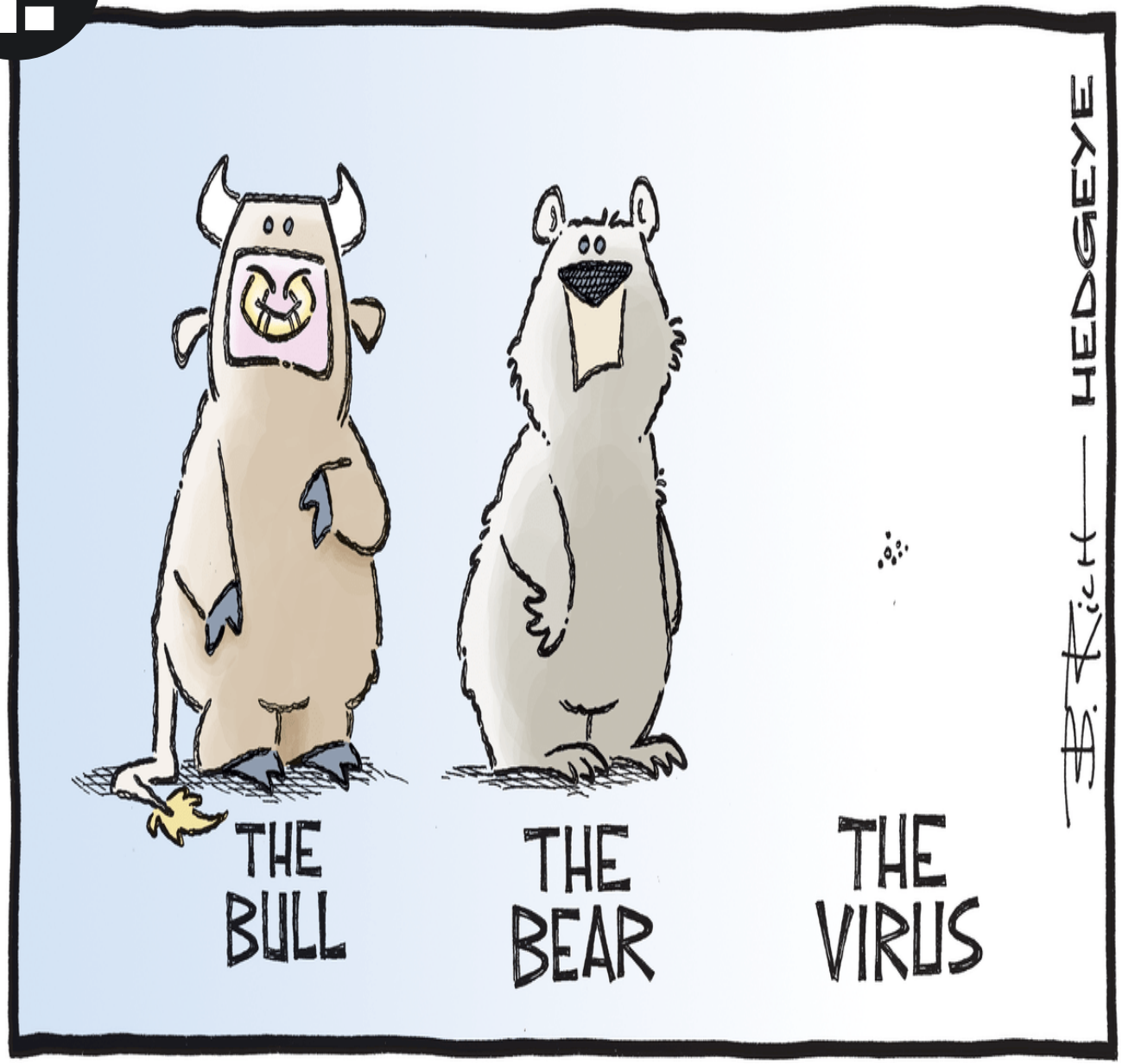
COVID-19: MARCH 19 UPDATE



March 19, 2020

LEGAL

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COVID-19, UPDATE MARCH 19

OUTLINE

- Overall Observations
- Global Case & Death Count Update + China Indicators
- What is the True Infection Fatality Rate (IFR)?
- New Imperial College Model… Why It's Alarming Policymakers
- Emerging Policy Dilemma: Mitigation versus Suppression
- Why Universal Testing May Be Essential

FOR STARTERS...

OVERALL OBSERVATIONS

- Updated nomenclature (per WHO):
  - the disease is called COVID-19… but the virus is called SARS-CoV-2

- Comparison of known COVID-19 deaths to annual flu deaths (per CDC) is apples-to-oranges
  - COVID-19 deaths identified case by case with positive pathogen test (limited estimate)
  - Annual flu deaths are statistically inferred after-the-fact (expansive estimate)

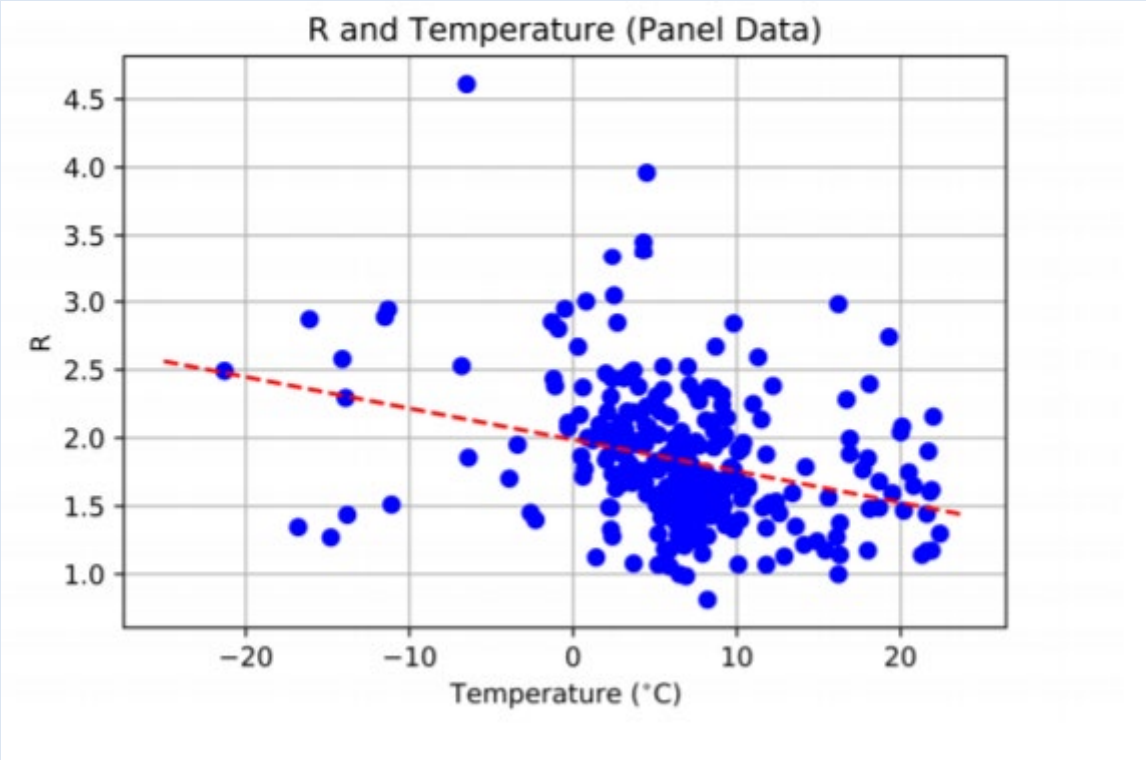
- Rising research interest in personal preventative measures (this is NOT medical advice):
  - Physician groups currently recommend continuing to take ACEI or ARB meds.
  - There is research evidence that Vitamin D supplementation helps protect against risk of viral respiratory illness in general and of ARDS in particular.

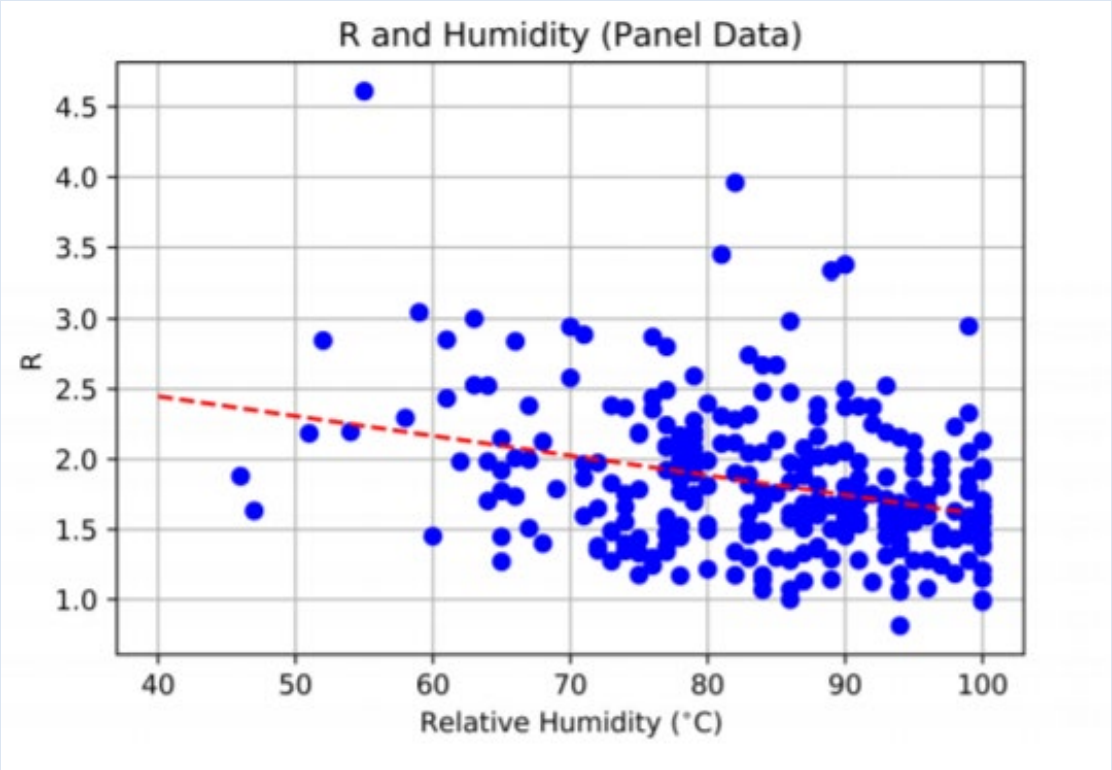
- What is the link between climate and COVID-19 transmissibility?

- What is the link between bear markets and recessions?

WILL WARMER TEMPERATURES BRING RELIEF?

Effective Reproductive Number R vs. Temperature and Relative Humidity for 100 Chinese Cities

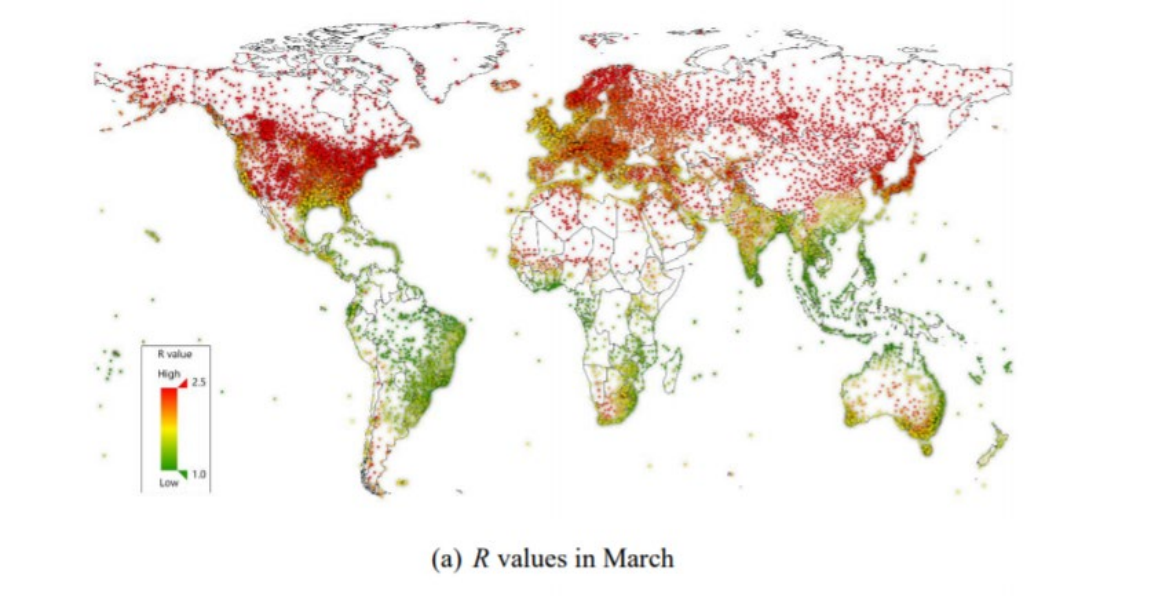




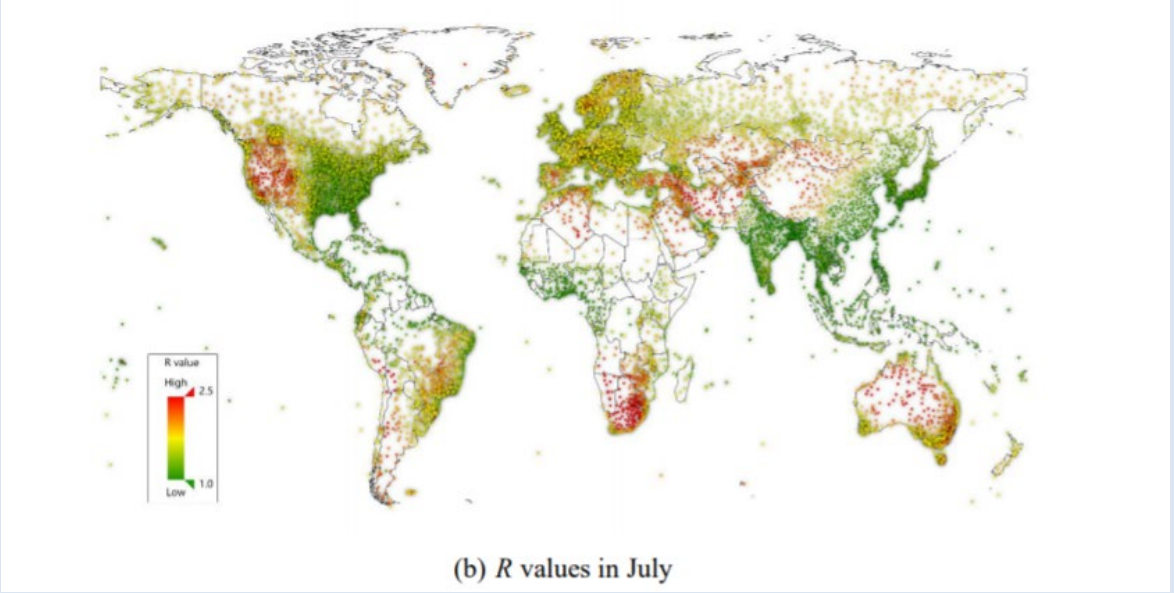
SOURCE: *High Temperature and High Humidity Reduce the Transmission of COVID-19* (2020)

WILL WARMER TEMPERATURES BRING RELIEF?

Worldwide Risks of COVID-19 Outbreaks in Cities, March and July 2020



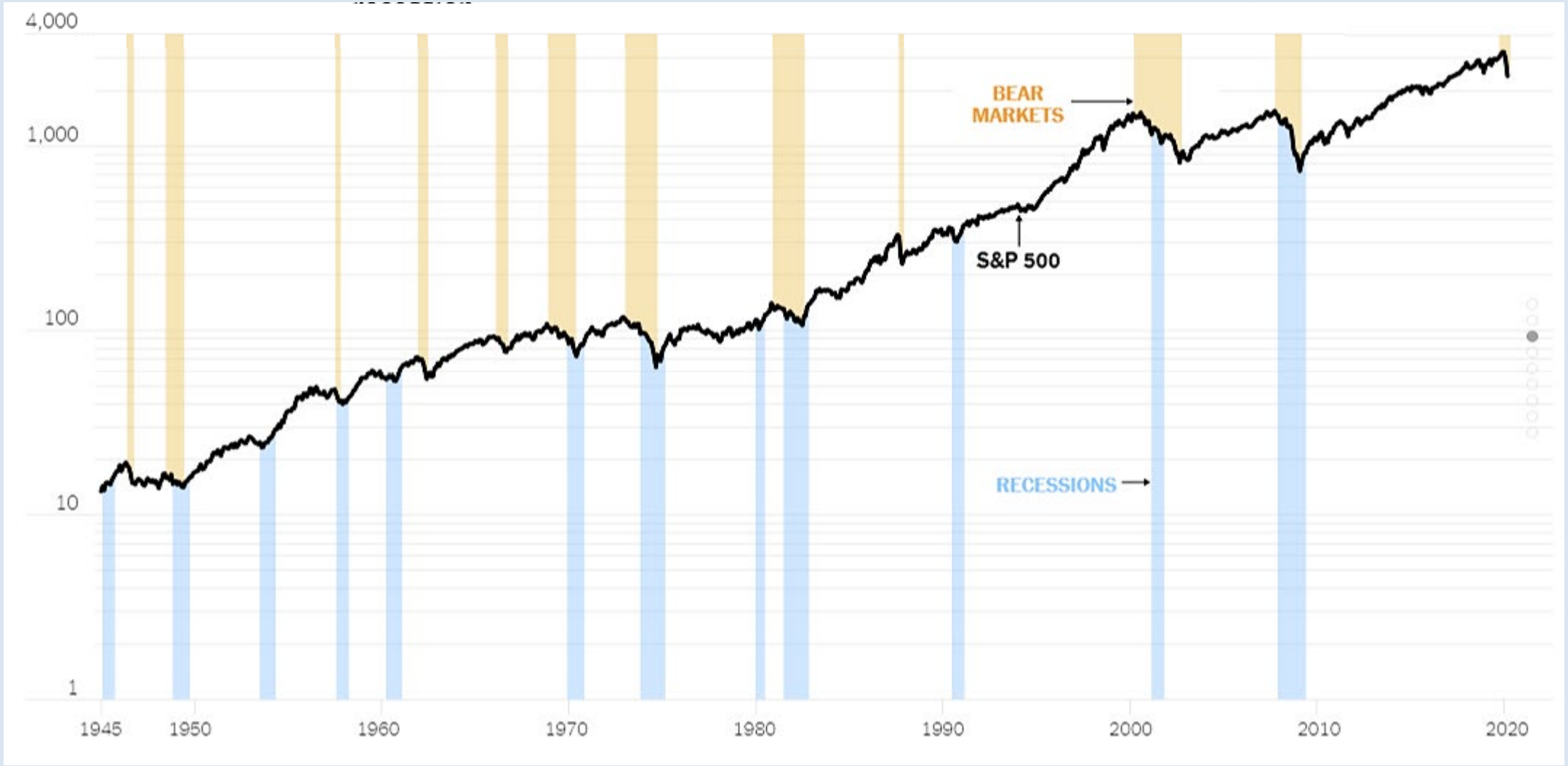
(a) *R* values in March



(b) *R* values in July

SOURCE: *High Temperature and High Humidity Reduce the Transmission of COVID-19* (2020)

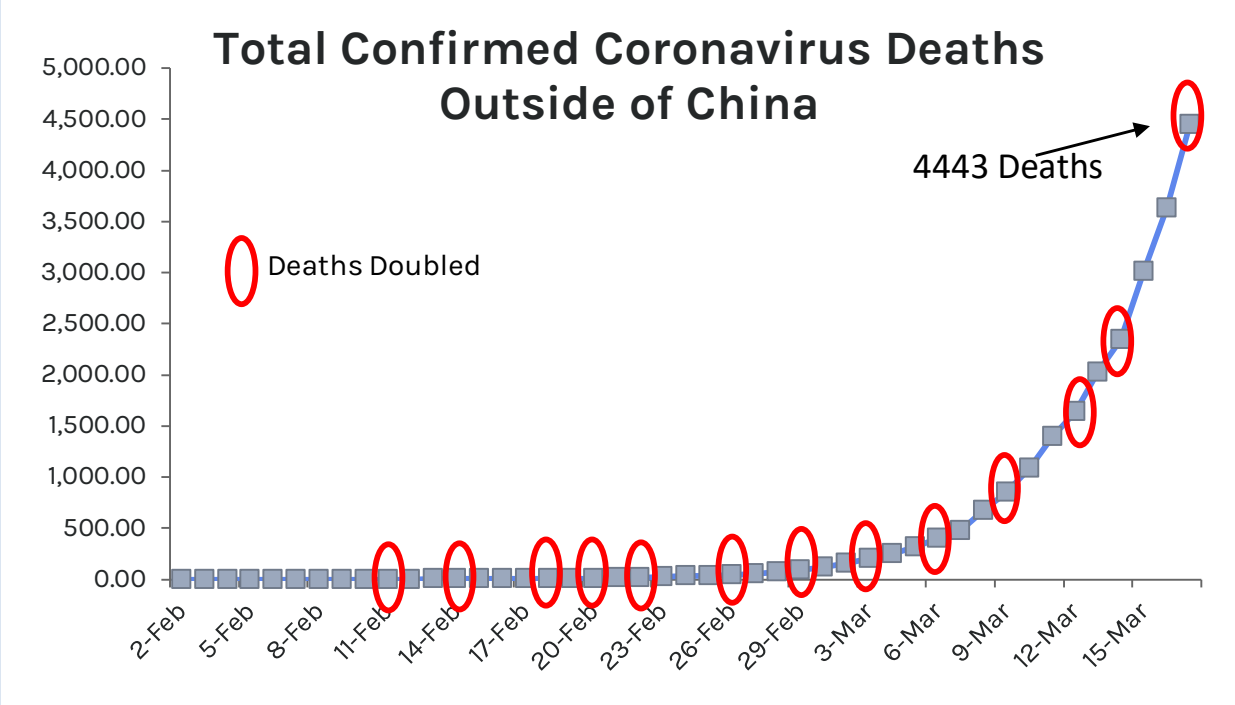
DO BEAR MARKETS TYPICALLY LEAD INTO RECESSIONS?

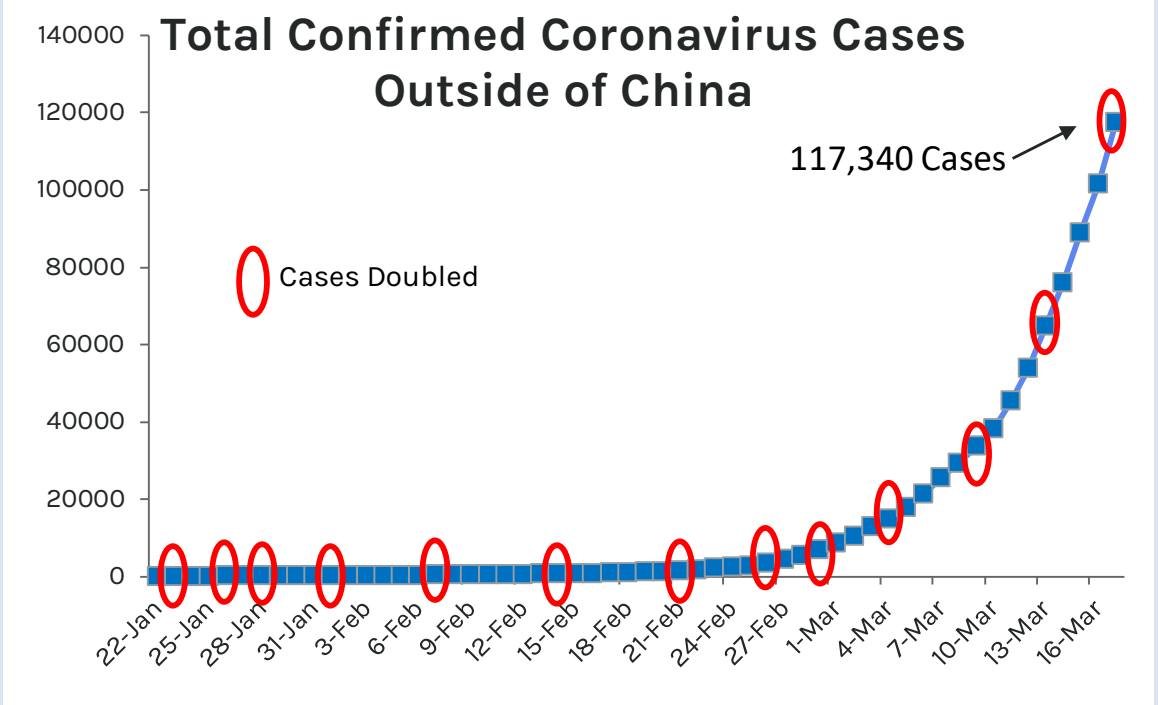


SOURCE: *New York Times* (2020)

CASES SHOW EXPONENTIAL GROWTH

Total Cases and Deaths Outside of China, Updated March 18, 2020

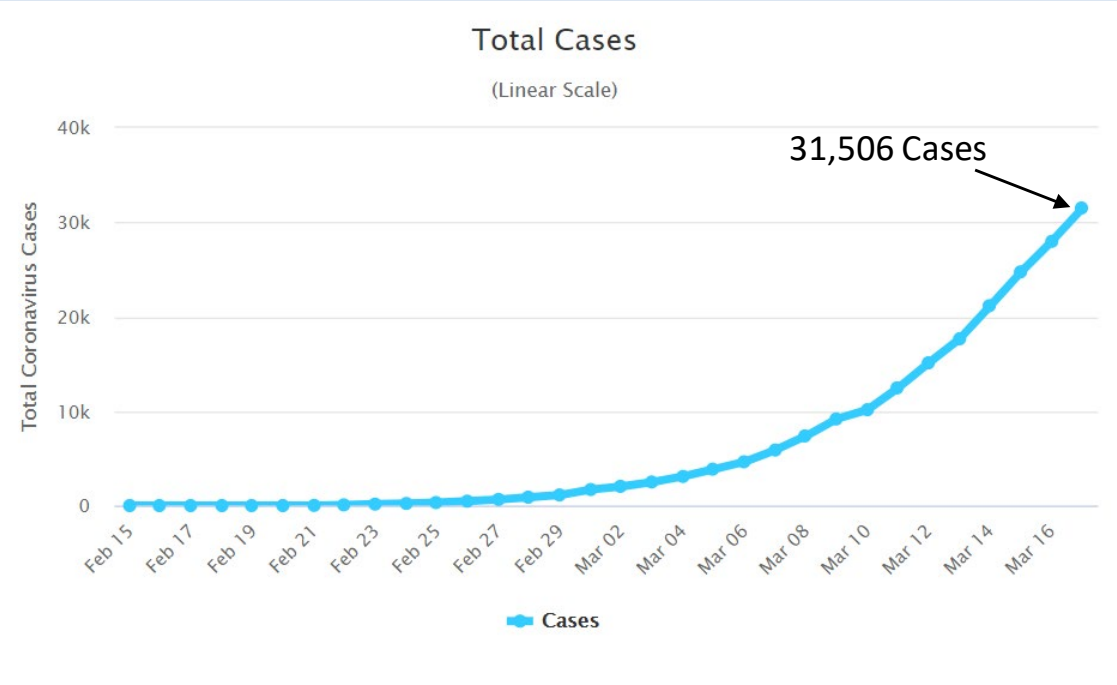


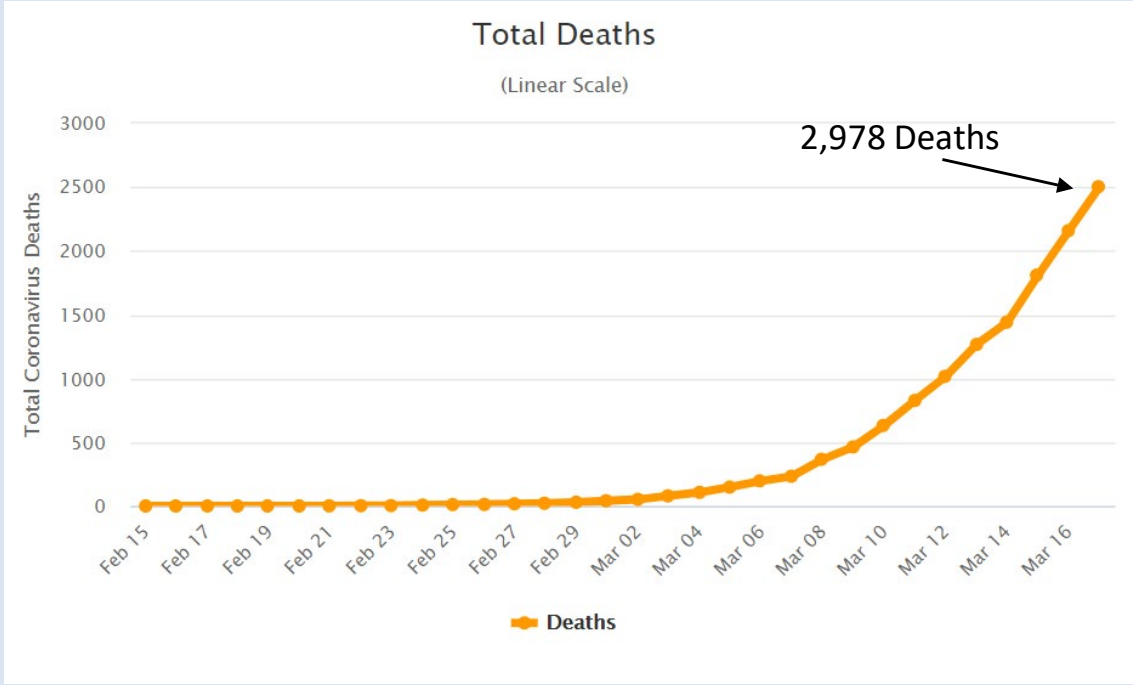


SOURCE: Worldometers, from assorted official sources (2020)

THE SITUATION IN... ITALY

COVID-19 Cases and Deaths in Italy
Updated March 18, 2020

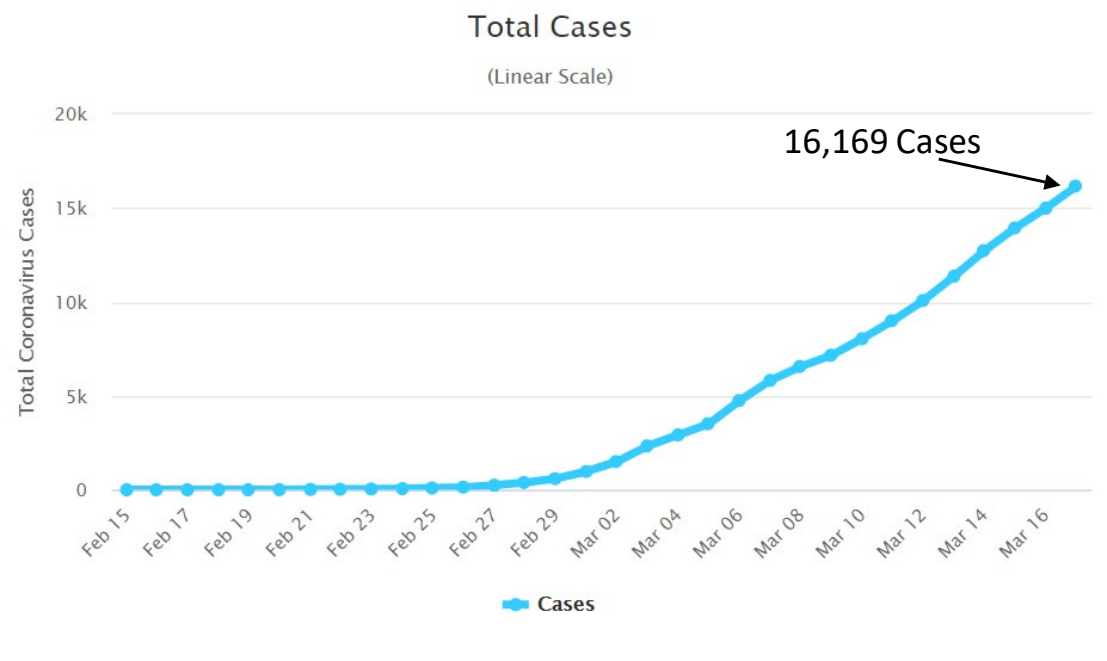


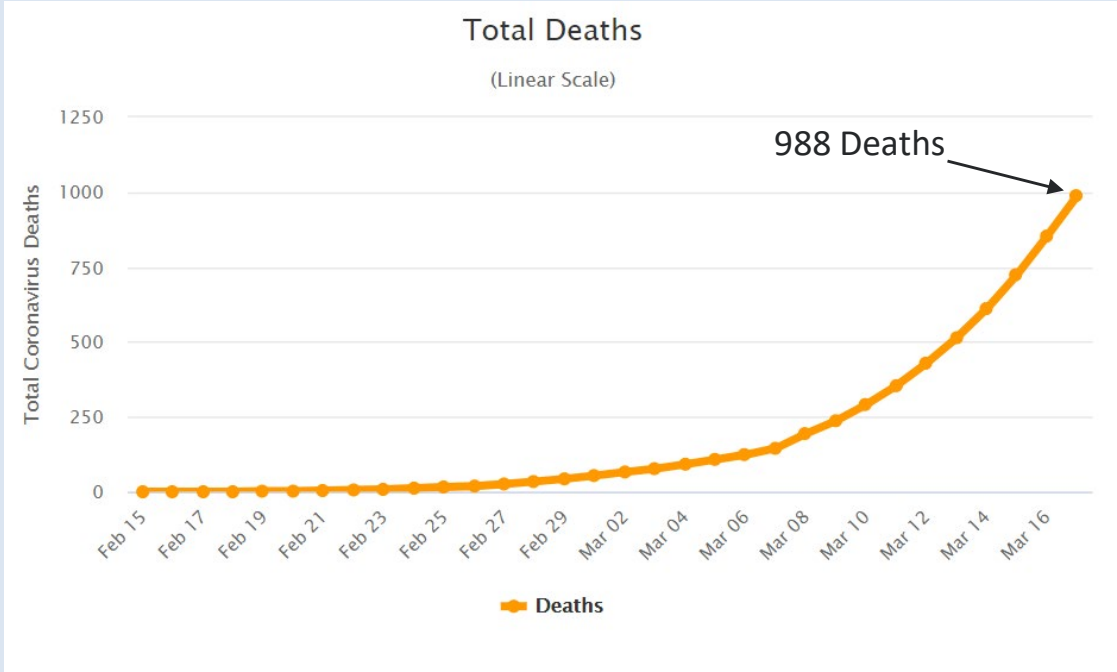


SOURCE: Worldometers, from assorted official sources (2020)

THE SITUATION IN... IRAN

COVID-19 Cases and Deaths in Iran
Updated March 18, 2020

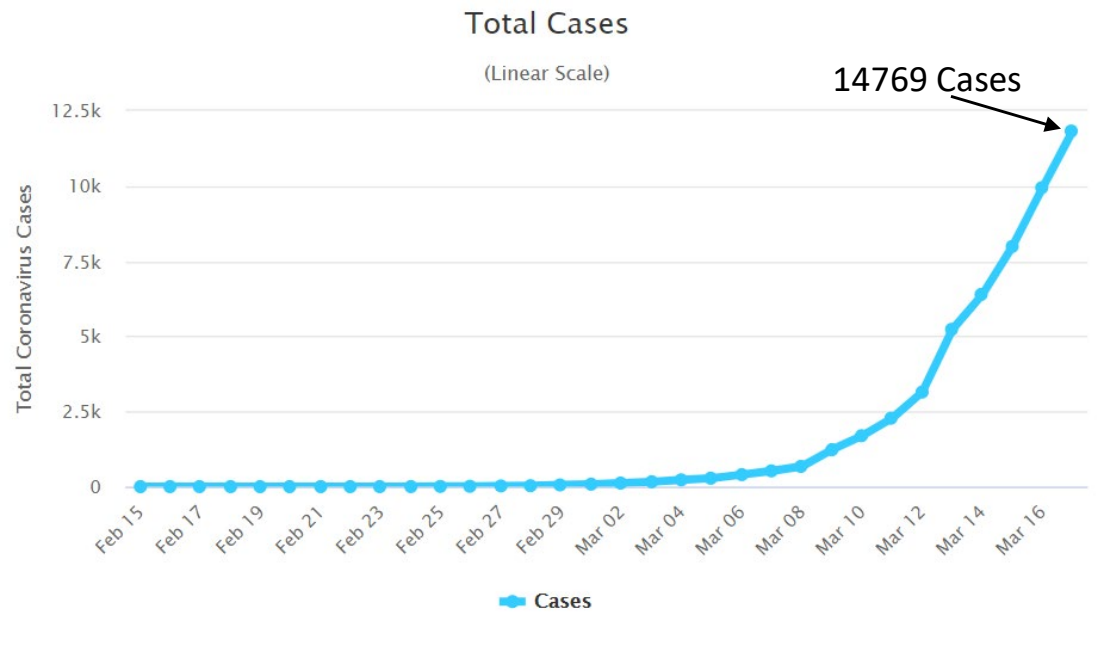


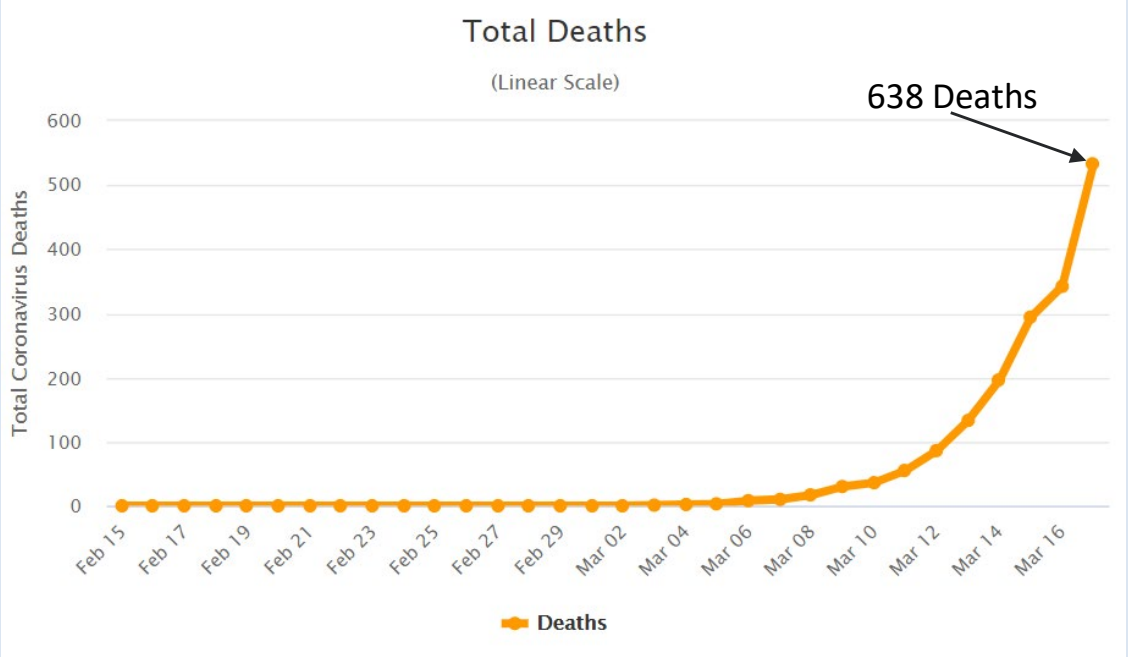


SOURCE: Worldometers, from assorted official sources (2020)

THE SITUATION IN... SPAIN

COVID-19 Cases and Deaths in Spain
Updated March 18, 2020

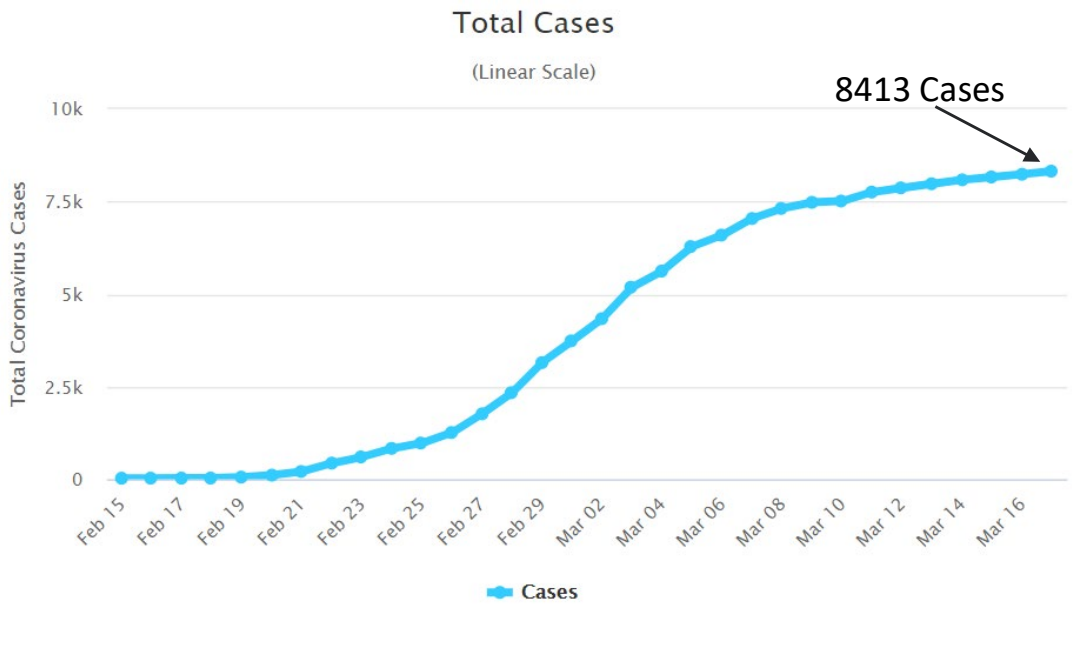


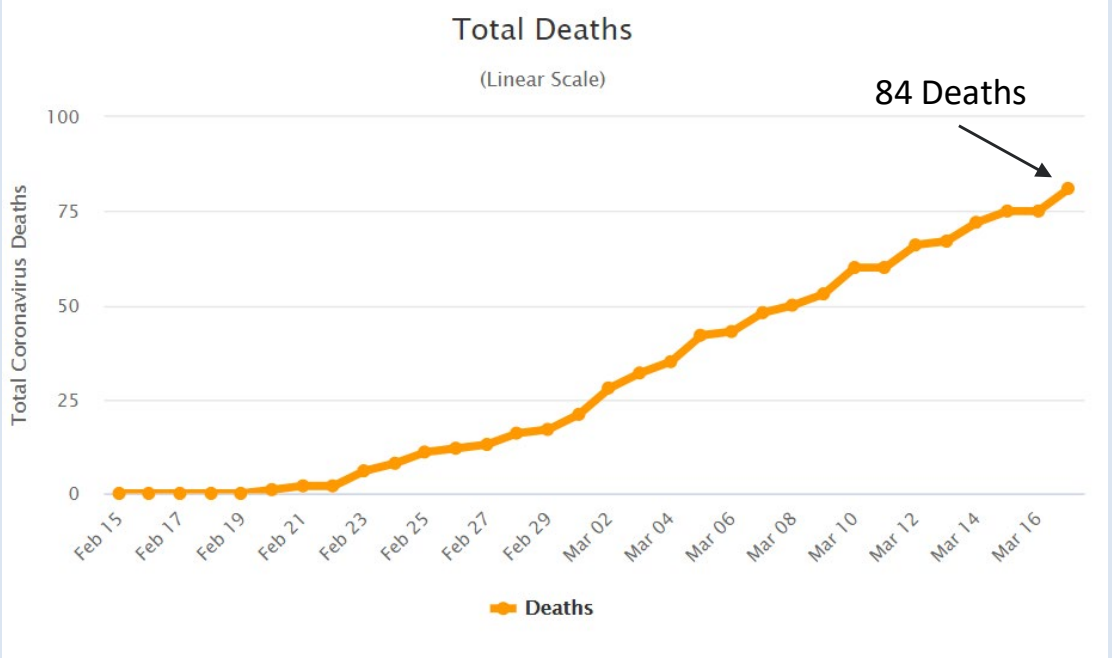


SOURCE: Worldometers, from assorted official sources (2020)

THE SITUATION IN... SOUTH KOREA

COVID-19 Cases and Deaths in South Korea
Updated March 18, 2020

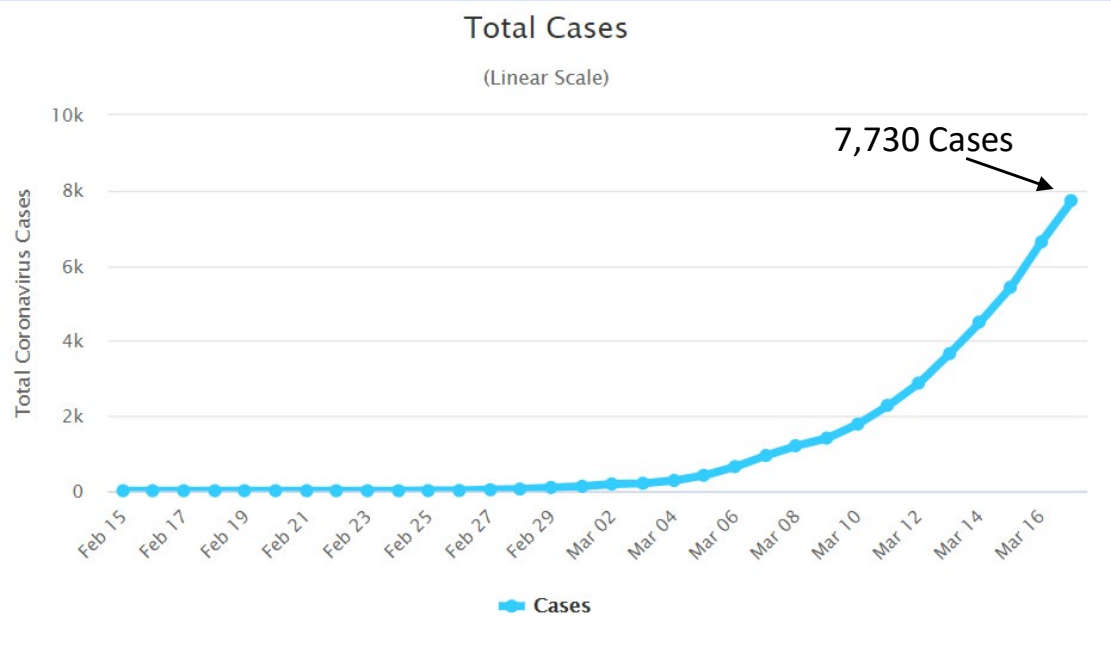


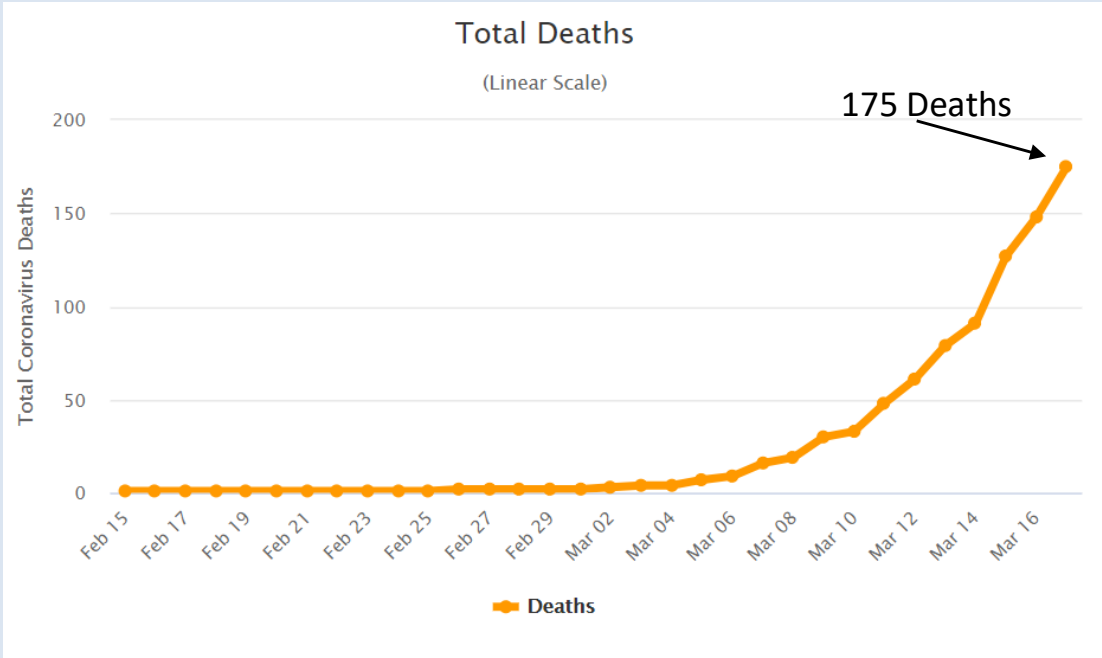


SOURCE: Worldometers, from assorted official sources (2020)

THE SITUATION IN... FRANCE

COVID-19 Cases and Deaths in France
Updated March 18, 2020

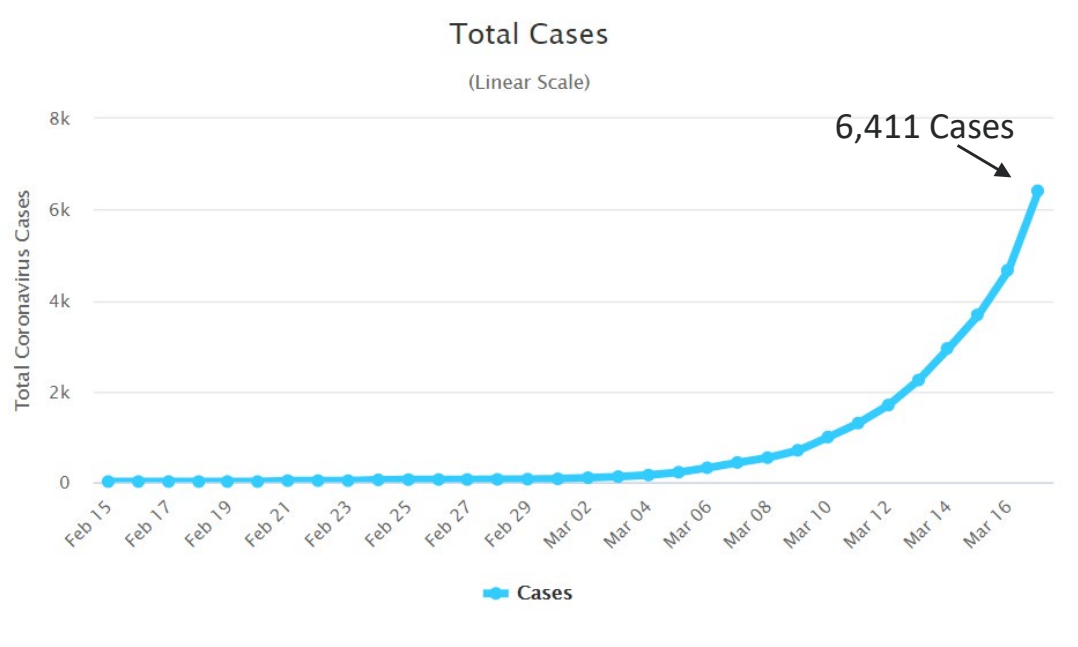


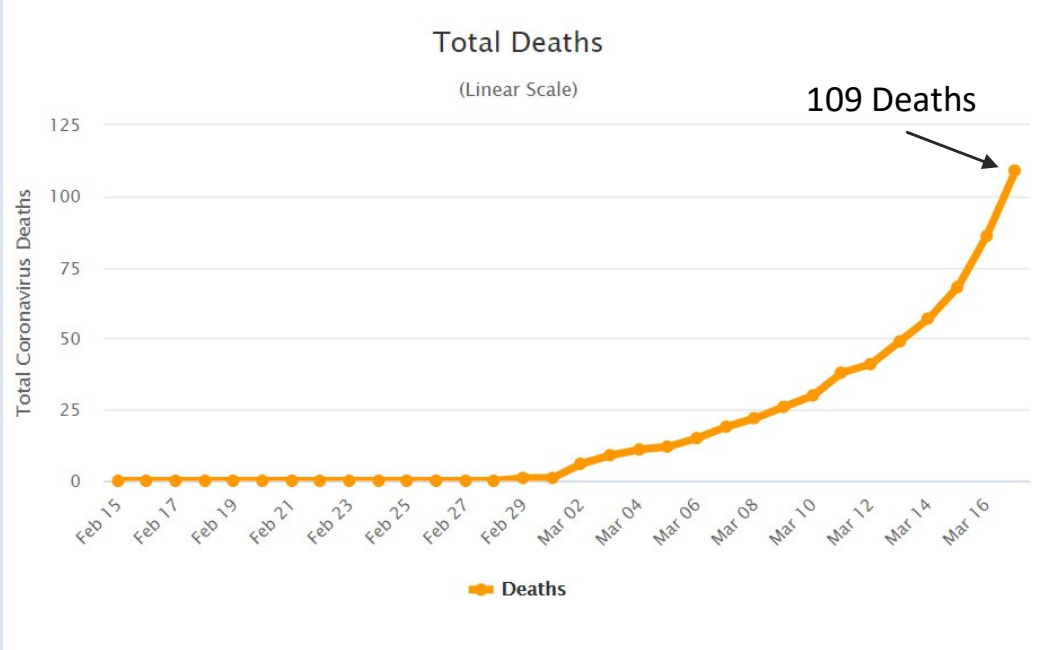


SOURCE: Worldometers, from assorted official sources (2020)

THE SITUATION IN... USA

COVID-19 Cases and Deaths in USA
Updated March 18, 2020

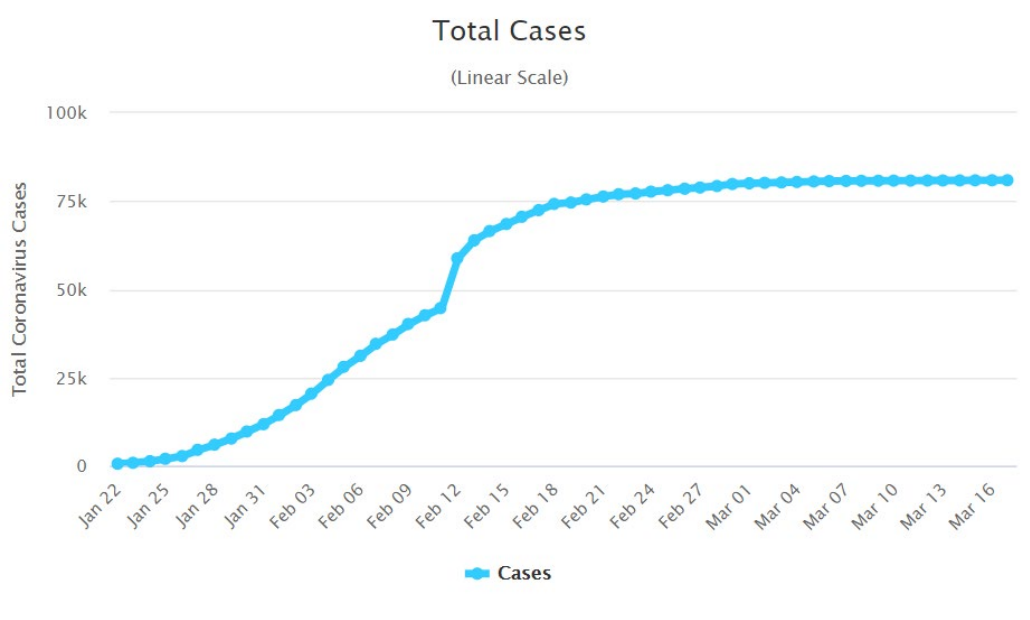


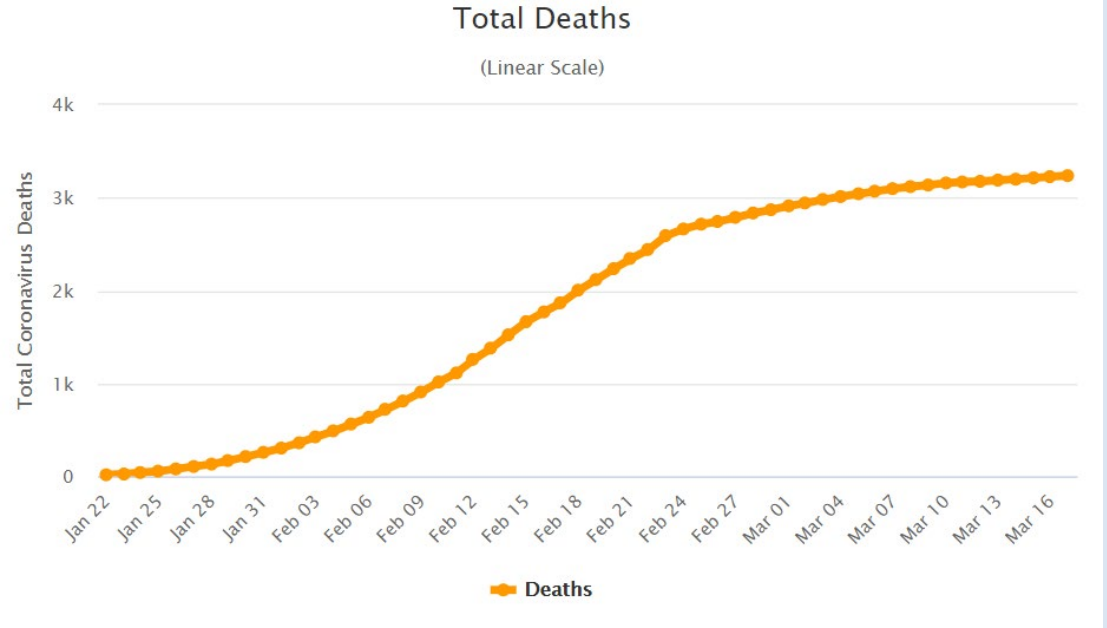


SOURCE: Worldometers, from assorted official sources

THE SITUATION IN... CHINA

COVID-19 Cases and Deaths in China
Updated March 18, 2020

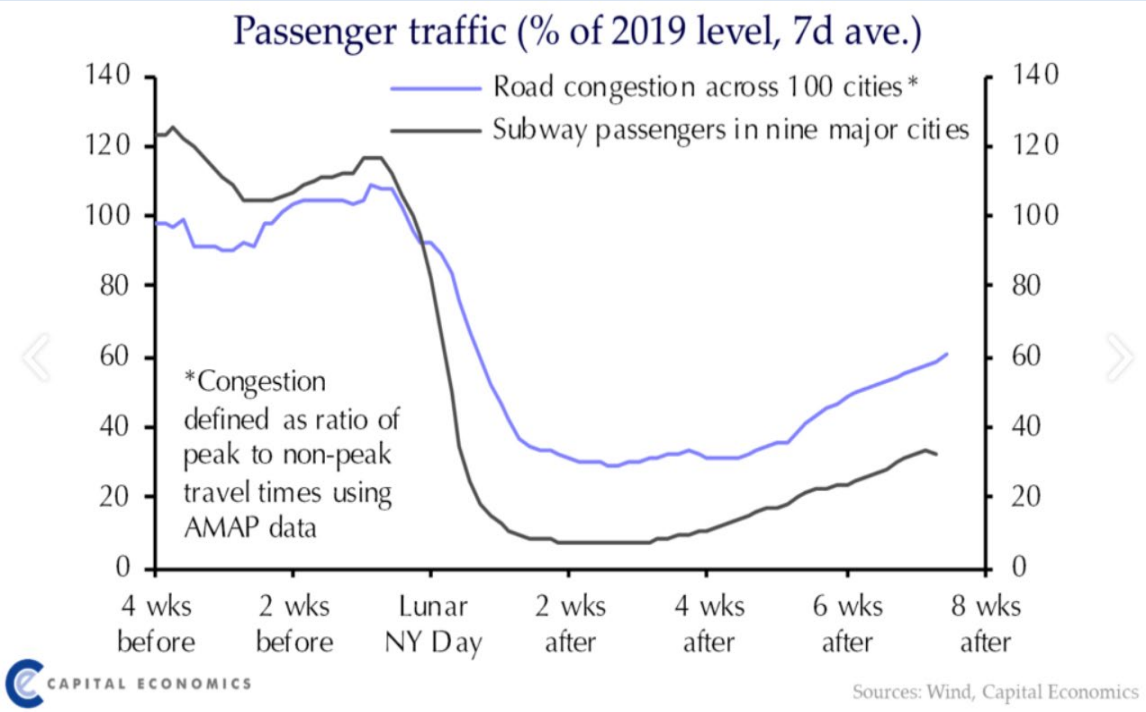


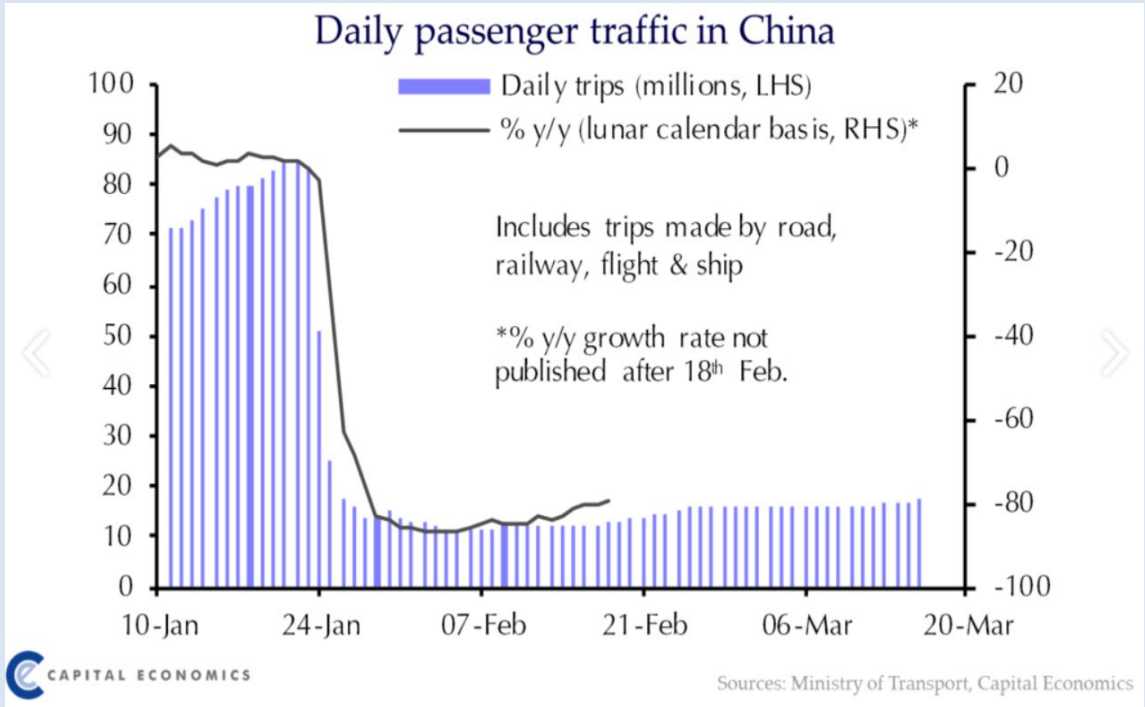


SOURCE: Worldometers, from assorted official sources (2020)

CHINA... COMING OUT OF DEEP FREEZE?

Road Congestion, Subway Passengers, and Daily Passenger Traffic in China
Updated March 19, 2020

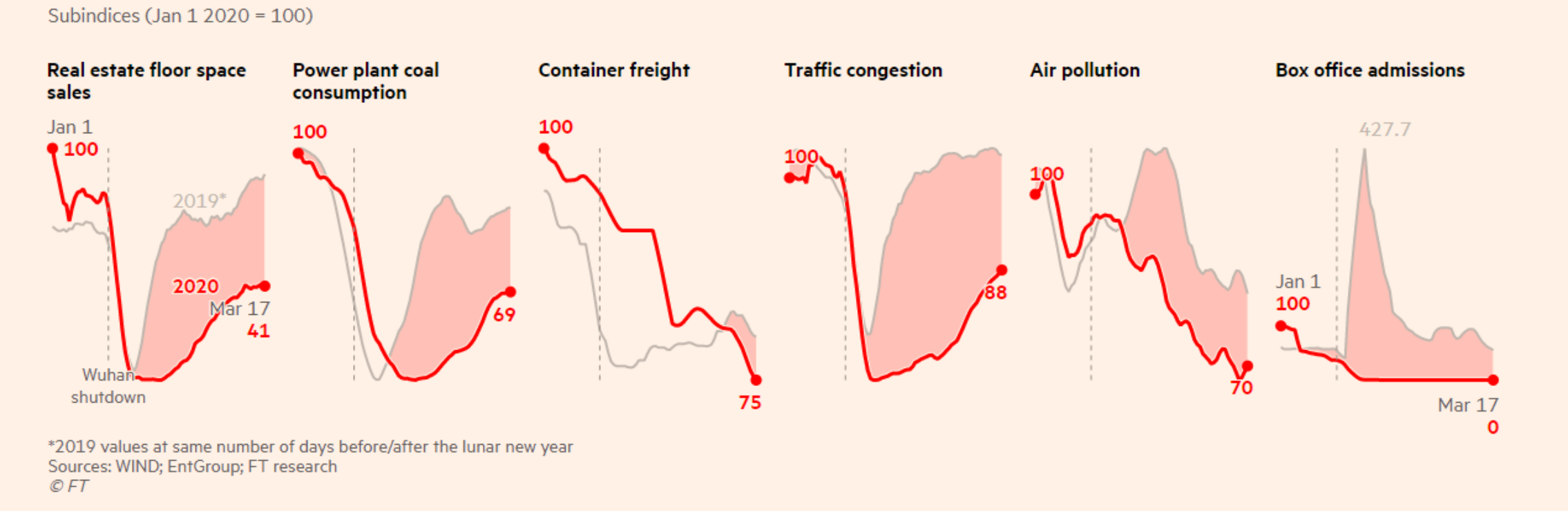




SOURCE: Capital Economics (2020)

CHINA… COMING OUT OF DEEP FREEZE?

Store Floor Space, Coal Consumption, Container Freights, Traffic, Pollution, and Box Office Sales in China
Updated March 19, 2020



SOURCE: Financial Times (2020)

THE TRUE IFR IS (PROBABLY) 0.5% TO 1.0%

PROBLEMS WITH ESTIMATING THE TRUE IFR

IFR = eventual deaths as a % of all infected people. That's extremely difficult to estimate in a dynamic pandemic with variable time from infection to death and where both numerator (deaths) and denominator (relevant infections) are unknown.

- AGAIN, REMINDER: IFR ≠ CFR ≠ [current total deaths] ÷ [current total cases]

IDEAL TEST CASE: THE *"DIAMOND KING"*

Health statistician's dream: Fixed and tested population with reasonable n-size (3,711) & with all outcomes known:

- 705 tested positive (410 asymptomatic), of which 7 died; IFR ≈ 1.0%
- population older, but also healthier than avg; assumed 0.5% < IFR < 1.5%

INFERENCE FROM NATIONAL CASE DATE

- CFR declines (and approaches true IFR) with more extensive testing, and
- True IFR rises with older population; older initial spread; and stressed healthcare system.

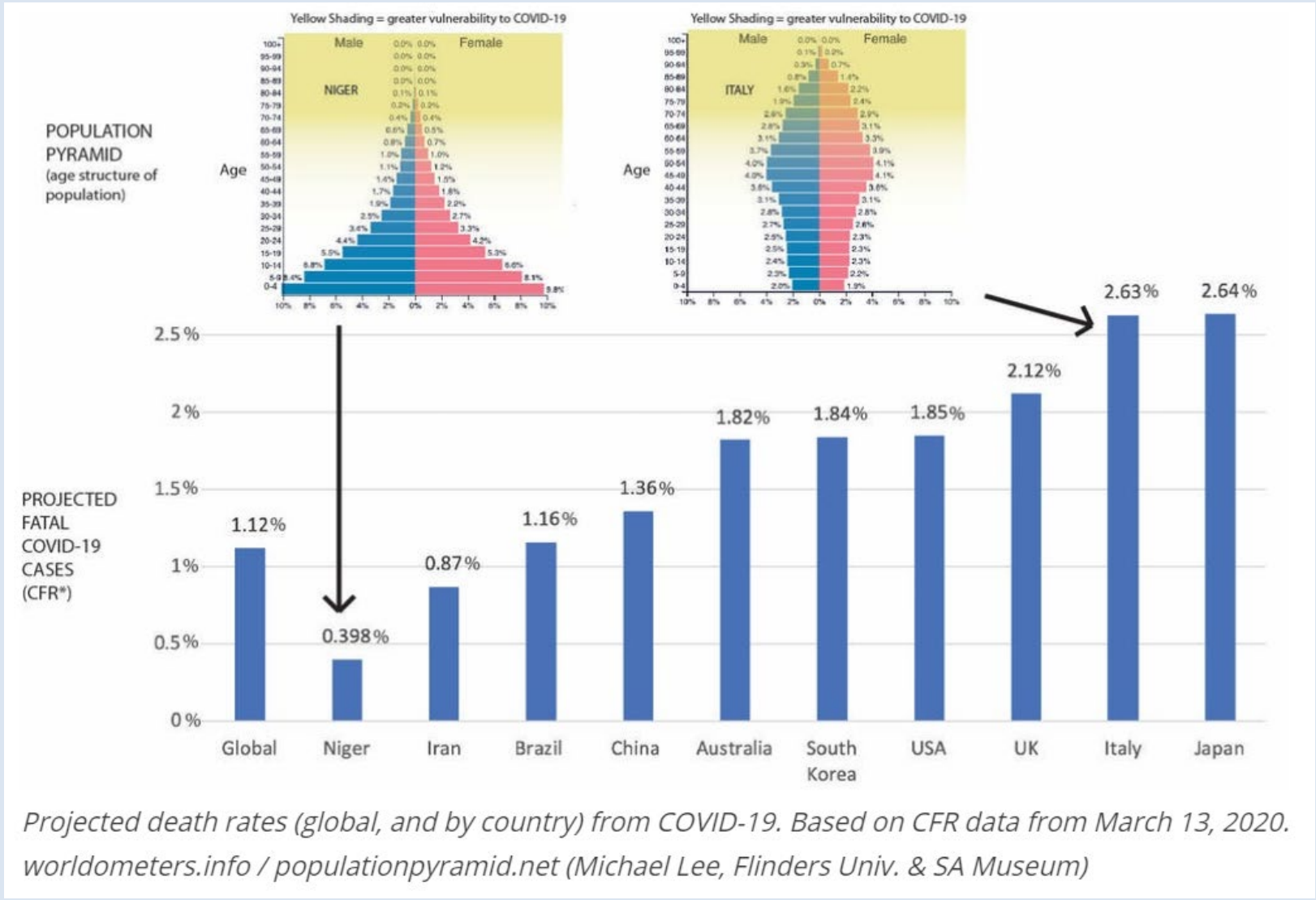
  E.g., CFR's of 2-4% come down to (IFRs) of 1% or lower with widespread testing

  E.g., South Korea has CFR of just under 1%; Italy has CFR of > 6%

EPIDEMIOLOGICAL MODELING

Widely respected model of Imperial College COVID-19 Response Team for UK and US now estimates IFR = 0.9%. Other modeled data (e.g., from China), point to 0.5% to 1.5%.

IFR GOES UP WITH DEMOGRAPHIC AGING

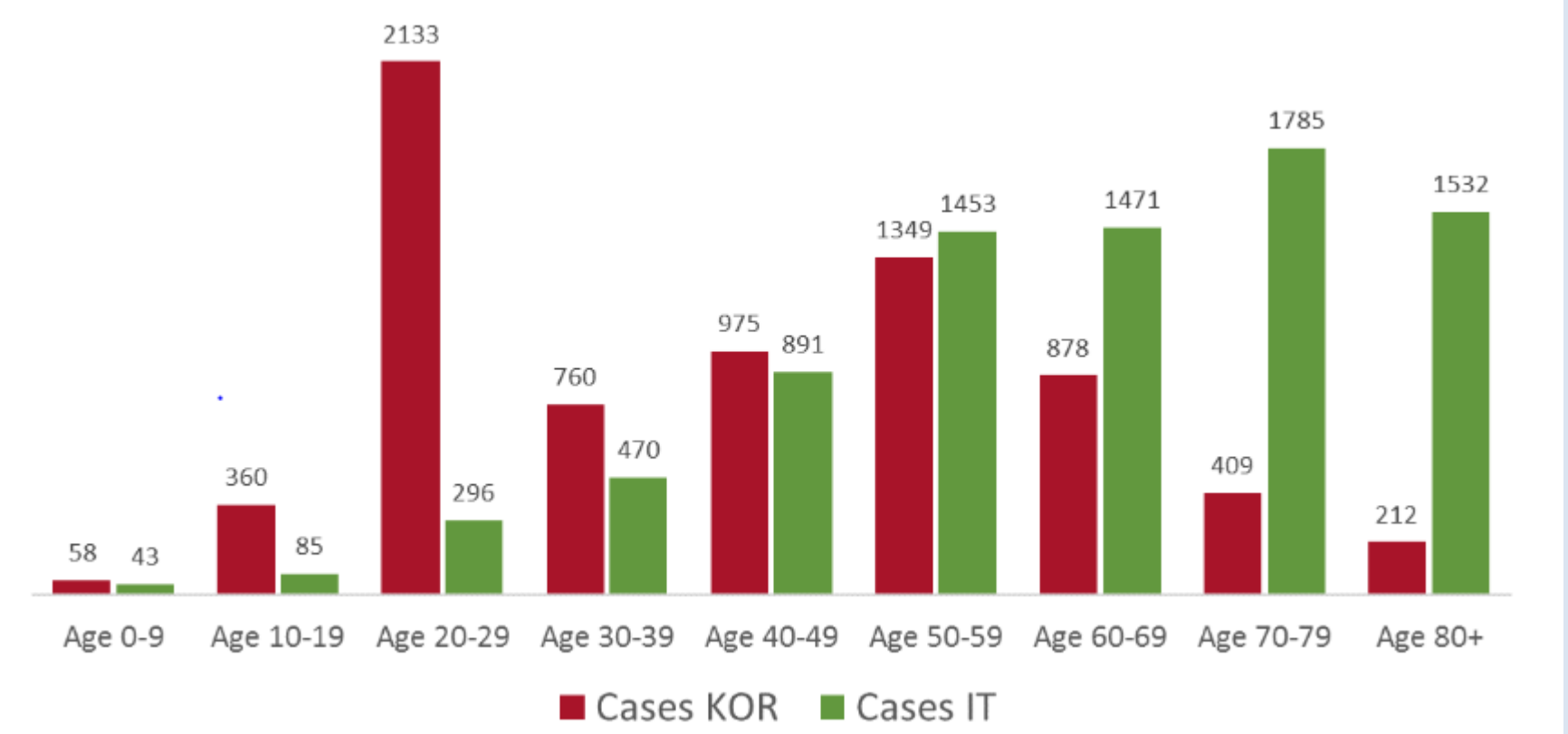


Projected death rates (global, and by country) from COVID-19. Based on CFR data from March 13, 2020. worldometers.info / populationpyramid.net (Michael Lee, Flinders Univ. & SA Museum)

Source: Michael Lee, Flinders University (Australia, 2020)

THE CURIOUS CASE OF SOUTH KOREA V ITALY...

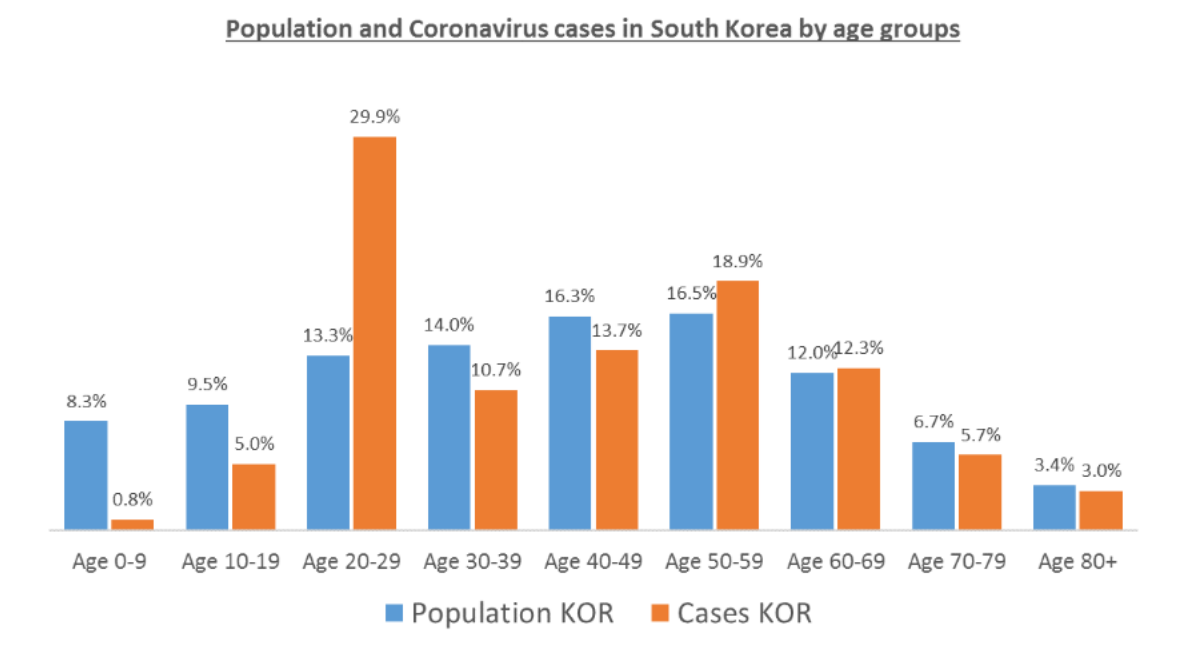
COVID-19 Cases By Age-Group in South Korea and Italy
Updated March 13, 2020

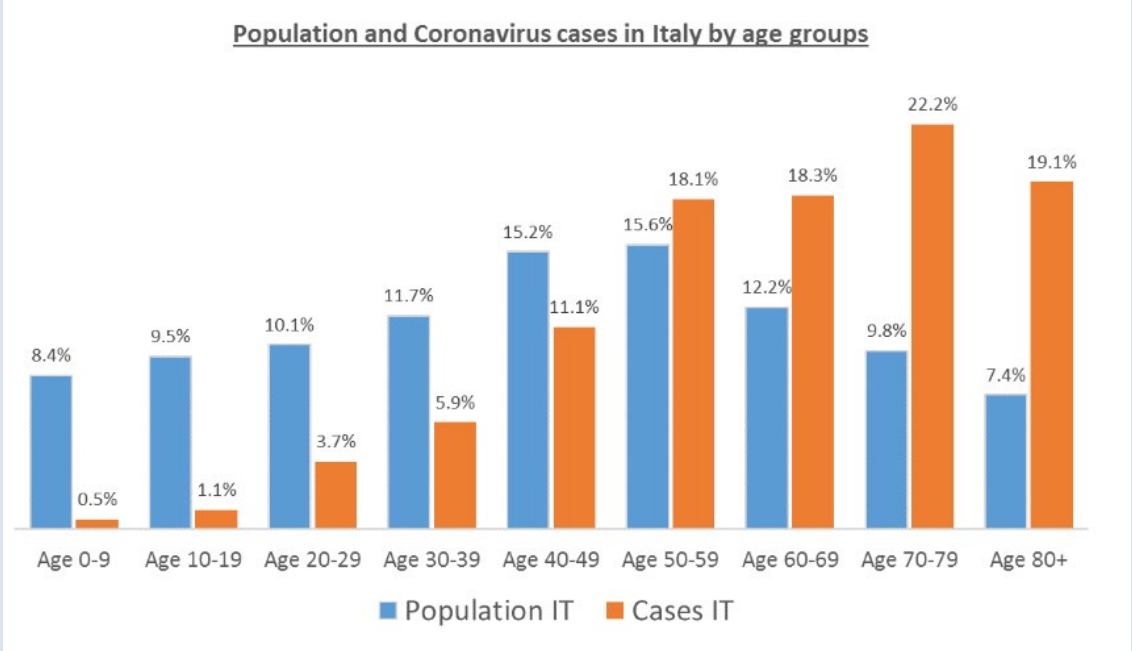


SOURCE: *Medium*, from News1 and Corriere della Sera (2020)

DIFFERENCES IN DEMOGRAPHICS OR TESTING?

Population and COVID-19 Cases By Age-Group
South Korea and Italy, Updated March 13, 2020





SOURCE: *Medium*, from News1 and Corriere della Sera (2020)

THE STUNNING IMPERIAL COLLEGE MODEL

NEW IMPERIAL COLLEGE MODEL (PUBLISHED MAR 16, 2020):

Title: "*Impact of Non-pharmaceutical Interventions (NPIs) to reduce COVID-19 mortality and healthcare demand.*" Authors: Neil M. Ferguson, et al. Published: March 16, 2020.

Basic assumptions in unconstrained ("do nothing") model:

- R_0 = 2.0-2.6; avg generation = 6.5 days; incubation = 5.1 days
- considered interventions: (1) case isolation; (2) home quarantining; (3) closing schools/colleges; (4) social distancing, > age 70; (5) universal social distancing.

Basic results:

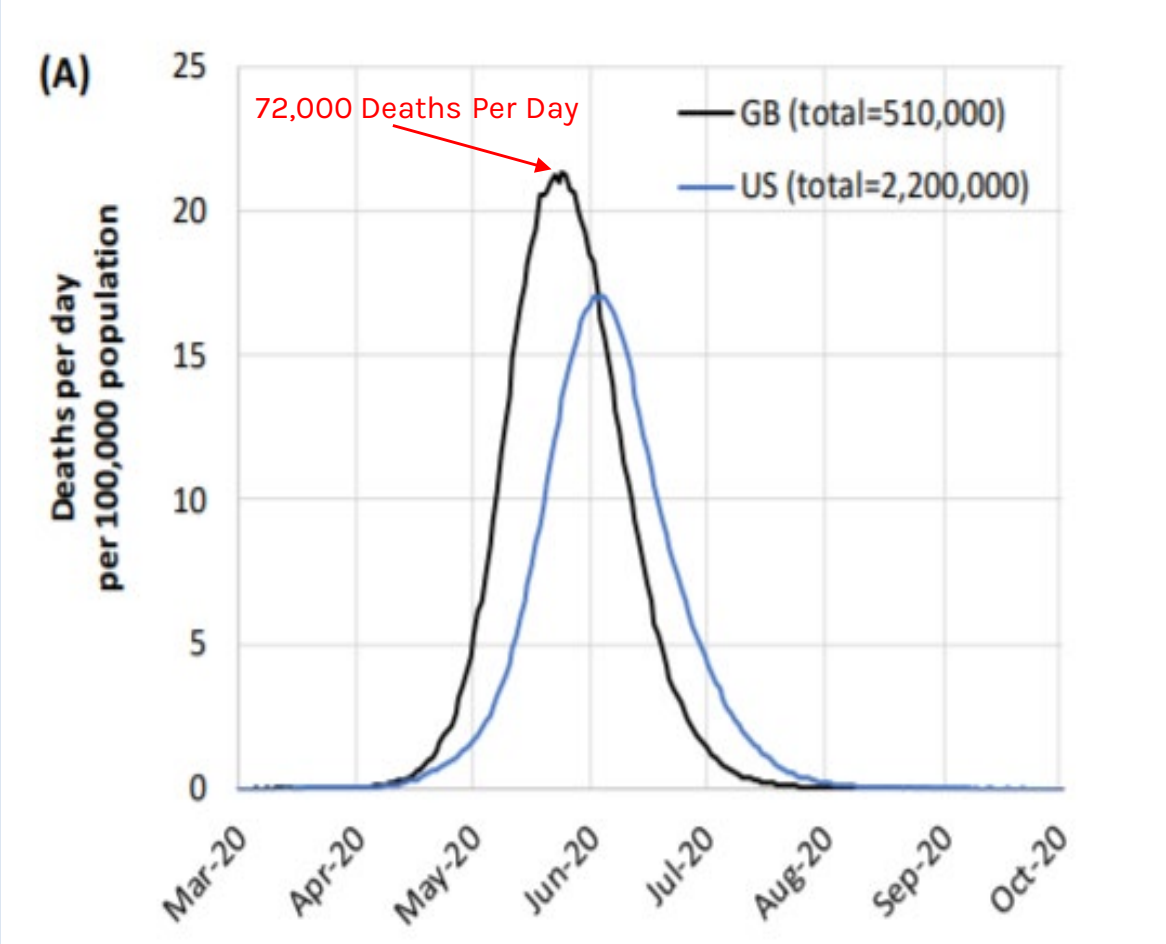
- In do-nothing model, total deaths (ex effects of overwhelmed healthcare system):
  0.5 million (UK) peaking in early June, ending in late July
  2.2 million (US) peaking in late June, ending in mid-August

Effect of interventions:

- Anything less than (5) does indeed "flatten the curve," but still overwhelms the healthcare system—with many additional deaths.
- (5)+ does flatten curve asymptotically to zero (R0<1), but then would need to stay in place indefinitely.
- "The more successful a strategy is at temporary suppression, the larger the later epidemic is predicted to be in the absence of vaccination, due to lesser build-up of herd immunity. "

BLEAK OUTLOOK…

Deaths Per Day Per 100,000 Population in "Do Nothing" Scenario: UK and US



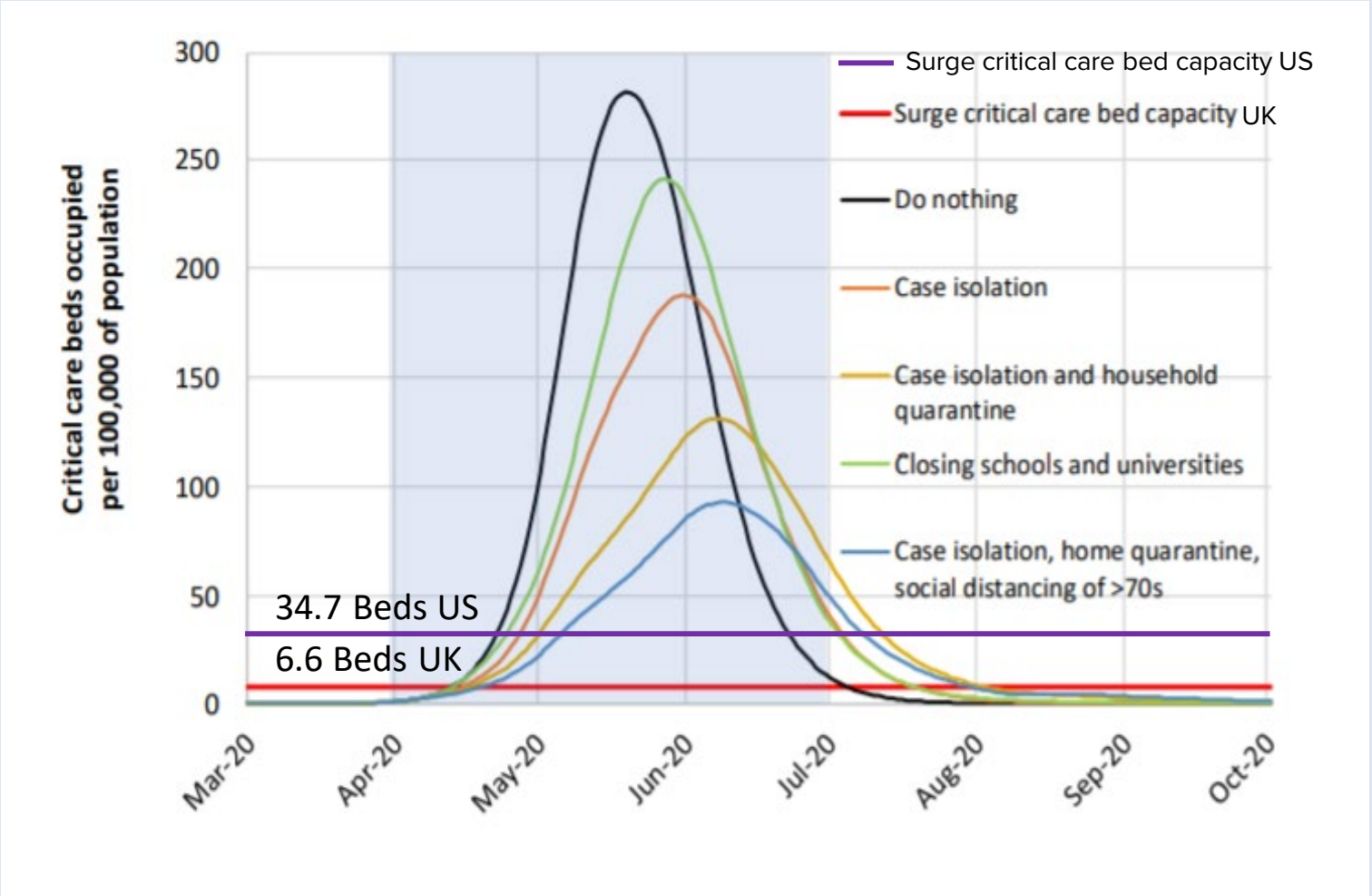
Estimated Severity of Cases

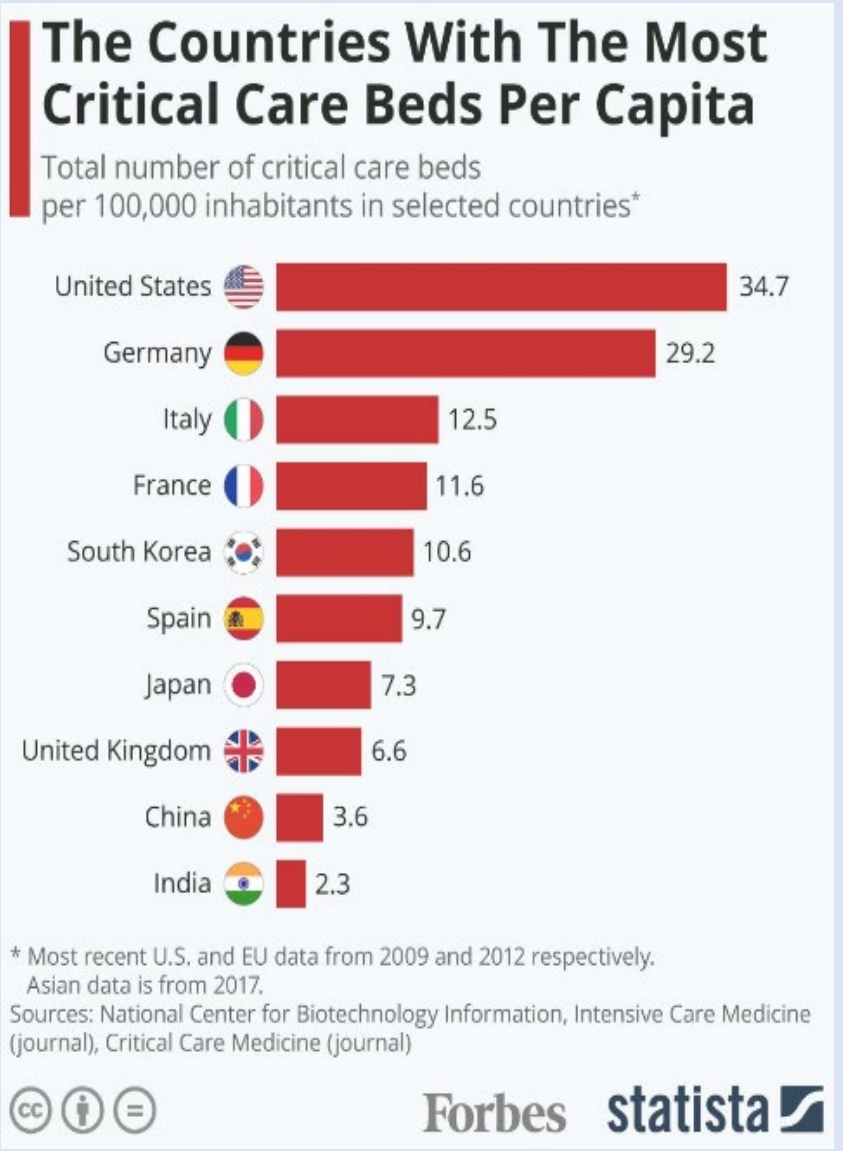
Age-group (years)	% symptomatic cases requiring hospitalisation	% hospitalised cases requiring critical care	Infection Fatality Ratio
0 to 9	0.1%	5.0%	0.002%
10 to 19	0.3%	5.0%	0.006%
20 to 29	1.2%	5.0%	0.03%
30 to 39	3.2%	5.0%	0.08%
40 to 49	4.9%	6.3%	0.15%
50 to 59	10.2%	12.2%	0.60%
60 to 69	16.6%	27.4%	2.2%
70 to 79	24.3%	43.2%	5.1%
80+	27.3%	70.9%	9.3%

SOURCE: Imperial College COVID-19 Response Team (2020)

EVEN WITH SWEEPING MITIGATION STRATEGIES

Critical Care Beds Occupied Per 100,000 Population With Differing Control Methods, Great Britain and US



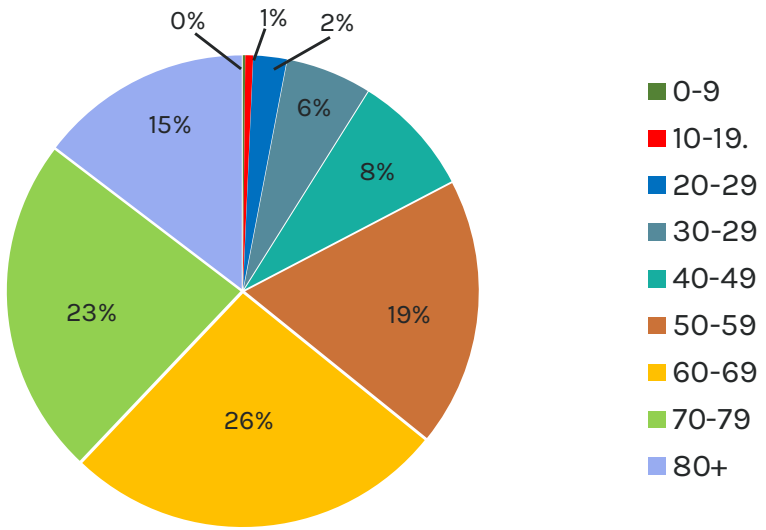


SOURCE: Imperial College COVID-19 Response Team (2020)

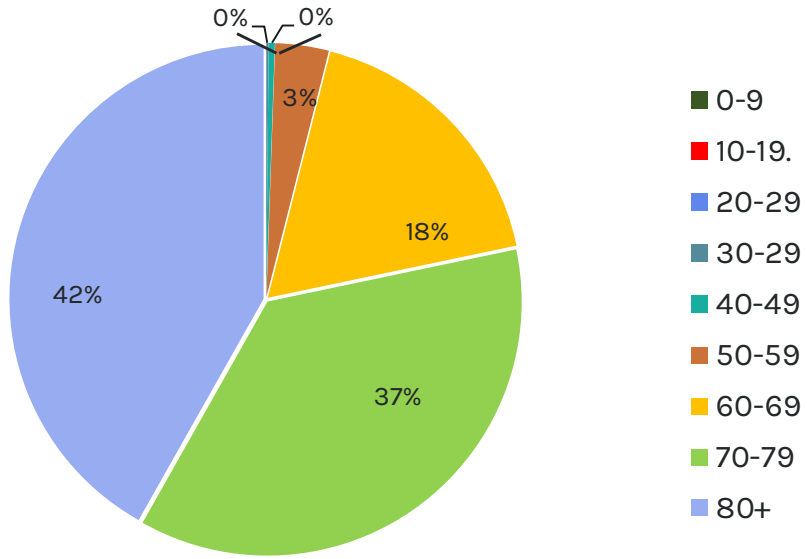
PROJECTED TOLL OF COVID-19: MAINLY > AGE 60

Share of US Covid-19 Hospitalizations and Deaths by Age Group

Age Group Share of Total Covid-19 Hospitalizations



Age Group Share of Total Covid-19 Deaths



SOURCE: Imperial College COVID-19 Response Team (2020)

TWO PATHS AHEAD… BOTH VERY DIFFICULT

THE DILEMMA NOW FACING NATIONAL POLICYMAKERS

Go For Mitigation: Flatten curve while allowing more infections sooner, pursue "herd immunity."

- Strengths: Minimizes duration of epidemic; much less economic damage
- Weaknesses: Overwhelms health system (ICUs, ventilators, ECMOs, personnel), which multiplies death rate
- UK, Netherlands, Sweden opting for this… but now backing away

Go For Suppression: Flatten curve all the way down to $R_0<1$, defer "herd immunity"

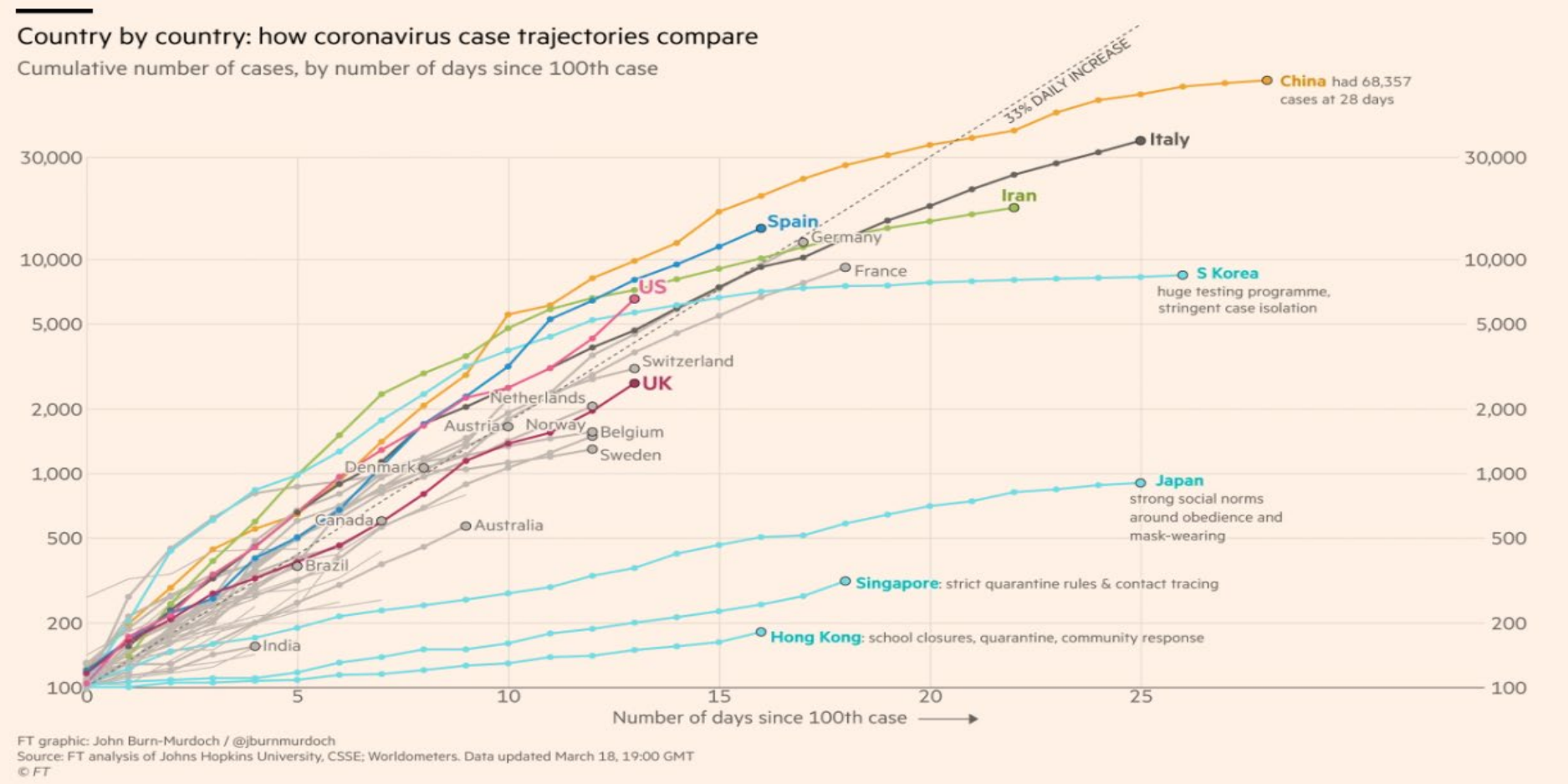
- Strengths: Minimizes deaths, both by minimizing cases and by allow health system to care fully for the sick.
- Weaknesses: Maximizes duration; much more economic damage
- China in February opted for this… esp in Hubei Province

Are There Variants to the Above?

- "Smart Mitigation": Allow more infections, but strictly sequester older, sicker population.
- "Smart Suppression": Suppression with minimal hindrance to work activity—with widespread testing; diligent contact tracking; compliance with universal social distancing; etc.
- Possible requirements: Early containment; systematic testing; culture of social discipline.

WHICH COUNTRIES SUCCEEDING AT SMART SUPPRESSION?

Country By Country COVID-19 Case Trajectories



SOURCE: *Financial Times* (2020)

IN TESTING, U.S. IS STARTING OUT WAY BEHIND

FORMULA FOR LIKELY INFECTIONS IN COMMUNITY FOR EACH CURRENT DEATH IN UNCONSTRAINED EPIDEMIC

Assumptions: R0 = 2.3; generation = 5 days; avg infection to death = 17 days; IFR = 0.5%

Result: For every new death, there will be approx. 3,400 new cases.

On May 18:

- There were 41 recorded new deaths
- There were 2,848 recorded new cases

But actually, if there were 41 new deaths, we should have noticed 13,940 new cases.

Thus, for every ONE new case ("positive") we know about there are FIVE new cases we do not know about.