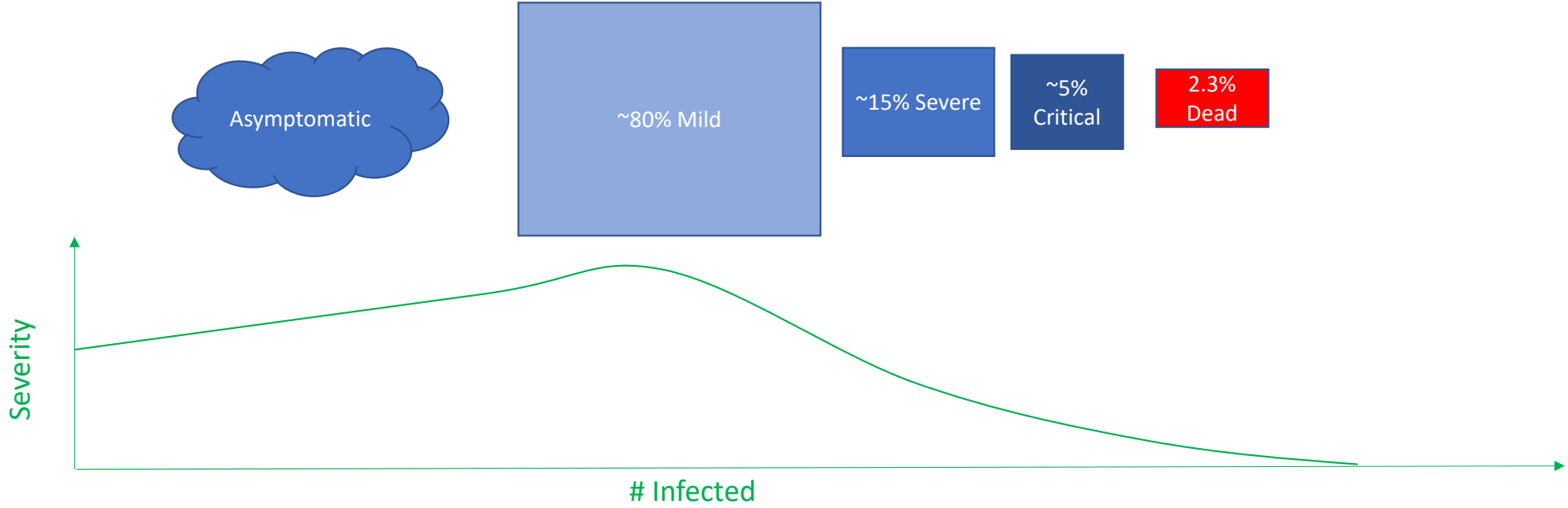coronavirus <u>disease</u> 2019 (COVID-19)

COVID-19 presents a huge range of symptoms in the individuals it affects "encompassing asymptomatic infection, mild upper respiratory tract illness, and severe viral pneumonia with respiratory failure and even death"

~80% Mild

~15% Severe

~5% Critical

2.3% Dead

Based on 44,672 *confirmed cases* in Hubei, China

https://www.thelancet.com/journals/lancet/article/PIIS0140-6736(20)30566-3/fulltext

https://www.ncbi.nlm.nih.gov/books/NBK554776/

https://www.ncbi.nlm.nih.gov/pubmed/32064853

The range of symptoms also extends to NO SYMPTOMS

Asymptomatic

~80% Mild

~15% Severe

~5% Critical

2.3% Dead

Severity

Infected

https://www.ncbi.nlm.nih.gov/books/NBK554776/

https://www.thelancet.com/journals/lancet/article/PIIS0140-6736(20)30566-3/fulltext

https://www.ncbi.nlm.nih.gov/pubmed/32064853

There may be many asymptomatic cases
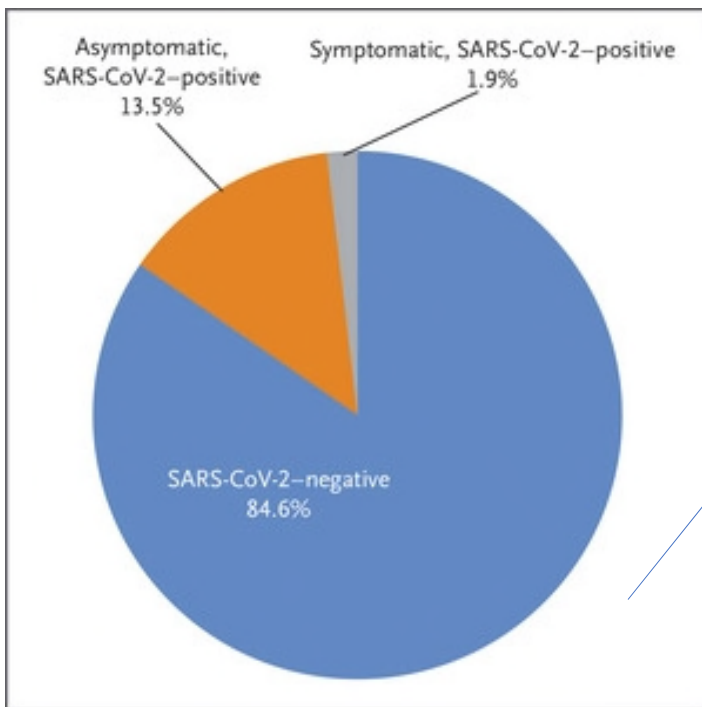
- Random invitation to ~2000 Icelanders, with 33% acceptance rate….resulted in discovering that **43% of cases were asymptomatic**.
  - Note that there were only 87 positive cases in this study

- Separately, screening of 214 mothers entering labor and delivery unit showed **13% asymptotic cases**
  - Small sample size

https://www.nejm.org/doi/full/10.1056/NEJMoa2006100?query=featured_home
https://www.nejm.org/doi/full/10.1056/NEJMc2009316

~90% of patients have fever whether case is severe or not (exclusive of asymptomatic)

Table 1. Clinical Characteristics of the Study Patients, According to Disease Severity and the Presence or Absence of the Primary Composite End Point.*

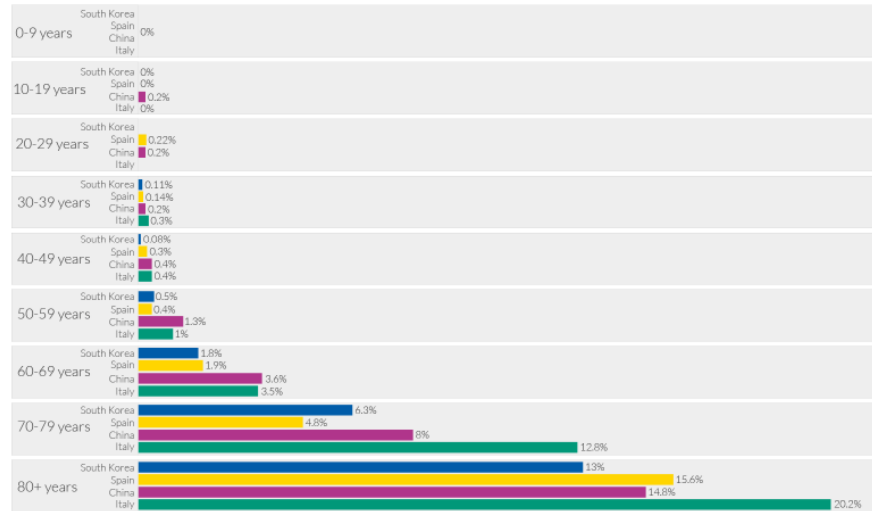| Characteristic	All Patients (N=1099)	Disease Severity		Presence of Primary Composite End Point†	
		Nonsevere (N=926)	Severe (N=173)	Yes (N=67)	No (N=1032)
Age					
Median (IQR) — yr	47.0 (35.0–58.0)	45.0 (34.0–57.0)	52.0 (40.0–65.0)	63.0 (53.0–71.0)	46.0 (35.0–57.0)
Distribution — no./total no. (%)					
0–14 yr	9/1011 (0.9)	8/848 (0.9)	1/163 (0.6)	0	9/946 (1.0)
15–49 yr	557/1011 (55.1)	490/848 (57.8)	67/163 (41.1)	12/65 (18.5)	545/946 (57.6)
50–64 yr	292/1011 (28.9)	241/848 (28.4)	51/163 (31.3)	21/65 (32.3)	271/946 (28.6)
≥65 yr	153/1011 (15.1)	109/848 (12.9)	44/163 (27.0)	32/65 (49.2)	121/946 (12.8)
Female sex — no./total no. (%)	459/1096 (41.9)	386/923 (41.8)	73/173 (42.2)	22/67 (32.8)	437/1029 (42.5)
Smoking history — no./total no. (%)					
Never smoked	927/1085 (85.4)	793/913 (86.9)	134/172 (77.9)	44/66 (66.7)	883/1019 (86.7)
Former smoker	21/1085 (1.9)	12/913 (1.3)	9/172 (5.2)	5/66 (7.6)	16/1019 (1.6)
Current smoker	137/1085 (12.6)	108/913 (11.8)	29/172 (16.9)	17/66 (25.8)	120/1019 (11.8)
Exposure to source of transmission within past 14 days — no./total no.					
Living in Wuhan	483/1099 (43.9)	400/926 (43.2)	83/173 (48.0)	39/67 (58.2)	444/1032 (43.0)
Contact with wildlife	13/687 (1.9)	10/559 (1.8)	3/128 (2.3)	1/41 (2.4)	12/646 (1.9)
Recently visited Wuhan‡	193/616 (31.3)	166/526 (31.6)	27/90 (30.0)	10/28 (35.7)	183/588 (31.1)
Had contact with Wuhan residents‡	442/611 (72.3)	376/522 (72.0)	66/89 (74.2)	19/28 (67.9)	423/583 (72.6)
Median incubation period (IQR) — days§	4.0 (2.0–7.0)	4.0 (2.8–7.0)	4.0 (2.0–7.0)	4.0 (1.0–7.5)	4.0 (2.0–7.0)
Fever on admission					
Patients — no./total no. (%)	473/1081 (43.8)	391/910 (43.0)	82/171 (48.0)	24/66 (36.4)	449/1015 (44.2)
Median temperature (IQR) — °C	37.3 (36.7–38.0)	37.3 (36.7–38.0)	37.4 (36.7–38.1)	36.8 (36.3–37.8)	37.3 (36.7–38.0)
Distribution of temperature — no./total no. (%)					
<37.5°C	608/1081 (56.2)	519/910 (57.0)	89/171 (52.0)	42/66 (63.6)	566/1015 (55.8)
37.5–38.0°C	238/1081 (22.0)	201/910 (22.1)	37/171 (21.6)	10/66 (15.2)	228/1015 (22.5)
38.1–39.0°C	197/1081 (18.2)	160/910 (17.6)	37/171 (21.6)	11/66 (16.7)	186/1015 (18.3)
>39.0°C	38/1081 (3.5)	30/910 (3.3)	8/171 (4.7)	3/66 (4.5)	35/1015 (3.4)
Fever during hospitalization					
Patients — no./total no. (%)	975/1099 (88.7)	816/926 (88.1)	159/173 (91.9)	59/67 (88.1)	916/1032 (88.8)

Study on ~1000 patients from Jan 31 in China

https://www.nejm.org/doi/pdf/10.1056/nejmoa2002032

~70% of patients had a cough & fatigue, regardless of non-severe vs. severe

Symptoms — no. (%)					
Conjunctival congestion	9 (0.8)	5 (0.5)	4 (2.3)	0	9 (0.9)
Nasal congestion	53 (4.8)	47 (5.1)	6 (3.5)	2 (3.0)	51 (4.9)
Headache	150 (13.6)	124 (13.4)	26 (15.0)	8 (11.9)	142 (13.8)
Cough	745 (67.8)	623 (67.3)	122 (70.5)	46 (68.7)	699 (67.7)
Sore throat	153 (13.9)	130 (14.0)	23 (13.3)	6 (9.0)	147 (14.2)
Sputum production	370 (33.7)	309 (33.4)	61 (35.3)	20 (29.9)	350 (33.9)
Fatigue	419 (38.1)	350 (37.8)	69 (39.9)	22 (32.8)	397 (38.5)
Hemoptysis	10 (0.9)	6 (0.6)	4 (2.3)	2 (3.0)	8 (0.8)
Shortness of breath	205 (18.7)	140 (15.1)	65 (37.6)	36 (53.7)	169 (16.4)
Nausea or vomiting	55 (5.0)	43 (4.6)	12 (6.9)	3 (4.5)	52 (5.0)
Diarrhea	42 (3.8)	32 (3.5)	10 (5.8)	4 (6.0)	38 (3.7)
Myalgia or arthralgia	164 (14.9)	134 (14.5)	30 (17.3)	6 (9.0)	158 (15.3)
Chills	126 (11.5)	100 (10.8)	26 (15.0)	8 (11.9)	118 (11.4)
Signs of infection — no. (%)					
Throat congestion	19 (1.7)	17 (1.8)	2 (1.2)	0	19 (1.8)
Tonsil swelling	23 (2.1)	17 (1.8)	6 (3.5)	1 (1.5)	22 (2.1)
Enlargement of lymph nodes	2 (0.2)	1 (0.1)	1 (0.6)	1 (1.5)	1 (0.1)
Rash	2 (0.2)	0	2 (1.2)	0	2 (0.2)
Coexisting disorder — no. (%)					
Any	261 (23.7)	194 (21.0)	67 (38.7)	39 (58.2)	222 (21.5)
Chronic obstructive pulmonary disease	12 (1.1)	6 (0.6)	6 (3.5)	7 (10.4)	5 (0.5)
Diabetes	81 (7.4)	53 (5.7)	28 (16.2)	18 (26.9)	63 (6.1)
Hypertension	165 (15.0)	124 (13.4)	41 (23.7)	24 (35.8)	141 (13.7)
Coronary heart disease	27 (2.5)	17 (1.8)	10 (5.8)	6 (9.0)	21 (2.0)
Cerebrovascular disease	15 (1.4)	11 (1.2)	4 (2.3)	4 (6.0)	11 (1.1)
Hepatitis B infection¶	23 (2.1)	22 (2.4)	1 (0.6)	1 (1.5)	22 (2.1)
Cancer‖	10 (0.9)	7 (0.8)	3 (1.7)	1 (1.5)	9 (0.9)
Chronic renal disease	8 (0.7)	5 (0.5)	3 (1.7)	2 (3.0)	6 (0.6)
Immunodeficiency	2 (0.2)	2 (0.2)	0	0	2 (0.2)

* The denominators of patients who were included in the analysis are provided if they differed from the overall numbers in the group. Percentages may not total 100 because of rounding. Covid-19 denotes coronavirus disease 2019, and IQR interquartile range.
‡ The primary composite end point was admission to an intensive care unit, the use of mechanical ventilation, or death

The elderly and/or those with underlying conditions are most at-risk

Coronavirus: case fatality rates by age

Coronavirus: early-stage case fatality rates by underlying health condition in China

https://www.medrxiv.org/content/medrxiv/early/2020/03/06/2020.02.25.20027672.full.pdf
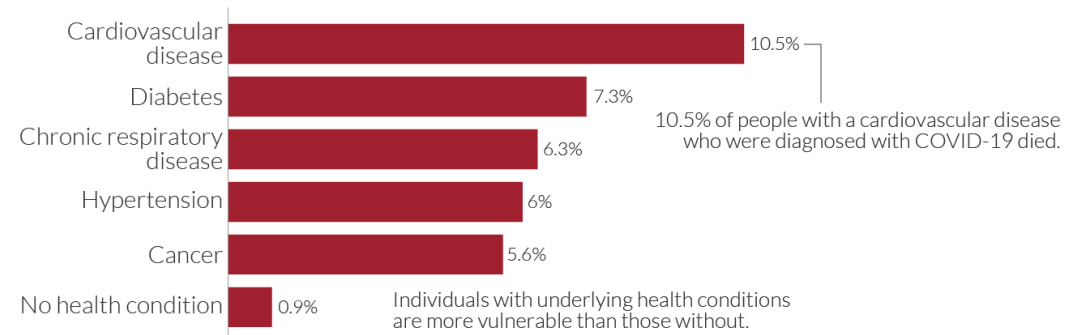
Therefore, keep demographics in mind when looking at CFR by county

Share of the population that is 70 years and older, 2015

Our World in Data

No data 0%   2%   4%   8%   12%   16%   20%

Source: UN Population Division (2017 Revision)

CC BY
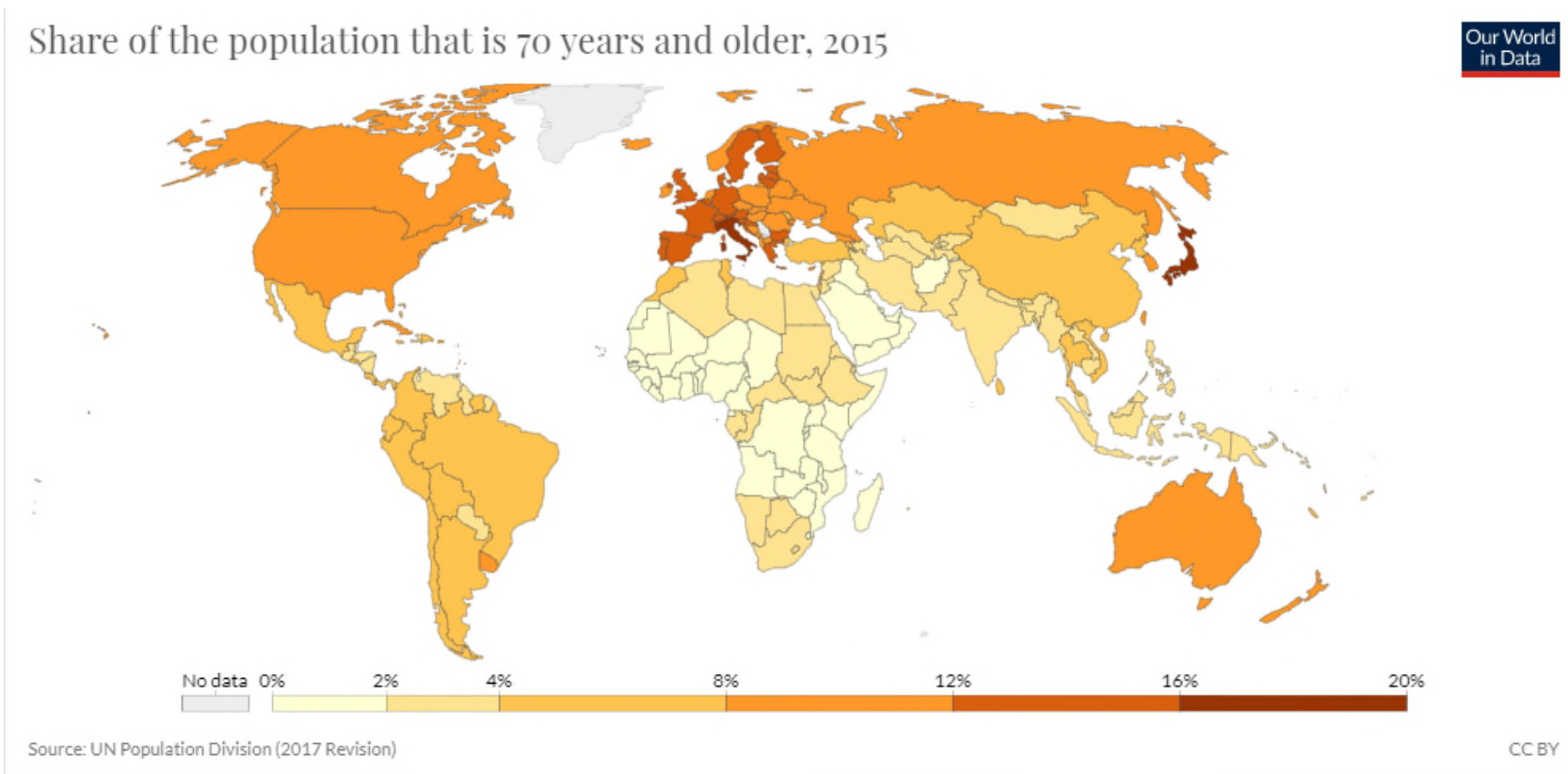
Also keep government transparency in mind (for which democracy index may serve as a suitlable proxy)

Global Democracy Index rates, by country/territory (2019)*
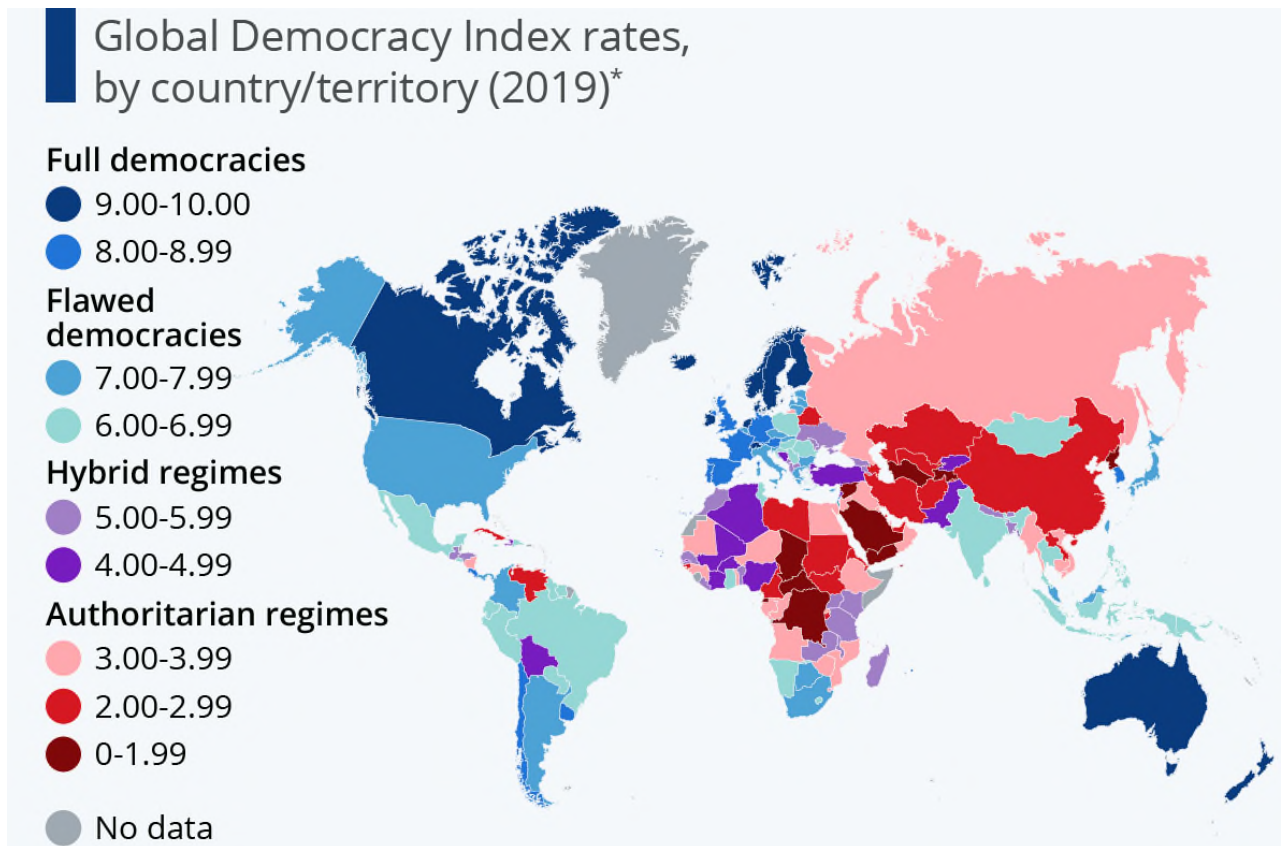
The Economist Intelligence Unit

Children are less severely impacted by the disease

- **Fever was present in only 41.5% of the infected children at any time during the illness**.
  - Other common signs and symptoms included cough and pharyngeal erythema (red throat)
- A total of 27 patients **(15.8%) did not have any symptoms of infection** or radiologic features of pneumonia.
- A total of 12 **(~7%) patients had radiologic features of pneumonia but did not have any symptoms of infection**.

Study of 1400 children in china….of which only 12.3% were infected….low sample size!

https://www.nejm.org/doi/full/10.1056/NEJMc2005073

# If you get COVID-19 you might be contagious for a while…and almost certainly prior to symptoms presenting
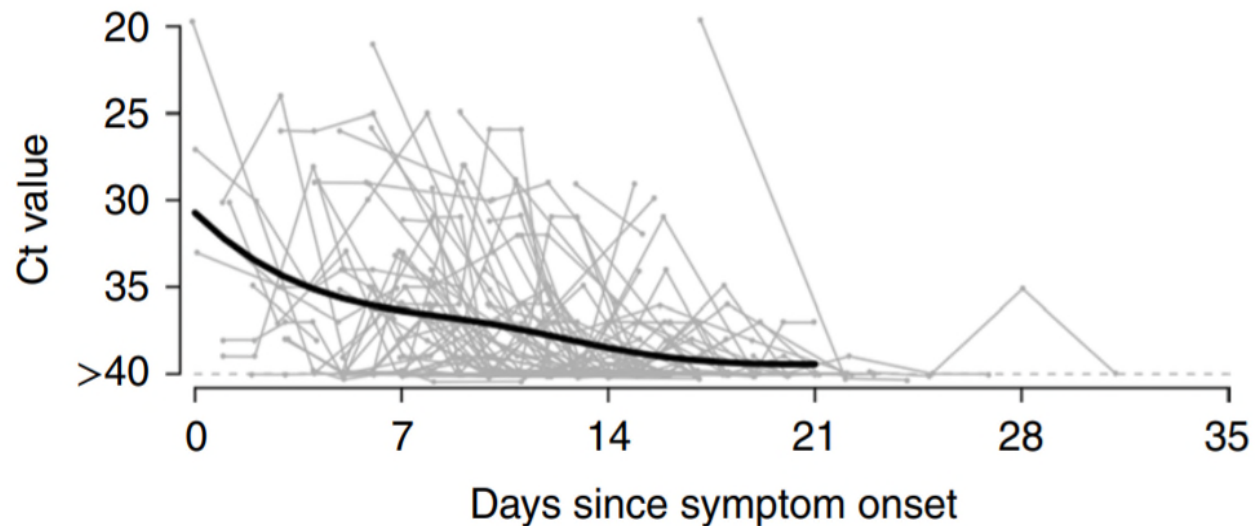
"We estimated that 44% (95% confidence interval, 25–69%) of secondary cases were infected during the index cases' presymptomatic stage"

https://www.thelancet.com/journals/lancet/article/PIIS0140-6736(20)30566-3/fulltext

https://www.nature.com/articles/s41591-020-0869-5.pdf

Coronavirus can live on surfaces for some period of time (surface – hands- face mechanism)
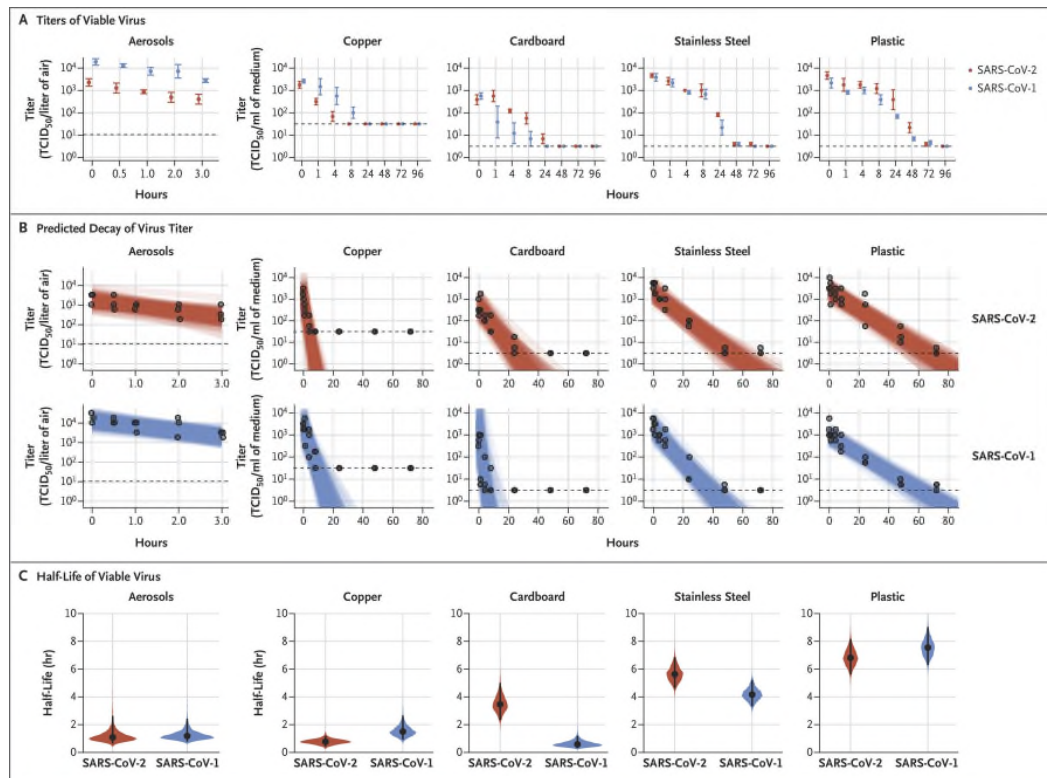
- On cardboard, no viable SARS-CoV-2 was measured after 24 hours

https://www.nejm.org/doi/full/10.1056/NEJMc2004973

COVID-19, like many diseases, started in animals

96% genetic match with original sars tracked from bats for sure, but 4% is huge difference....chimps vs humans,

https://www.thelancet.com/pdfs/journals/lancet/PIIS0140-6736(20)30251-8.pdf
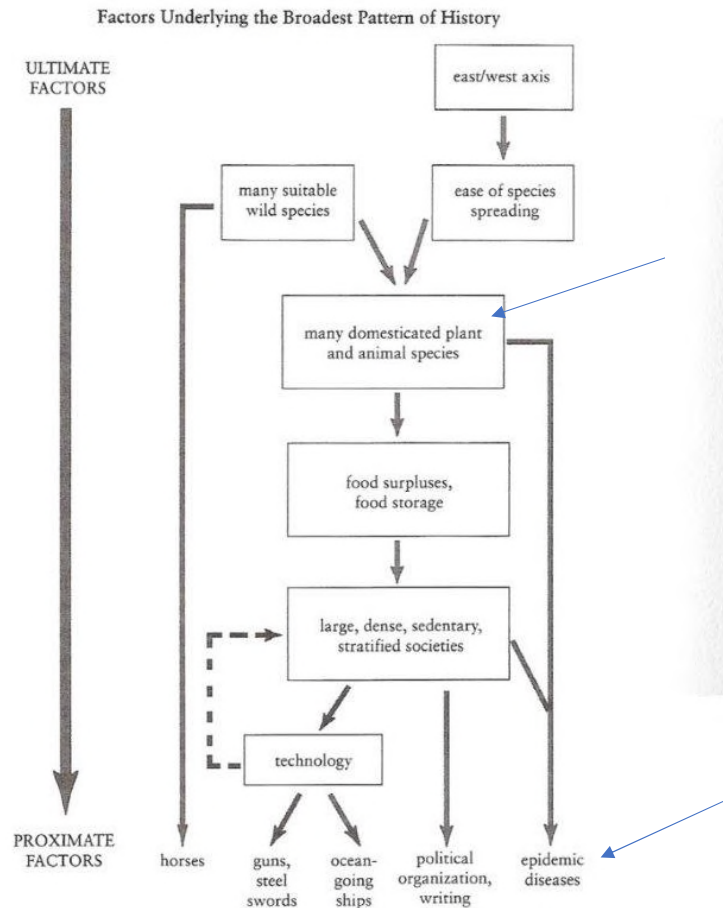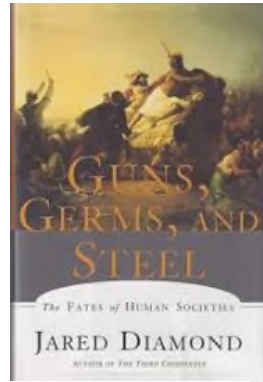
COVID-19, like many diseases, started in animals

Factors Underlying the Broadest Pattern of History

ULTIMATE FACTORS

east/west axis

many suitable wild species → ease of species spreading

many domesticated plant and animal species

food surpluses, food storage

large, dense, sedentary, stratified societies

technology

PROXIMATE FACTORS

horses | guns, steel swords | ocean-going ships | political organization, writing | epidemic diseases

TABLE 11.1 Deadly Gifts from Our Animal Friends

Human Disease	Animal with Most Closely Related Pathogen
Measles	cattle (rinderpest)
Tuberculosis	cattle
Smallpox	cattle (cowpox) or other livestock with related pox viruses
Flu	pigs and ducks
Pertussis	pigs, dogs
Falciparum malaria	birds (chickens and ducks?)

GUNS, GERMS, AND STEEL

The Fates of Human Societies

JARED DIAMOND

From animals, COVID 19 has spread to nearly every country, April 28
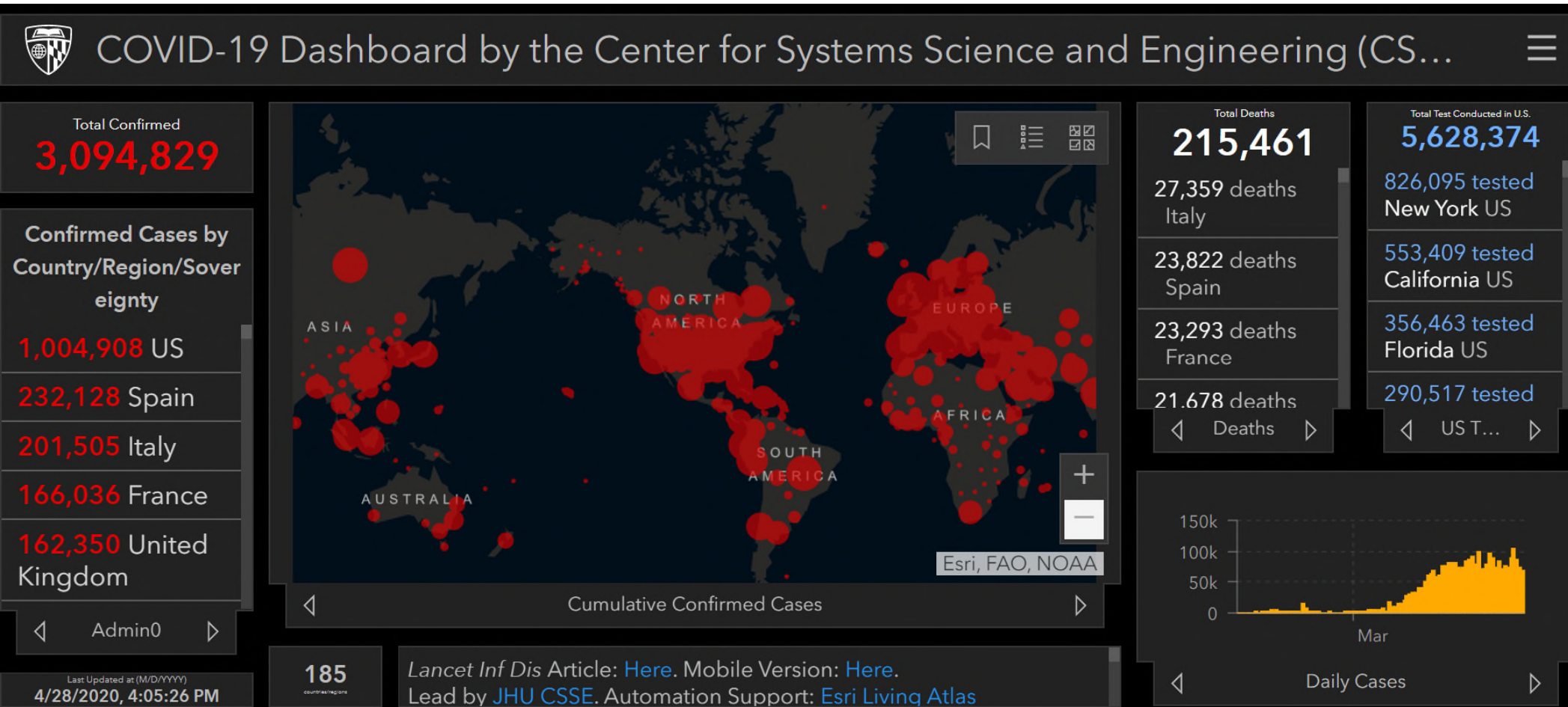
Remember trackers under-estimate both cases and deaths....and are out of date

One academic study indicates that only ~10% of COVID-19 cases are confirmed (making transmissibility and mortality rates difficult to pinpoint)

The Rate of Underascertainment of Novel Coronavirus (2019-nCoV) Infection: Estimation Using Japanese Passengers Data on Evacuation Flights

by ⊙ Hiroshi Nishiura [1,2,*] ✉ ⊙, ⊙ Tetsuro Kobayashi [1] ✉, ⊙ Yichi Yang [1] ✉, ⊙ Katsuma Hayashi [1] ✉, ⊙ Takeshi Miyama [3] ✉, ⊙ Ryo Kinoshita [1] ✉ ⊙, ⊙ Natalie M. Linton [1] ✉ ⊙, ⊙ Sung-mok Jung [1] ✉ ⊙, ⊙ Baoyin Yuan [1] ✉, ⊙ Ayako Suzuki [1] ✉ and ⊙ Andrei R. Akhmetzhanov [1] ⊙

[1] Graduate School of Medicine, Hokkaido University, Kita 15 Jo Nishi 7 Chome, Kita-ku, Sapporo-shi, Hokkaido 060-8638, Japan
[2] Core Research for Evolutionary Science and Technology, Japan Science and Technology Agency, Honcho 4-1-8, Kawaguchi, Saitama 332-0012, Japan
[3] Osaka Institute of Public Health, Nakamichi 1-3-69, Higashinari, Osaka 537-0025, Japan
* Author to whom correspondence should be addressed.

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Abstract: From 29 to 31 January 2020, a total of 565 Japanese citizens were evacuated from Wuhan, China on three chartered flights. All passengers were screened upon arrival in Japan for symptoms consistent with novel coronavirus (2019-nCoV) infection and tested for presence of the virus. Assuming that the mean detection window of the virus can be informed by the mean serial interval (estimated at 7.5 days), the ascertainment rate of infection was estimated at 9.2% (95% confidence interval: 5.0, 20.0). This indicates that the incidence of infection in Wuhan can be estimated at 20,767 infected individuals, including those with asymptomatic and mildly symptomatic infections. The infection fatality risk (IFR)—the actual risk of death among all infected individuals—is therefore 0.3% to 0.6%, which may be comparable to Asian influenza pandemic of 1957–1958.

- https://www.mdpi.com/2077-0383/9/2/419/htm

https://www.advisory.com/daily-briefing/2019/01/16/deaths

Anecdotal reports from news media support a ~10x multiplier

- Los Angeles: 4.1% actually infected (28x to 55x the Confirmed Case Count) – particularly controversial study

- New York State: 13.9% actually infected (~10x the confirmed case count)

- Miami-Dade: 6% actually infected (~15x confirmed case count)

https://news.usc.edu/168987/antibody-testing-results-covid-19-infections-los-angeles-county/

https://www.syracuse.com/coronavirus/2020/04/new-york-antibody-tests-27-million-possibly-infected-with-coronavirus-statewide.html
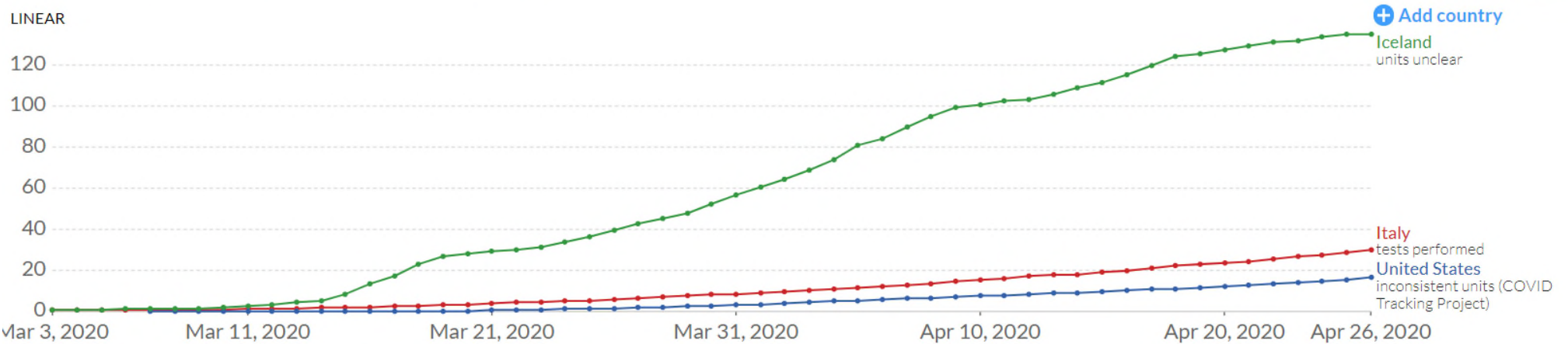https://www.miamiherald.com/news/coronavirus/article242260406.html

With that in mind, testing remains a limitation to understanding

Total COVID-19 tests per 1,000 people

Source: Official sources collated by Our World in Data
Note: For testing figures, there are substantial differences across countries in terms of the units, whether or not all labs are included, the extent to which negative and pending tests are included and other aspects. Details for each country can be found at the linked page.

OurWorldInData.org/coronavirus • CC BY

Testing remains a limitation to understanding

Daily COVID-19 tests per thousand, rolling 3-day average

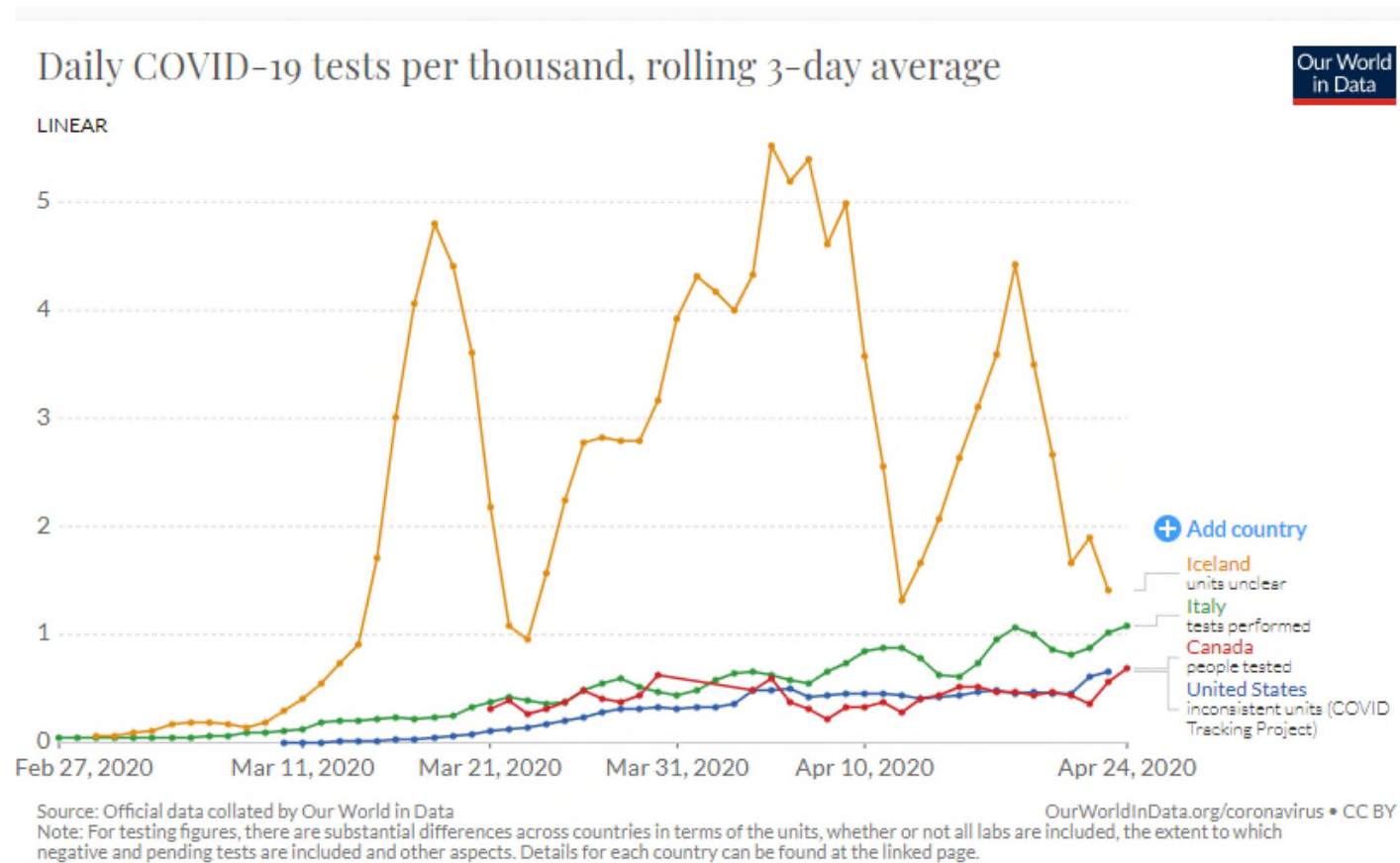Source: Official data collated by Our World in Data
Note: For testing figures, there are substantial differences across countries in terms of the units, whether or not all labs are included, the extent to which negative and pending tests are included and other aspects. Details for each country can be found at the linked page.
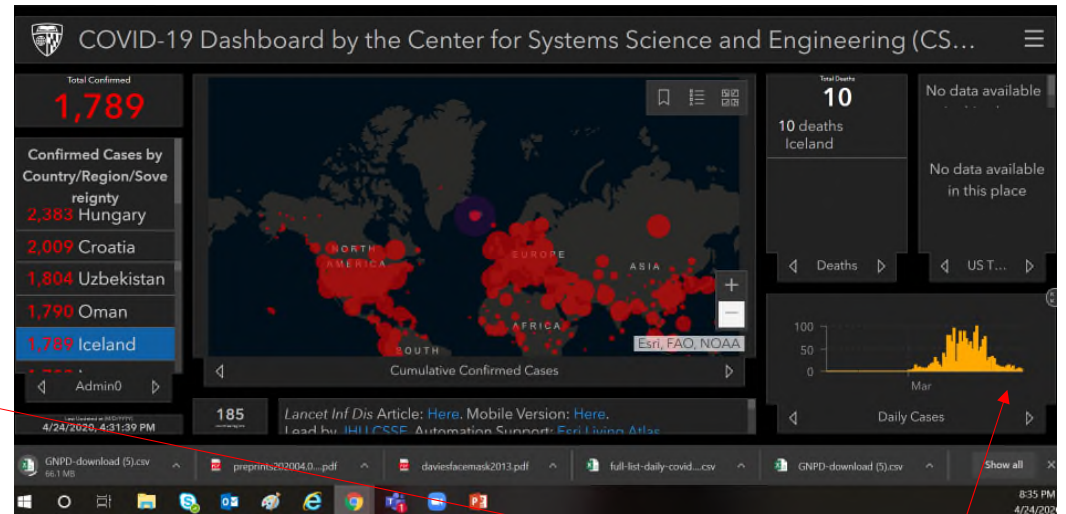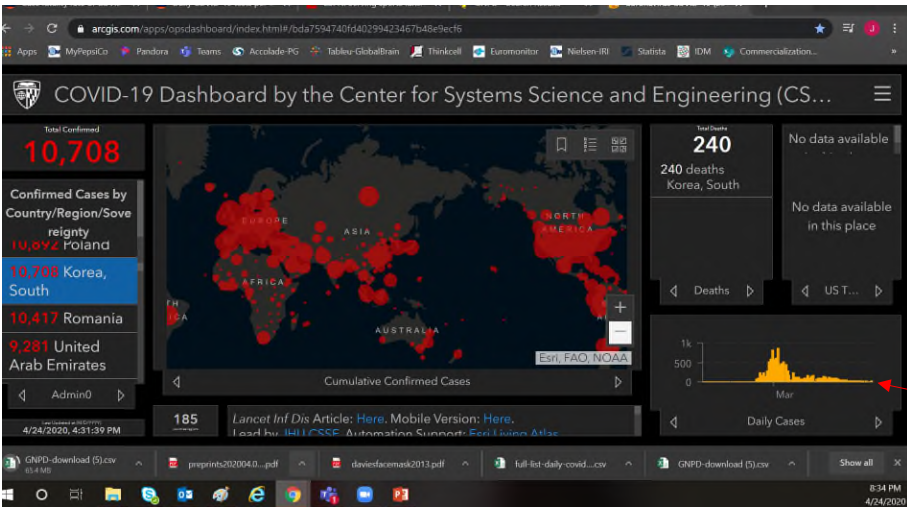OurWorldInData.org/coronavirus • CC BY

South Korea and <u>Iceland</u>, with their aggressive early testing and democratic ideals can inform CFR vs IFR

South Korea

Iceland

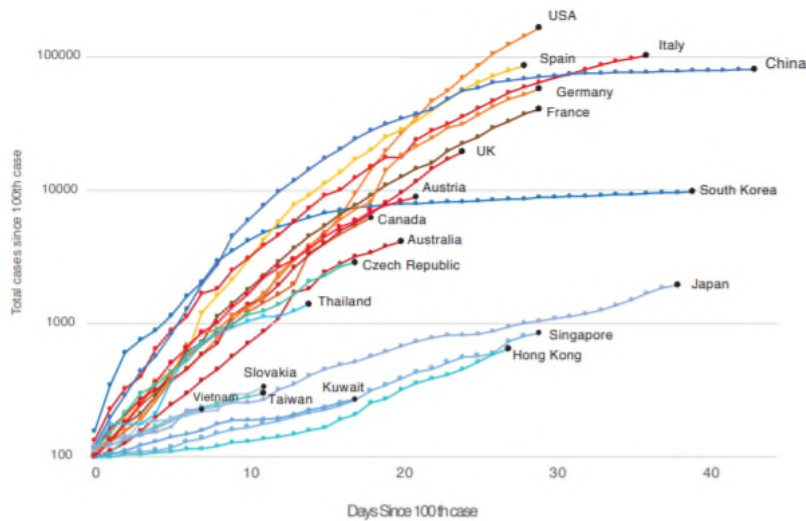Past Peak!

	South Korea	Iceland	USA
Total Tests/1000 People	11	132	14
Positive test rate	~2%	~4%	~20%
CFR	2.2%	0.6%	5.8%
IFR	n/a	n/a	n/a

Anecdotal evidence suggest the low-cost intervention of masks results in high RoI

Figure 3. Western countries (US, Canada, Australia, UK, Western Europe) with late mask adoption or no use of masks, versus countries and territories with early use of masks as part of official government or in practice policy (China, South Korea, Japan, Hong Kong, Taiwan, Vietnam, Thailand, Kuwait, Slovakia, Czech Republic, in blues and greens). Countries with early mask usage tend to have flatter curves, even without the use of lockdowns.

file:///C:/Users/71048825/Downloads/preprints202004.0021.v2.pdf
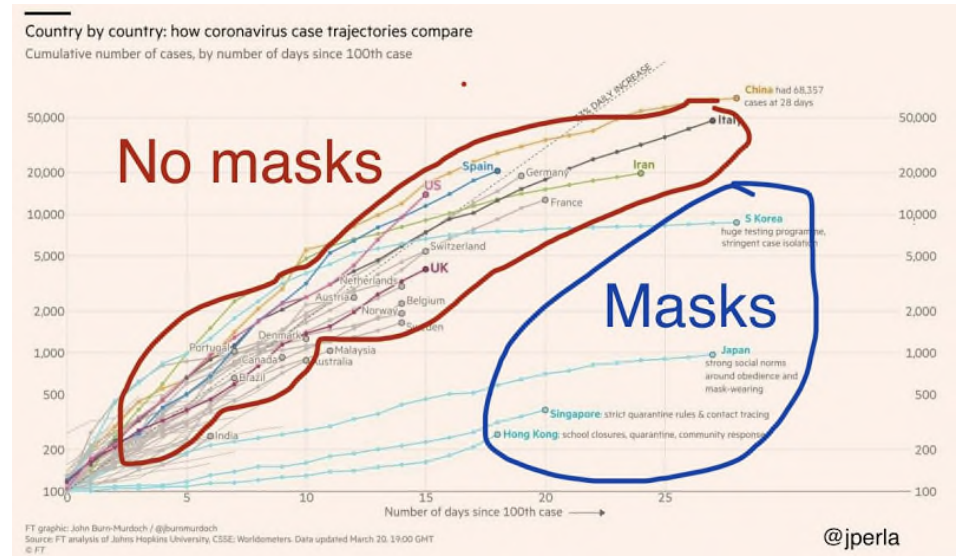
Small reductions in transmission make a big difference

Effect of small reductions of R on cases over time
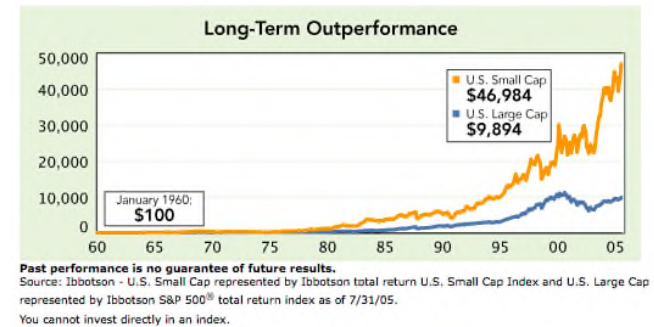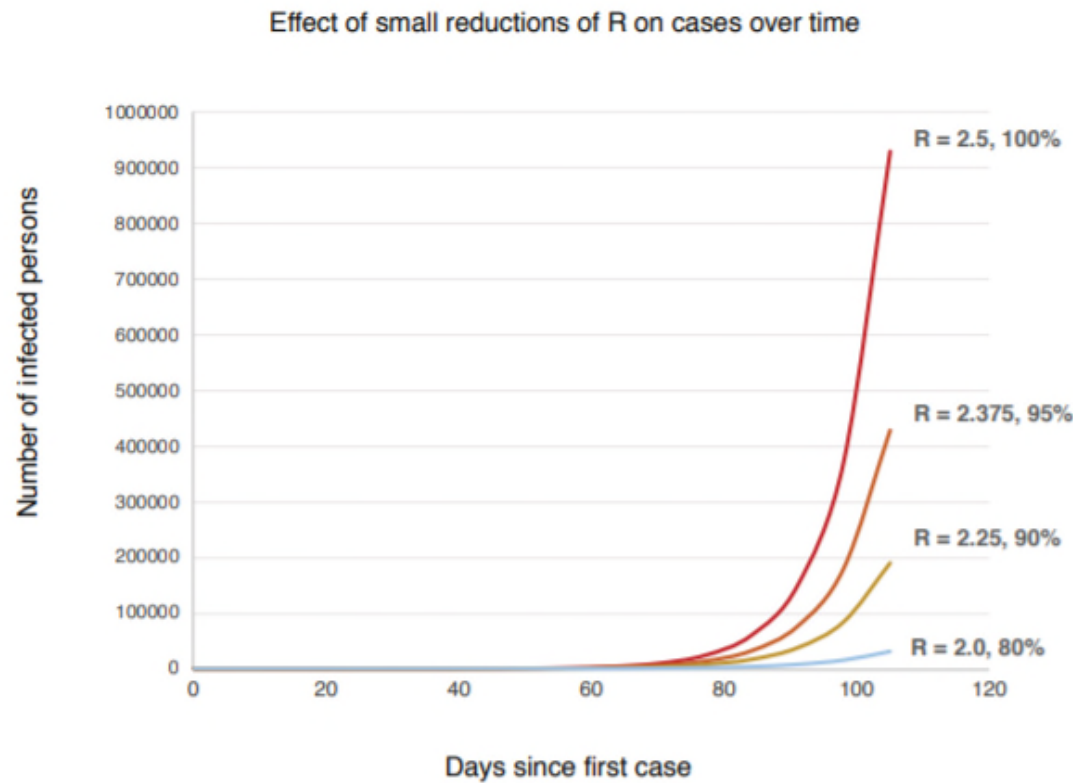
Figure 2. A simple model showing exponential growth in an uncontained outbreak over time (generation time = 7 days, R0 = 2.5) and with small reductions in the reproductive rate R.

Vacuum cleaner bags are the material of choice for home-made masks

Material	B atrophaeus		Bacteriophage MS2		Pressure Drop Across Fabric	
	Mean % Filtration Efficiency	SD	Mean % Filtration Efficiency	SD	Mean	SD
100% cotton T-shirt	69.42 (70.66)	10.53 (6.83)	50.85	16.81	4.29 (5.13)	0.07 (0.57)
Scarf	62.30	4.44	48.87	19.77	4.36	0.19
Tea towel	83.24 (96.71)	7.81 (8.73)	72.46	22.60	7.23 (12.10)	0.96 (0.17)
Pillowcase	61.28 (62.38)	4.91 (8.73)	57.13	10.55	3.88 (5.50)	0.03 (0.26)
Antimicrobial Pillowcase	65.62	7.64	68.90	7.44	6.11	0.35
Surgical mask	96.35	0.68	89.52	2.65	5.23	0.15
Vacuum cleaner bag	94.35	0.74	85.95	1.55	10.18	0.32
Cotton mix	74.60	11.17	70.24	0.08	6.18	0.48
Linen	60.00	11.18	61.67	2.41	4.50	0.19
Silk	58.00	2.75	54.32	29.49	4.57	0.31

[a] Numbers in parentheses refer to the results from 2 layers of fabric.

Note that surgical masks tend to fit/seal better than home-made masks as well

https://www.researchgate.net/publication/258525804_Testing_the_Efficacy_of_Homemade_Masks_Would_They_Protect_in_an_Influenza_Pandemic
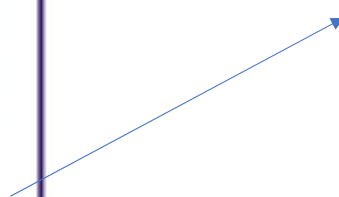
Homemade masks are much better than nothing

TABLE 4

Total Colony-Forming Units Isolated by Particle Size From 21 Volunteers Coughing When Wearing a Surgical Mask, Homemade Mask, and No Mask			
Particle Diameter, μm	No Mask	Homemade Mask	Surgical Mask
>7	9	3	5
4.7-7	18	7	7
3.3-4.7	5	4	4
2.1-3.3	47	7	5
1.1-2.1	100	16	6
0.65-1.1	21	6	3
Total	200	43	30

Coronavirus is 0.12 um, **excluding** spikes

Takeaways

- The st. deviation of COVID-19 outcomes is huge challenge
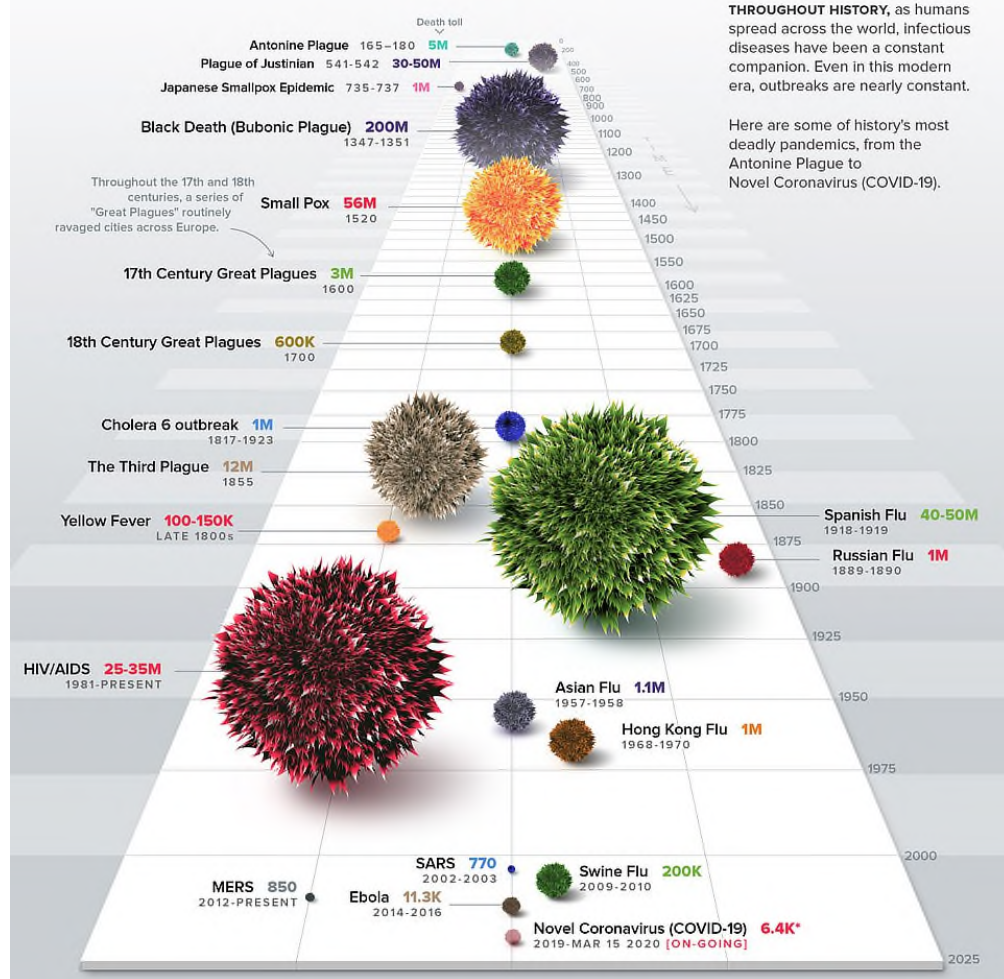
- Small reductions in transmission rate make big difference

- Break the lipid layer

This talk will proceed in 3 waves

- Science-based background

- Historian-based background of past pandemics

- What the above *might* mean for the months and years ahead

HISTORY OF **PANDEMICS**

PAN·DEM·IC (of a disease) prevalent over a whole country or the world.

THROUGHOUT HISTORY, as humans spread across the world, infectious diseases have been a constant companion. Even in this modern era, outbreaks are nearly constant.

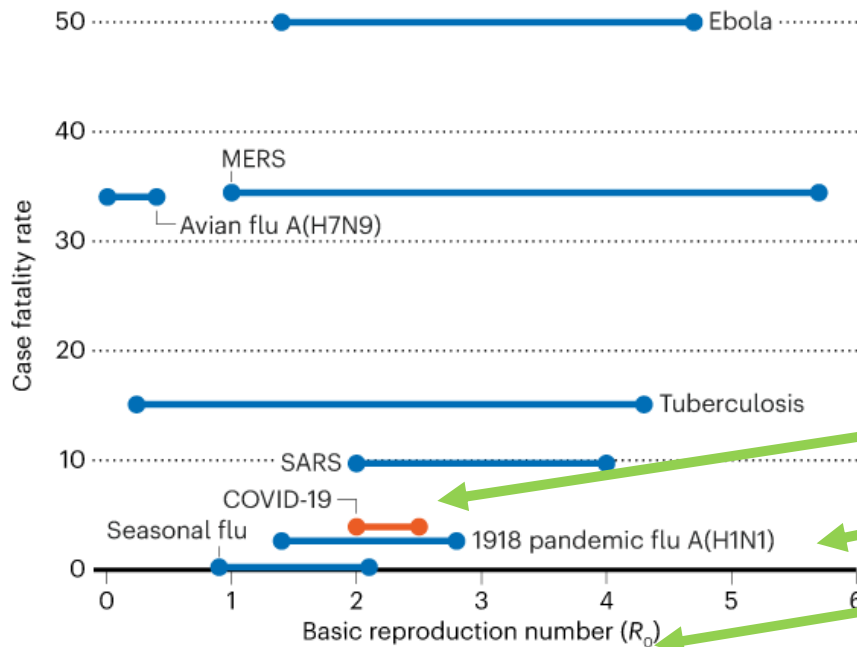Here are some of history's most deadly pandemics, from the Antonine Plague to Novel Coronavirus (COVID-19).

Death toll

Pandemic	Dates	Death toll
Antonine Plague	165–180	5M
Plague of Justinian	541-542	30-50M
Japanese Smallpox Epidemic	735-737	1M
Black Death (Bubonic Plague)	1347-1351	200M
Small Pox	1520	56M
17th Century Great Plagues	1600	3M
18th Century Great Plagues	1700	600K
Cholera 6 outbreak	1817-1923	1M
The Third Plague	1855	12M
Yellow Fever	LATE 1800s	100-150K
Spanish Flu	1918-1919	40-50M
Russian Flu	1889-1890	1M
HIV/AIDS	1981-PRESENT	25-35M
Asian Flu	1957-1958	1.1M
Hong Kong Flu	1968-1970	1M
SARS	2002-2003	770
MERS	2012-PRESENT	850
Ebola	2014-2016	11.3K
Swine Flu	2009-2010	200K
Novel Coronavirus (COVID-19)	2019-MAR 15 2020 [ON-GOING]	6.4K*

Throughout the 17th and 18th centuries, a series of "Great Plagues" routinely ravaged cities across Europe.

Timeline years: 0, 200, 400, 500, 600, 700, 800, 900, 1000, 1100, 1200, 1300, 1400, 1450, 1500, 1550, 1600, 1625, 1650, 1675, 1700, 1725, 1750, 1775, 1800, 1825, 1850, 1875, 1900, 1925, 1950, 1975, 2000, 2025

COVID-19 has the potential to kill millions

◈ March 18th, 2020

COVID-19 VS OTHER DISEASES

Estimates suggest the COVID-19 coronavirus is less deadly than the related illnesses SARS or MERS, but more infectious (R_0) than seasonal influenza.

- **Spanish flu infected ~27% of population**

- **~5% of all Indian citizens were killed by Spanish Flu**

- **US Population was ~20% "urban" at that time (80% "urban" now)**

https://www.nature.com/articles/d41586-020-00758-2

[Chart: Case fatality rate vs Basic reproduction number (R_0), showing Ebola, MERS, Avian flu A(H7N9), Tuberculosis, SARS, COVID-19, Seasonal flu, and 1918 pandemic flu A(H1N1). ©nature]
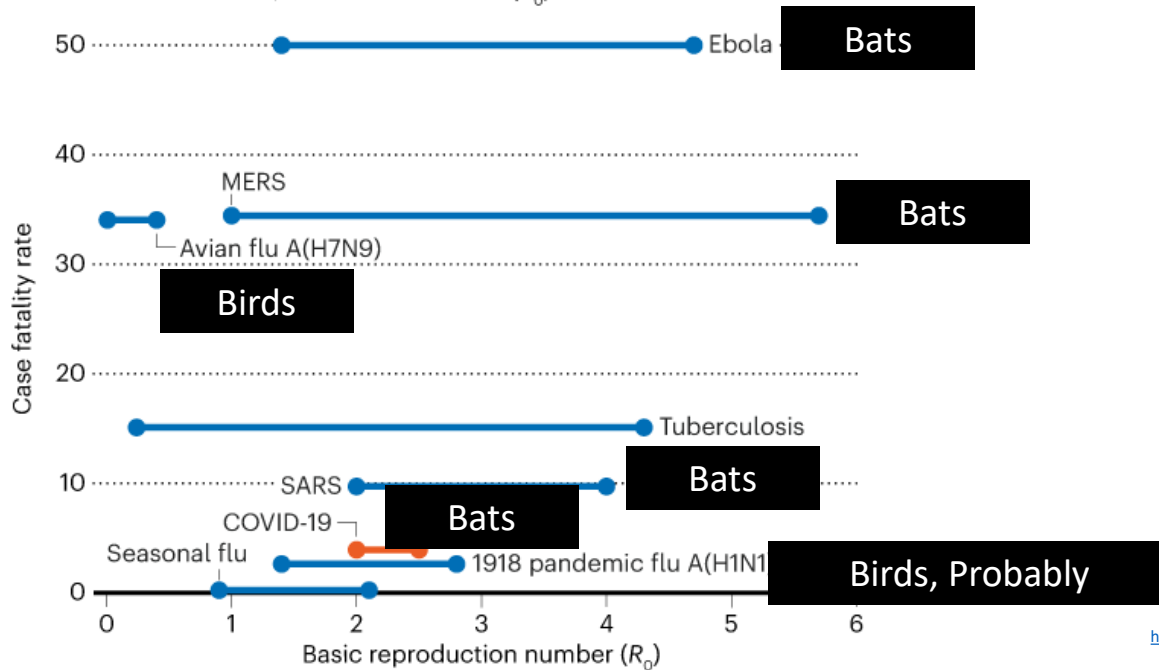
COVID-19 has the potential to kill millions
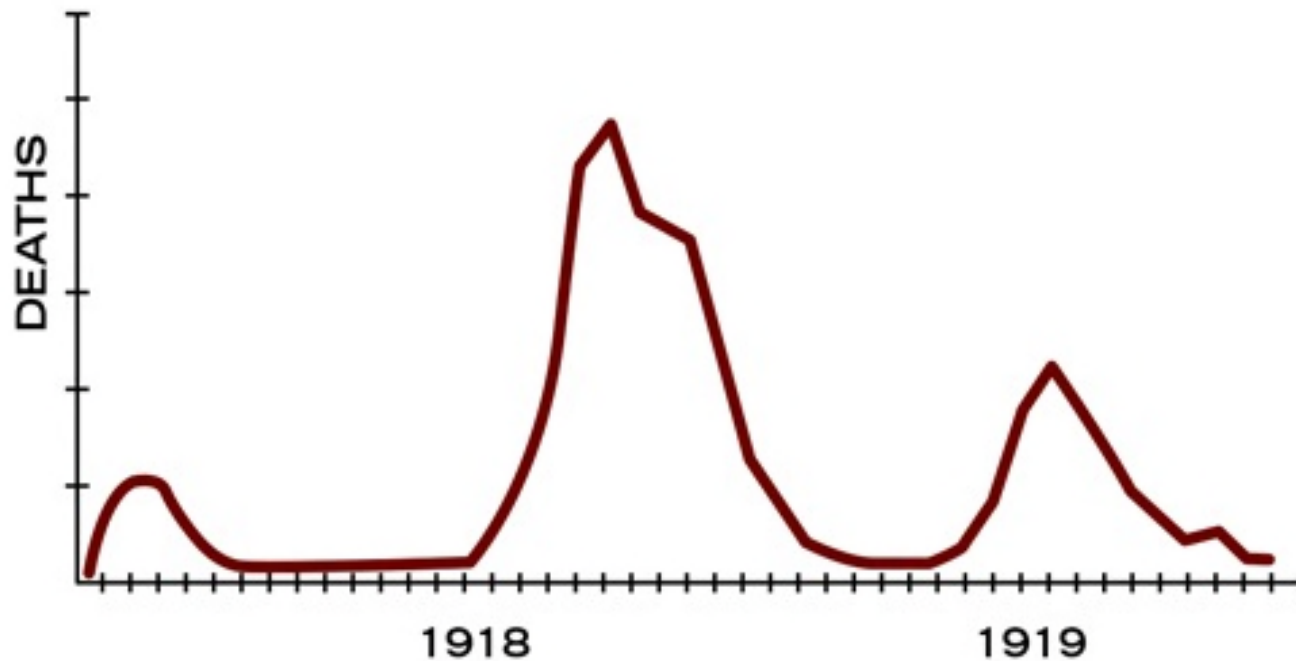
◈ March 18th, 2020

COVID-19 VS OTHER DISEASES
Estimates suggest the COVID-19 coronavirus is less deadly than the related illnesses SARS or MERS, but more infectious (R_0) than seasonal influenza.

Case fatality rate

- 50 ········· Ebola — **Bats**
- 40
- MERS — **Bats**
- Avian flu A(H7N9)
- 30 **Birds**
- 20
- Tuberculosis
- 10 ········· SARS — **Bats**
- COVID-19 — **Bats**
- Seasonal flu — 1918 pandemic flu A(H1N1) — **Birds, Probably**
- 0

Basic reproduction number (R_0)

©nature

https://www.nature.com/articles/d41586-020-00758-2

https://www.ncbi.nlm.nih.gov/pmc/articles/PMC2720273/

The Spanish Flu came in 3 waves, Spring '18 – Fall'18 – Spring '19

https://www.cdc.gov/flu/pandemic-resources/1918-commemoration/three-waves.htm

file:///C:/Users/71048825/Downloads/NBER_WhitePaper_Pandemic_economic_effect.pdf

PA Police enforce physical distancing in Oct. 1918

Effects of social distancing on 1918 flu deaths

250
deaths per
100,000 people

200

150

Social
distancing
interventions
first enacted,
Oct. 3

100

Philadelphia

50

First case in
Philadelphia,
Sept. 17

0

First case in St. Louis, Oct. 5
Social distancing
enacted Oct. 7

St. Louis

SEPT   OCT   NOV   DEC

1918

As the first cases of the 1918 flu were reported in Philadelphia in September 1918, authorities played down the significance and allowed public gatherings to continue. Closures in Philadelphia were only enacted once the virus had spread. The first cases in St. Louis were reported in early October, with measures to contain the spread enacted two days later. This resulted in a slower spread and lower mortality rate.

Sources: "Public health interventions and epidemic intensity during the 1918 influenza pandemic" by Richard J. Hatchett, Carter E. Mecher, Marc Lipsitch, Proceedings of the National Academy of Sciences May, 2007. Data derived from "Public health interventions and epidemic intensity during the 1918 influenza pandemic" by Richard J. Hatchett, Carter E. Mecher, Marc Lipsitch, Proceedings of the National Academy of Sciences May, 2007.
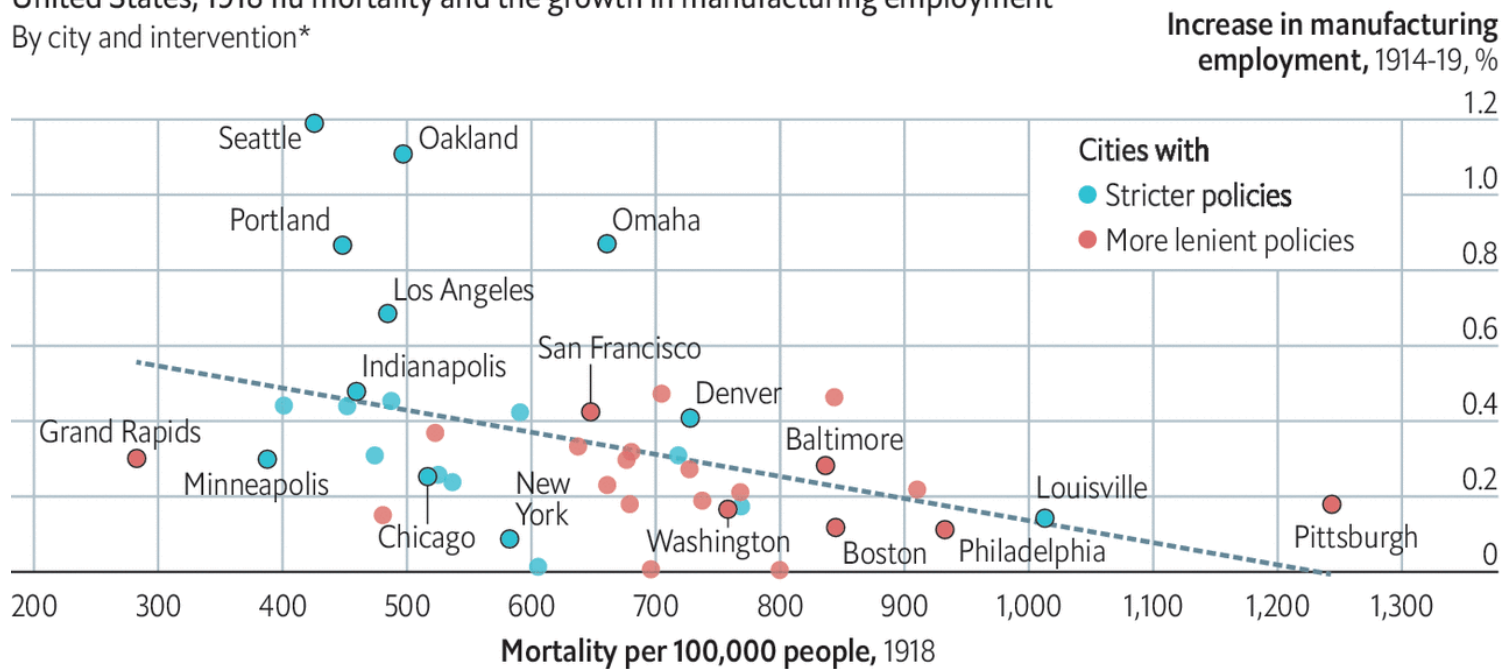
TIM MEKO/THE WASHINGTON POST

NPI's are a win-win

Necessary precautions

United States, 1918 flu mortality and the growth in manufacturing employment
By city and intervention*

Increase in manufacturing employment, 1914-19, %

Cities with
- Stricter policies
- More lenient policies

Seattle
Oakland
Portland
Omaha
Los Angeles
San Francisco
Indianapolis
Denver
Grand Rapids
Baltimore
Minneapolis
New York
Louisville
Chicago
Washington
Pittsburgh
Boston
Philadelphia

Mortality per 100,000 people, 1918

Source: "Pandemics depress the economy, public health interventions do not: evidence from the 1918 flu" by S. Correia, S. Luck and E. Verner, 2020

*Non-pharmaceutical measures, e.g. social distancing, closing schools and churches, mandatory face masks

The Economist

88 day avg. social distancing

"The impact of this pandemic was not limited to 1918–1919. All influenza A pandemics since that time, and indeed almost all cases of influenza A worldwide (excepting human infections from avian viruses such as H5N1 and H7N7), have been caused by descendants of the 1918 virus, including "drifted" H1N1 viruses and reassorted H2N2 and H3N2 viruses. "

This talk will proceed in three waves

- Science-based background (mostly review for all the arm-chair epidemiologist's we've become)

- Historian-based background of past pandemics

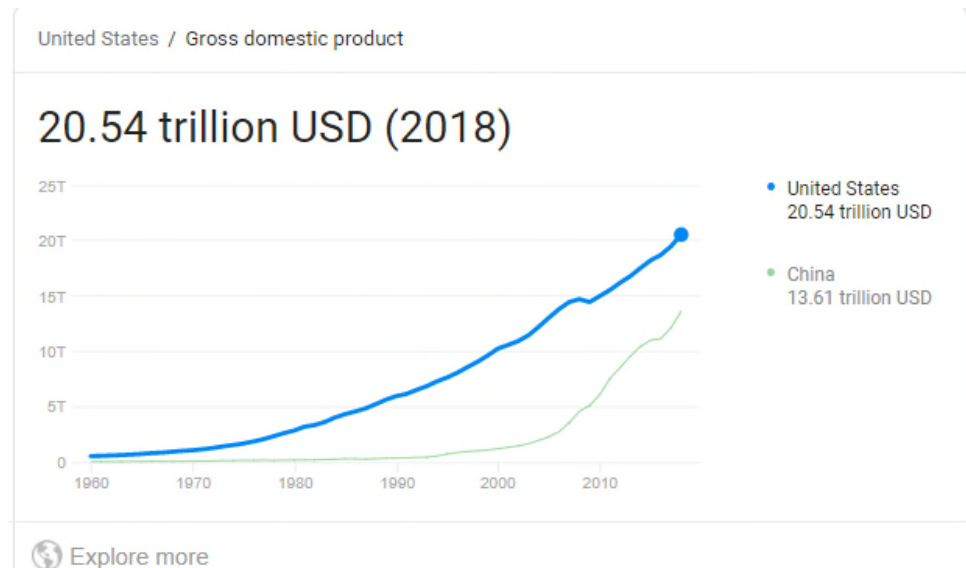- What the above *might* mean for the months and years ahead

There are at least 4 approaches humanity can take to influence the future (societal decision)

1) Let it rip

2) Mitigation

3) Containment

4) Prevention (or cure)

1 - Let it rip is highly unlikely...not even the Swedes will do it

EPA's value of
statistical life,
2016

$10M

United States / Gross domestic product

20.54 trillion USD (2018)

- United States 20.54 trillion USD
- China 13.61 trillion USD

Explore more

⚠ DANGER

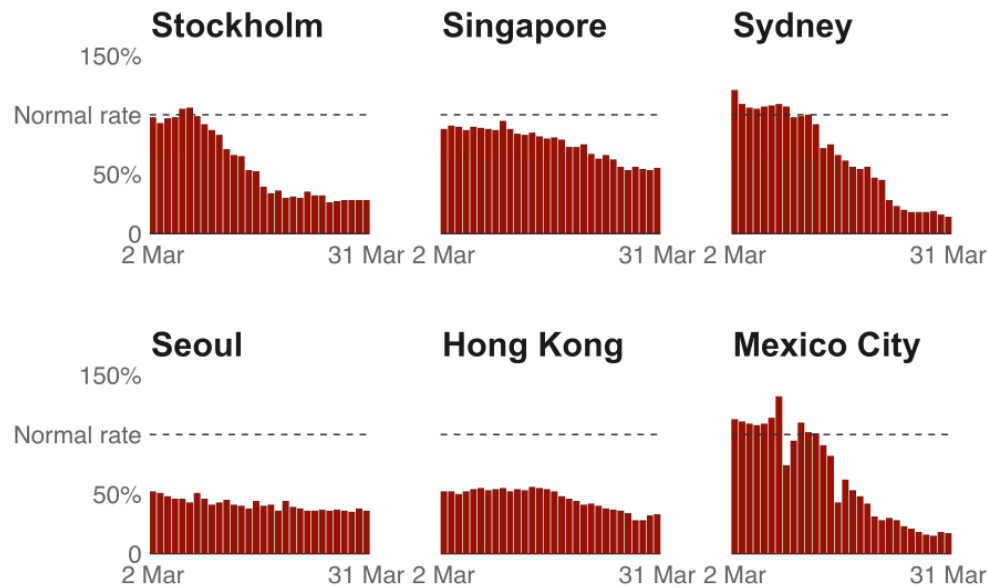Sulfuric acid.
Contact will result
in severe burns or
death.

10 million dollars x 1 million lives saved = 10 Trillion dollars

Human behavior won't go back to normal in a "let-it-rip" world

Travel declines even without official lockdowns
Data shows trips planned compared with typical pre-virus period

Stockholm | Singapore | Sydney
Seoul | Hong Kong | Mexico City

(Charts show percentage axis with 150%, Normal rate, 50%, 0; x-axis from 2 Mar to 31 Mar)

Note: Data includes walking and use of public transport.
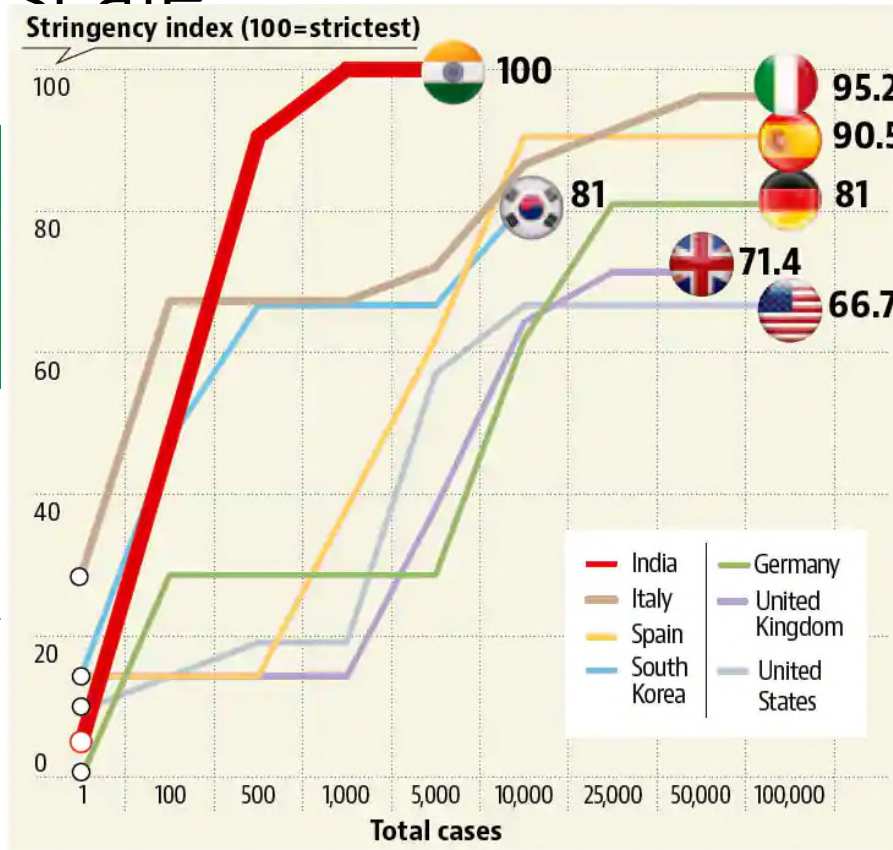Sydney introduced a lockdown on 31 March

Source: Citymapper Mobility Index

BBC

2 – Mitigation is where we are now and exists on a sliding scale

Suppression

Designated Neighborhood shopper

Striving for sustainable
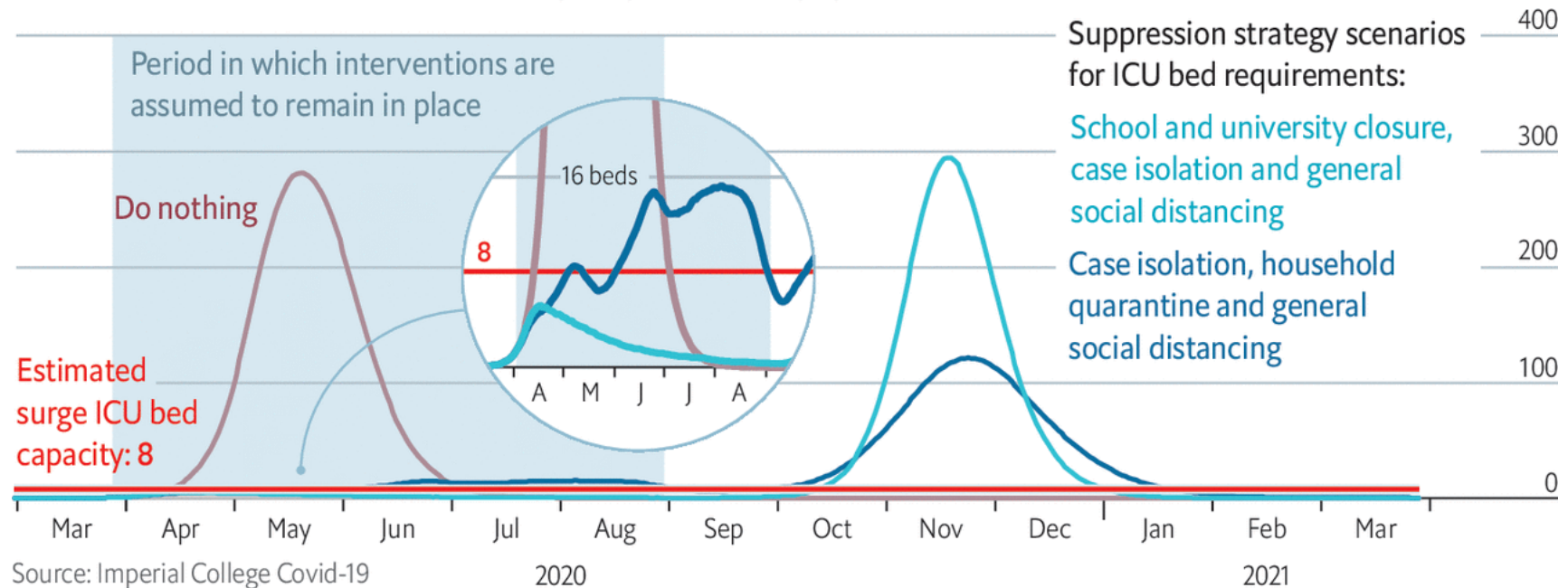
- 3ft distancing
- Schools open

Stringency index (100=strictest)

India — 100
Italy — 95.2
Spain — 90.5
Germany — 81
South Korea — 81
United Kingdom — 71.4
United States — 66.7

Total cases

https://www.bsg.ox.ac.uk/research/research-projects/coronavirus-government-response-tracker

https://www.hindustantimes.com/india-news/india-s-nationwide-lockdown-move-to-contain-covid-19-spread-quicker-than-most-nations-study/story-0X4nUF6rhaNTcsH07k3P2H.html
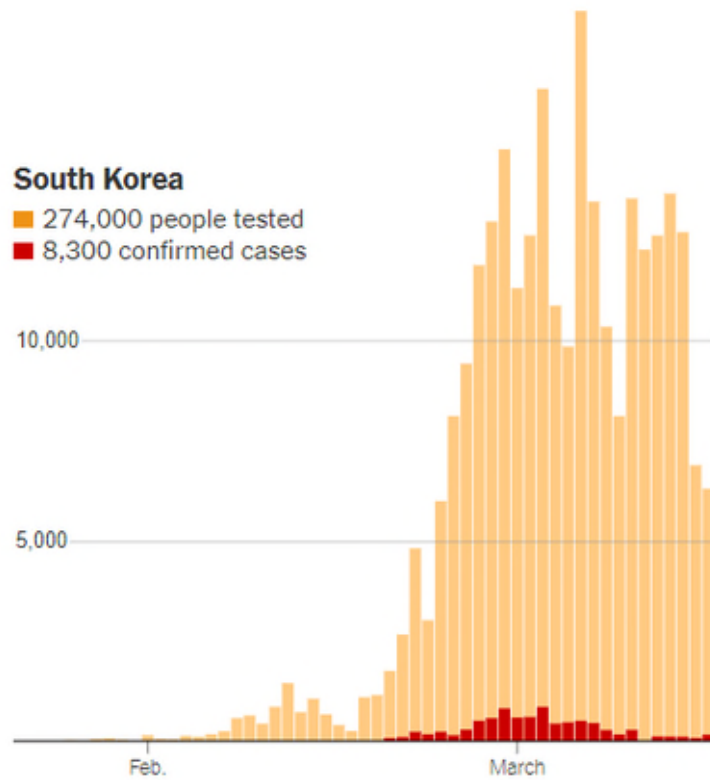
2 – Mitigation likely means multiple waves

Anticipating an encore

Britain, covid-19, critical-care beds occupied per 100,000 population

Period in which interventions are assumed to remain in place

Do nothing

Estimated surge ICU bed capacity: 8

16 beds

8

Suppression strategy scenarios for ICU bed requirements:

School and university closure, case isolation and general social distancing

Case isolation, household quarantine and general social distancing

Mar Apr May Jun Jul Aug Sep Oct Nov Dec Jan Feb Mar

2020   2021

400
300
200
100
0

Source: Imperial College Covid-19 Response Team, March 16th 2020

The Economist

3- Containment – South Korea/Iceland model

South Korea
- 274,000 people tested
- 8,300 confirmed cases

10,000

5,000

Feb. March

Icelandic tracer

https://www.theguardian.com/world/2020/apr/23/test-trace-contain-how-south-korea-flattened-its-coronavirus-curve

Prevention: As of April 8, 78 confirmed vaccine candidates with 5 in clinical trials – one promising one out of Oxford

Nature Reviews | Drug Discovery

https://www.nature.com/articles/d41573-020-00073-5
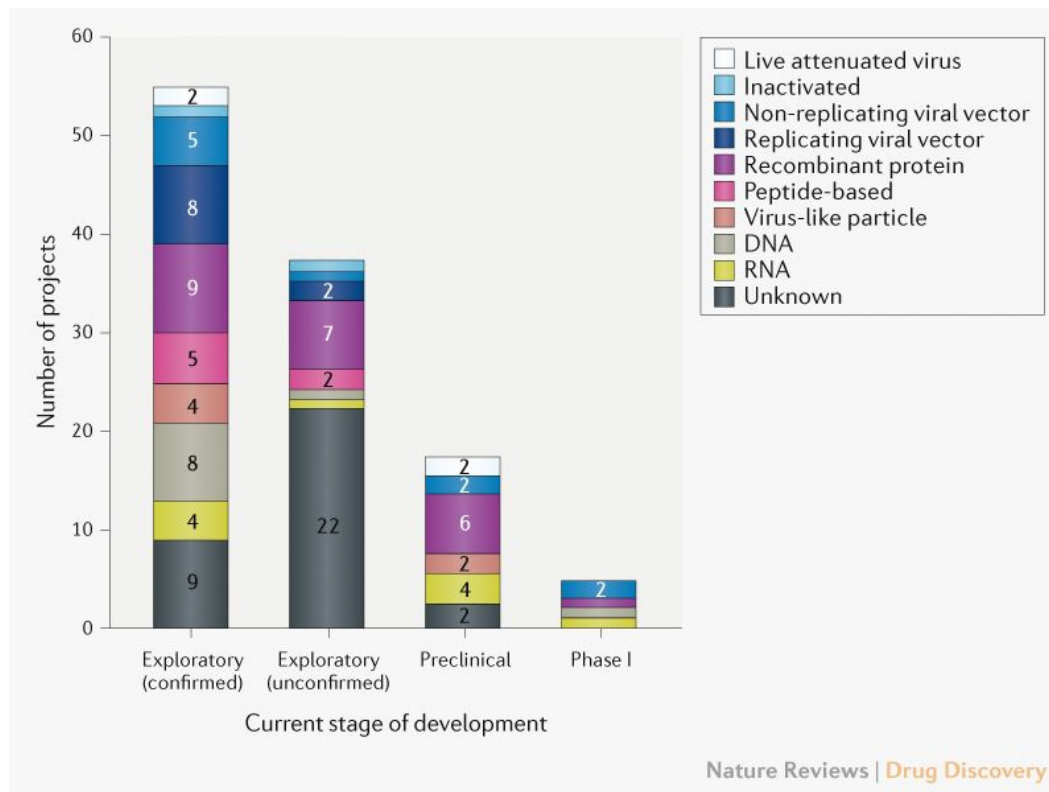
There is an indication that vaccine could be available **under emergency use** or similar protocols **by early 2021**. This would represent a fundamental step change from the traditional vaccine development pathway, which takes on average over 10 years, even compared with the accelerated 5-year timescale for development of the first Ebola vaccine,

Other countries (China/Italy right now) will often shine light on the future

Wuhan Lockdown "ends" after 76 days
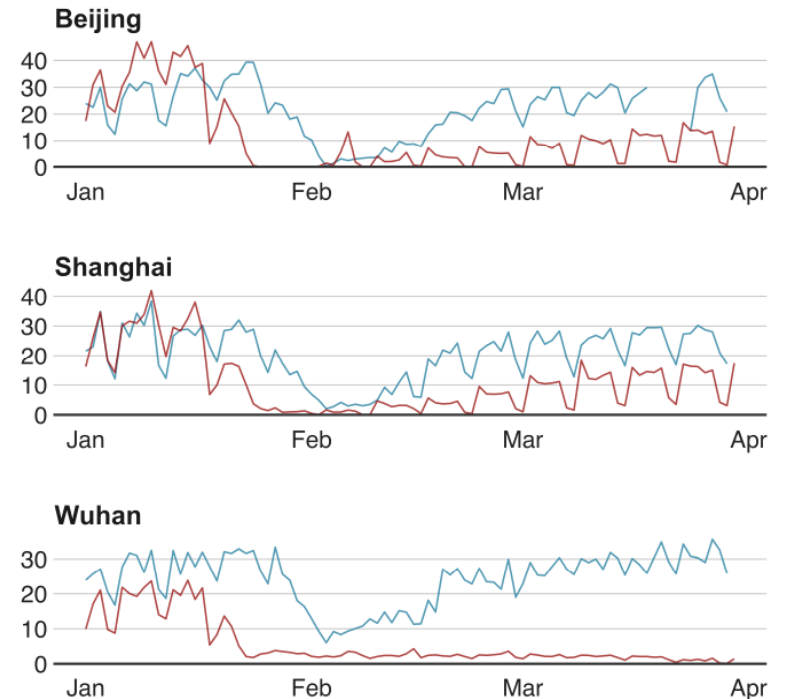
As of April 10:

- However….workers alternate days in office
- Schools still closed

Wuhan is still quiet but weekday traffic is starting to return to other Chinese cities

Average congestion per day

— 2019 — 2020

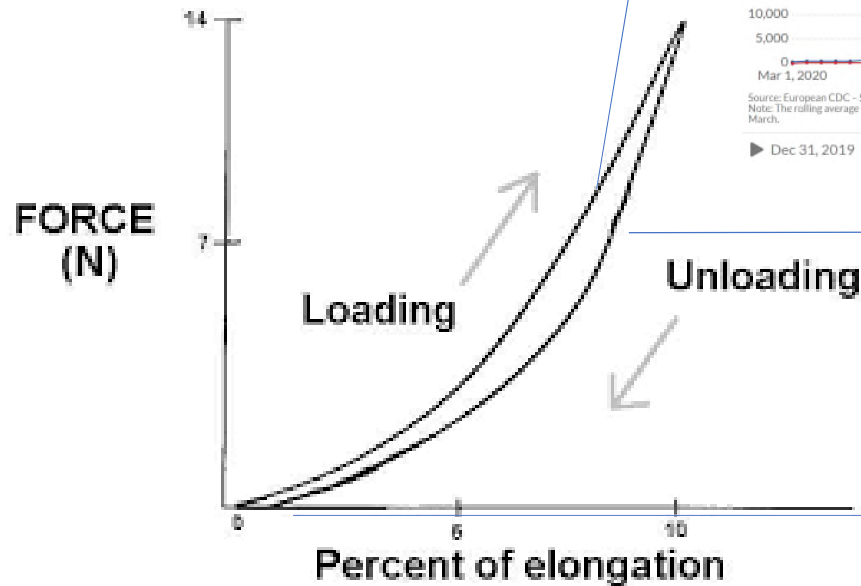**Beijing**

Shanghai

Wuhan

Note: Data missing for certain dates in 2019. Chinese New Year earlier in 2020

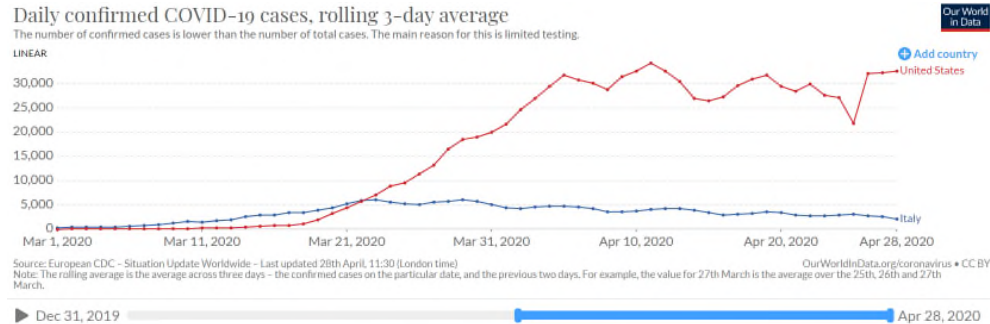Source: TomTom, 31 March 2020

BBC

Hysteresis

We are far from done with Coronavirus and may have "false dawns" before we end (volatile)

Unclear "escape route"

- How long do you retain immunity?
- What aftershocks remain?
- How long to create a vaccine?

Uncertain new steady-state:
- Larger gov't
- E-commerce
- "de-optimized" supply chains
- Automation, especially retail
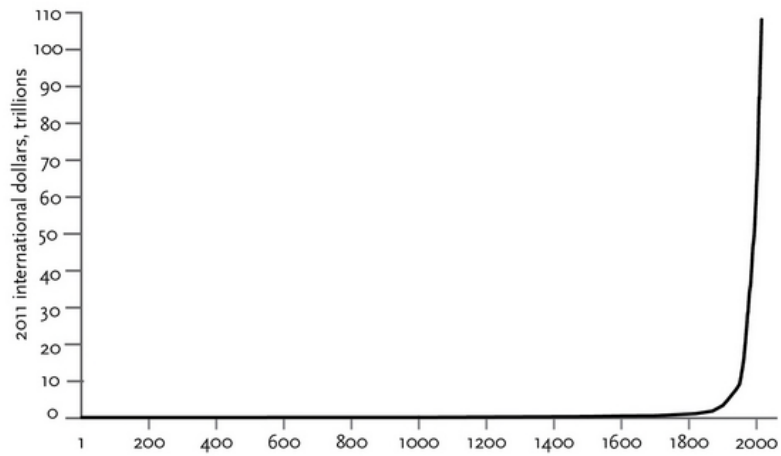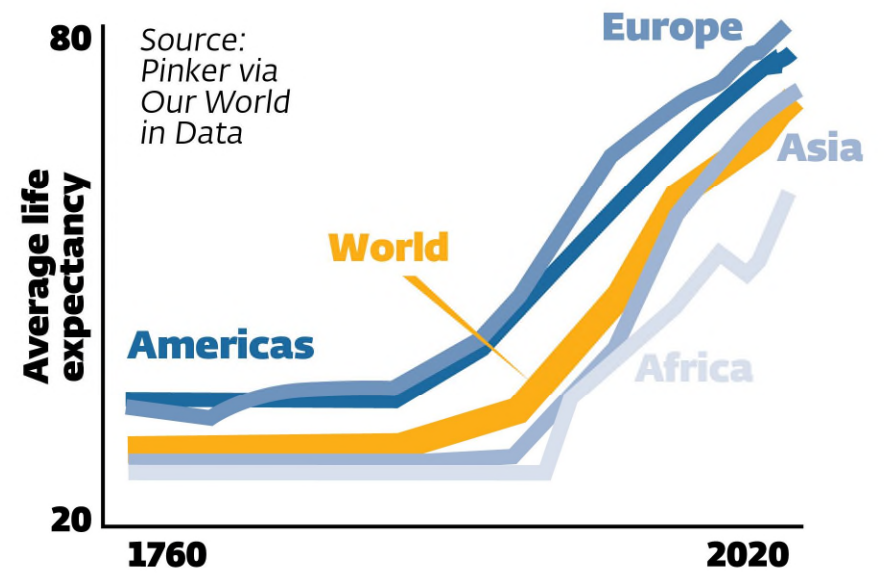- New forms of entertainment
- Etc.

Hormesis

Figure 8-1: Gross World Product, 1–2015

Source: *Our World in Data*, Roser 2016c, based on data from the World Bank and from Angus Maddison and Maddison Project 2014.


Source: Pinker via Our World in Data

Further Reading

- Nice modeling paper:
  https://science.sciencemag.org/content/early/2020/04/24/science.abb5793.full

- The famous/infamous IHME Model: https://covid19.healthdata.org/united-states-of-america

- Exponential growth mathematics: https://www.youtube.com/watch?v=Kas0tIxDvrg

- Weekly Updates from "Nature": https://www.nature.com/articles/d41591-020-00012-2

- Google search on Spanish Flu will lead you to some interesting papers from St. Louis Fed, NBER, and MIT Sloan,

Appendix

COVID-19 deaths vs. other common causes

■ COVID-19 (2020) ■ Flu/pneumonia (2018) ■ Car crashes (2018)
■ Cancer (2018 weekly average) ■ Heart disease (2018 weekly average)

Deaths per million people
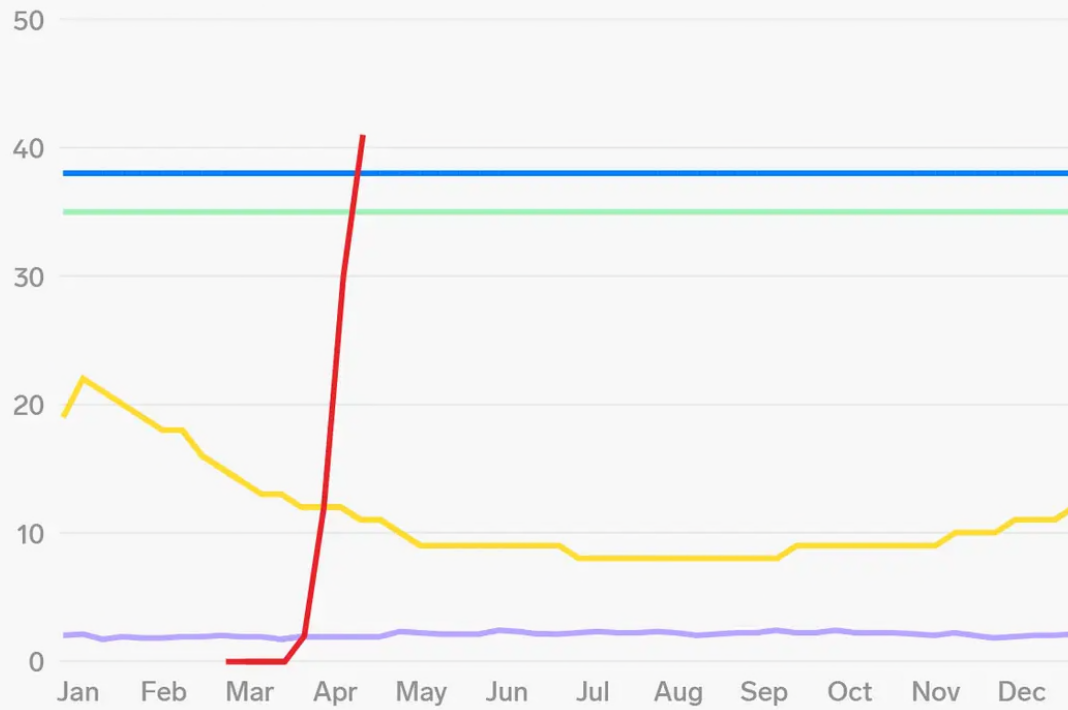
Source: The New Atlantis; CDC; US Census; COVID Tracking Project;NHTSA

BUSINESS INSIDER

Life expectancy

Legend:
- Switzerland
- Spain
- Sweden
- Norway
- Finland
- United States

Y-axis: 0 years, 10 years, 20 years, 30 years, 40 years, 50 years, 60 years, 70 years, 80 years

X-axis: 1830, 1840, 1860, 1880, 1900, 1920, 1940, 1960, 1980, 2000, 2019
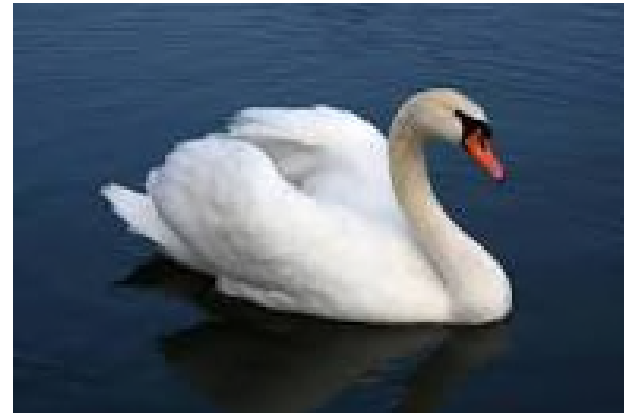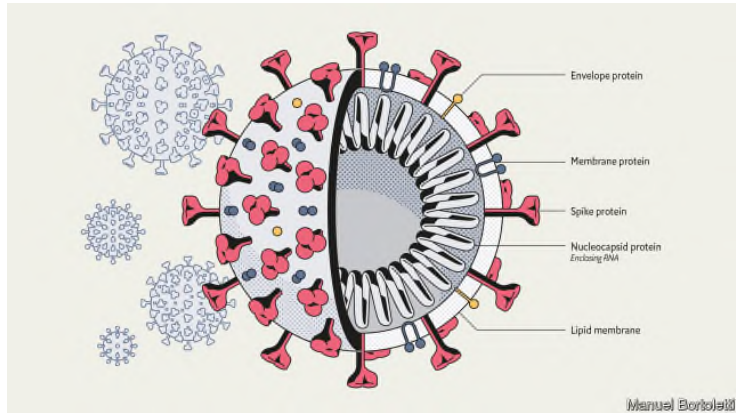
Add country

Asia, Australia and New Zealand in lockdown
Dates and severity of restricted internal movement by country

- First case
- Localised recommendations
- Localised lockdown
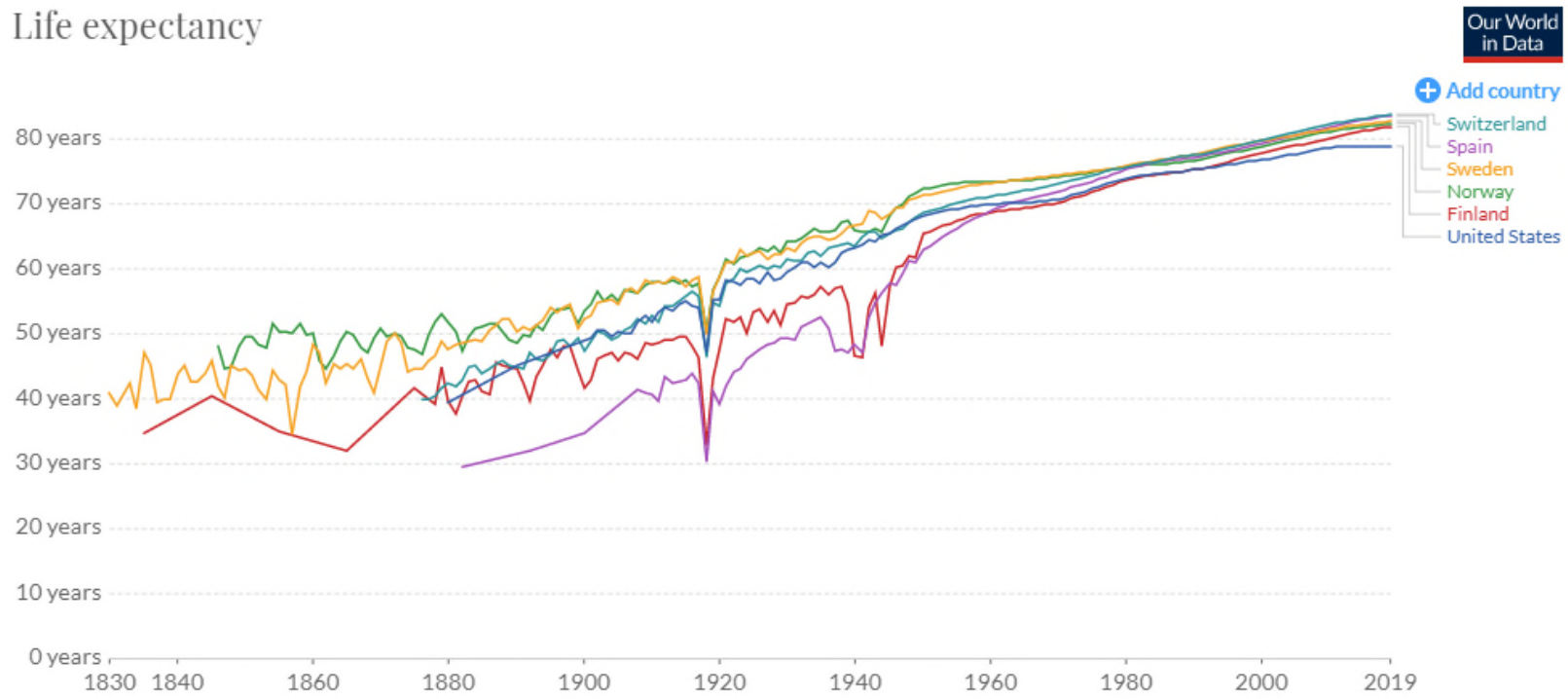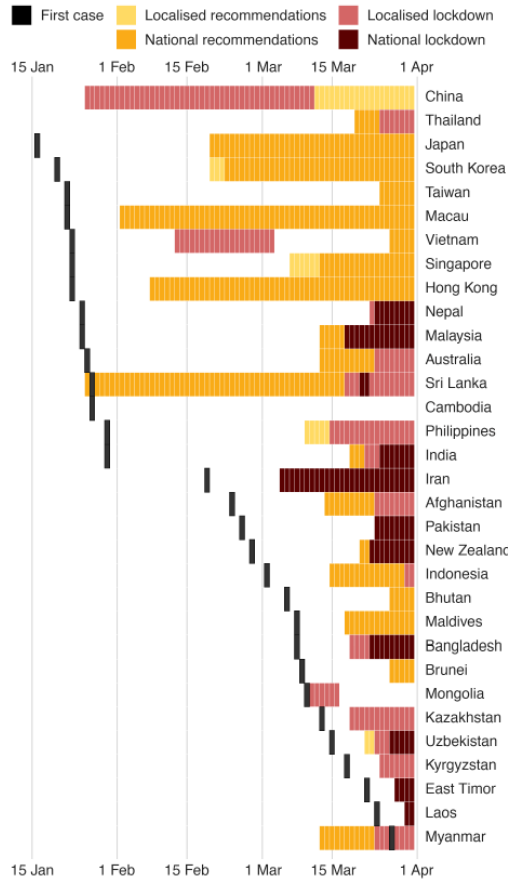- National recommendations
- National lockdown

15 Jan | 1 Feb | 15 Feb | 1 Mar | 15 Mar | 1 Apr

China, Thailand, Japan, South Korea, Taiwan, Macau, Vietnam, Singapore, Hong Kong, Nepal, Malaysia, Australia, Sri Lanka, Cambodia, Philippines, India, Iran, Afghanistan, Pakistan, New Zealand, Indonesia, Bhutan, Maldives, Bangladesh, Brunei, Mongolia, Kazakhstan, Uzbekistan, Kyrgyzstan, East Timor, Laos, Myanmar
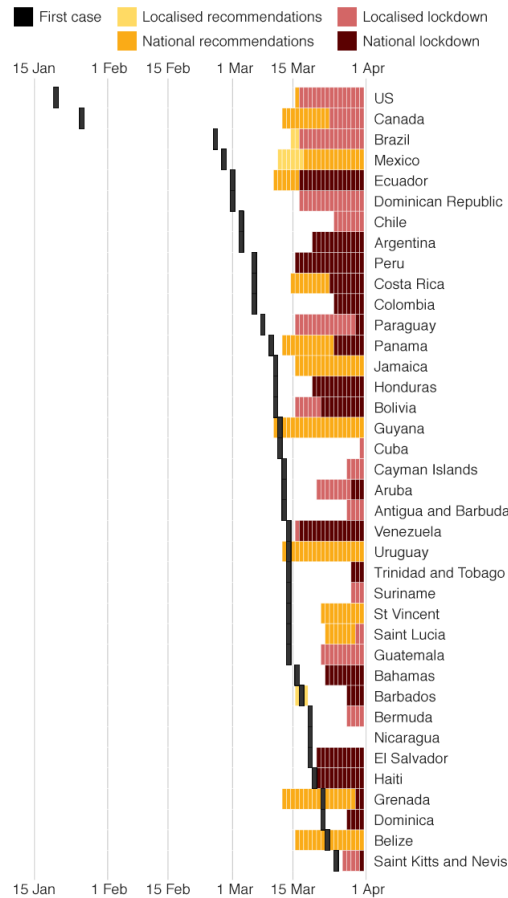
Note: China and Thailand confirmed their first cases prior to 15 January 2020

Source: Oxford COVID–19 Government Response Tracker, BBC Research

Countries in the Americas in lockdown
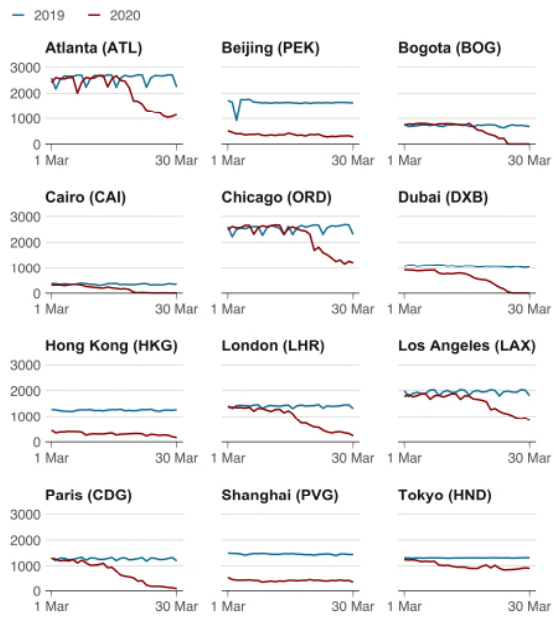Dates and severity of restricted internal movement by country

- First case
- Localised recommendations
- Localised lockdown
- National recommendations
- National lockdown

15 Jan | 1 Feb | 15 Feb | 1 Mar | 15 Mar | 1 Apr

US, Canada, Brazil, Mexico, Ecuador, Dominican Republic, Chile, Argentina, Peru, Costa Rica, Colombia, Paraguay, Panama, Jamaica, Honduras, Bolivia, Guyana, Cuba, Cayman Islands, Aruba, Antigua and Barbuda, Venezuela, Uruguay, Trinidad and Tobago, Suriname, St Vincent, Saint Lucia, Guatemala, Bahamas, Barbados, Bermuda, Nicaragua, El Salvador, Haiti, Grenada, Dominica, Belize, Saint Kitts and Nevis

Source: Oxford COVID–19 Government Response Tracker, BBC Research

Purpose	Data source	Civil liberties risk	Where it's happening
Knowing people are where they should be	GPS data sent from bracelet or phone	Medium	Hong Kong, Taiwan, Singapore, China
Knowing whose paths have crossed	Top-down: Government takes data from platforms	High	Singapore, S. Korea
	Bottom up: Phones provide data to each other	Low	Worldwide
Knowing how many people pass through places, and how quickly	Mobile-phone-tower data	Low	Google, US, probably more
Knowing which people tend to meet repeatedly	Mobile-phone-tower data with machine learning	High	Nowhere known

...covid-19 pandemic

https://www.bbc.com/news/world-52103747

Number of flights around the world decrease

— 2019 — 2020

Atlanta (ATL), Beijing (PEK), Bogota (BOG), Cairo (CAI), Chicago (ORD), Dubai (DXB), Hong Kong (HKG), London (LHR), Los Angeles (LAX), Paris (CDG), Shanghai (PVG), Tokyo (HND)
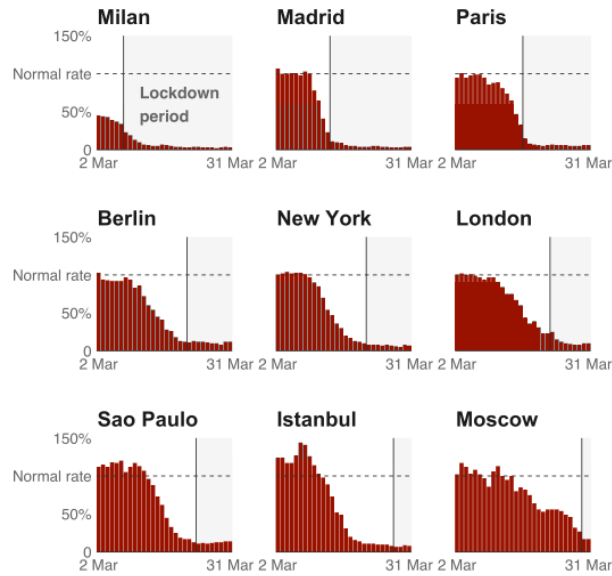
Source: Flightstats.com

BBC

How travel has plummeted in major cities
Data shows trips planned compared with typical pre-virus period

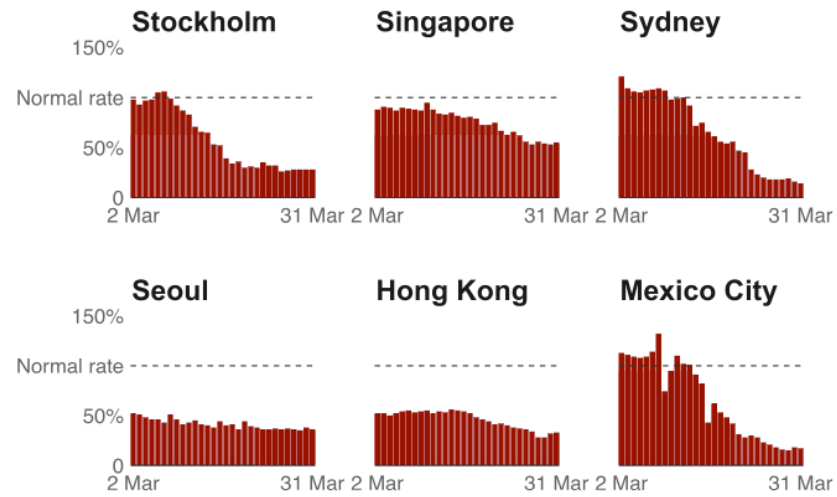Milan, Madrid, Paris, Berlin, New York, London, Sao Paulo, Istanbul, Moscow

Note: Data includes walking and use of public transport

Source: Citymapper Mobility Index

BBC

Travel declines even without official lockdowns
Data shows trips planned compared with typical pre-virus period

Stockholm, Singapore, Sydney, Seoul, Hong Kong, Mexico City

Note: Data includes walking and use of public transport.
Sydney introduced a lockdown on 31 March

Source: Citymapper Mobility Index

BBC

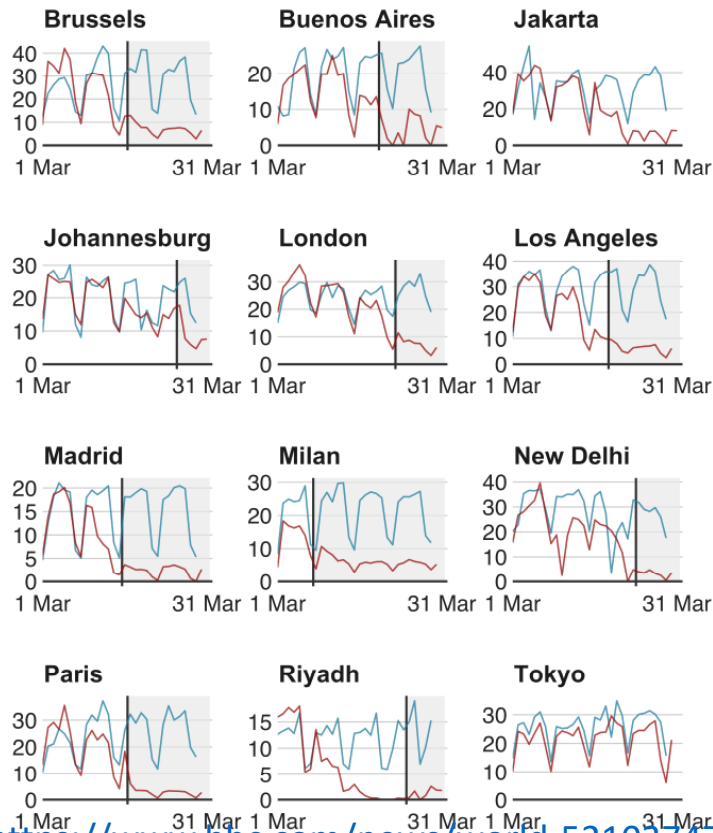https://www.bbc.com/news/world-52103747

Traffic flows in selected cities

Average congestion per day

— 2019 — 2020 ▬ Lockdown

Brussels

Buenos Aires

Jakarta

Johannesburg

London

Los Angeles

Madrid

Milan

New Delhi

Paris

Riyadh

Tokyo

Source: TomTom, 31 March 2020
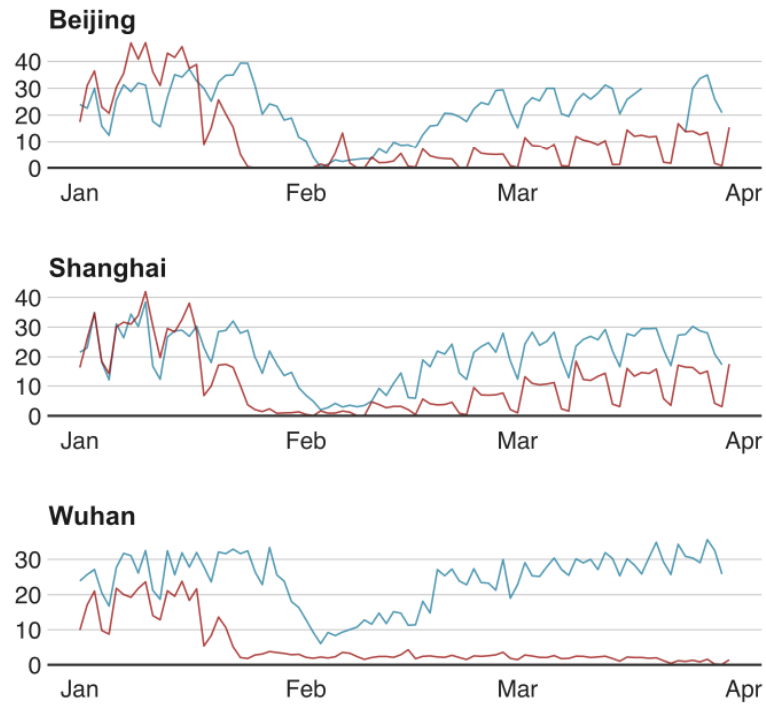
BBC

Wuhan is still quiet but weekday traffic is starting to return to other Chinese cities

Average congestion per day

— 2019 — 2020

Beijing

Shanghai

Wuhan

Note: Data missing for certain dates in 2019. Chinese New Year earlier in 2020

Source: TomTom, 31 March 2020

BBC

U.S. deaths soared in early weeks of pandemic, exceeding number attributed to covid-19

Total U.S.

Excess deaths minus covid-19

60,000 weekly deaths

Deaths

Seasonal average

Excess deaths are deaths above what is historically expected

Reported covid-19 deaths

50,000

Jan.   Feb.   Mar.   **Apr. 4**