2019 novel coronavirus disease (COVID-19)

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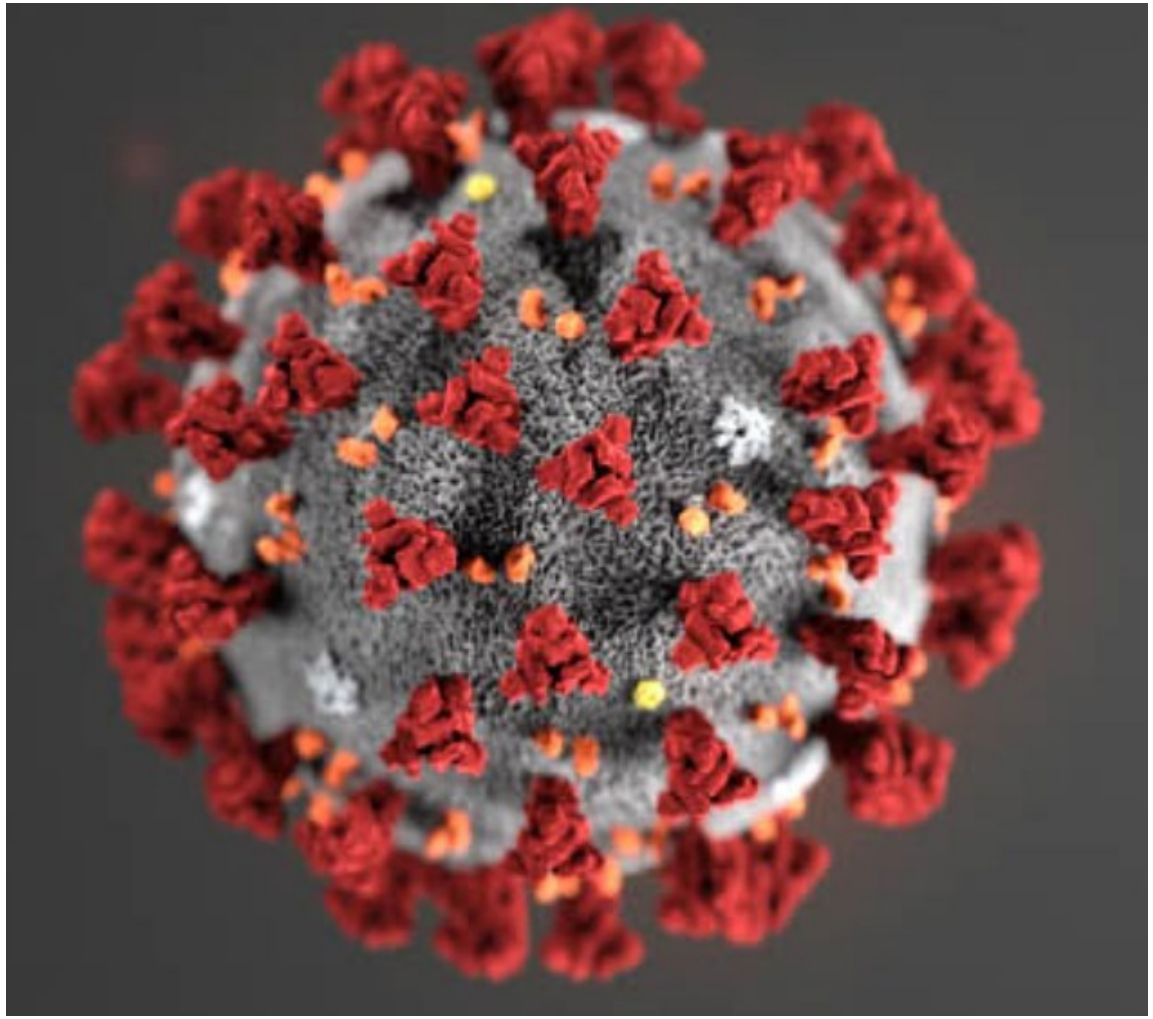
6 May 2020

What we'll discuss today

- The emergence of SARS-CoV-2 and its associated disease (COVID-19) in Wuhan, China
- Worldwide and local epidemiology
- Population-level prevention
- School closing and reopening
- Future



SARS and MERS

- Both closely related to bat strains of coronavirus
- Transmitted through other secondarily infected species
  - SARS Himalayan palm civets
  - MERS dromedaries
- SARS originally associated with wet market in Guangzhou
  - 26 countries
  - $10-$30B economic damage

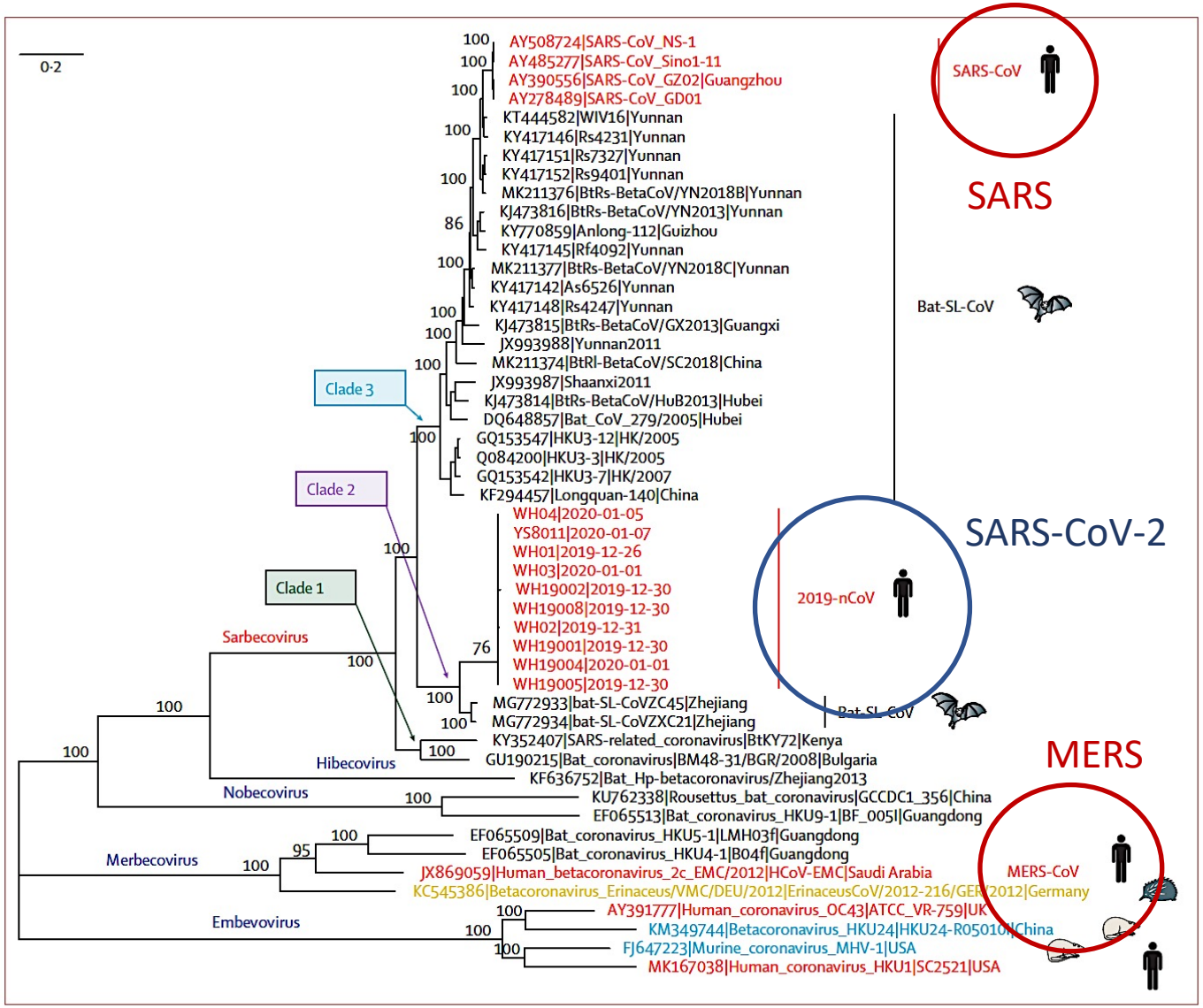


Figure 3: **Phylogenetic analysis of full-length genomes of 2019-nCoV and representative viruses of the genus Betacoronavirus**
2019-nCoV=2019 novel coronavirus. MERS-CoV=Middle East respiratory syndrome coronavirus. SARS-CoV=severe acute respiratory syndrome coronavirus.

From: Lu R, Li J, N P, et al. Genomic characterisation of and epidemiology of 2019 novel coronavirus: implications for virus origins and receptor binding. Lancet 2020 Jan 29 [Epub ahead of print].

Epizoology of COVID-19

- Genetic sequence close to bat strains of coronavirus
- Suggestion of a secondary host, which acquired COVID-19 from bats and transmitted it to humans at Huanan Wholesale Seafood Market
- Possible candidate is the *pangolin*, a mammal whose scales used in traditional medicine
  - Most illegally trafficked animal in the world

Total Confirmed
3,646,206

Confirmed Cases by Country/Region/Sovereignty

- 1,199,238 US
- 218,011 Spain
- 213,013 Italy
- 196,239 United Kingdom
- 169,583 France
- 166,696 Germany
- 155,370 Russia
- 129,491 Turkey
- 110,156 Brazil
- 99,970 Iran
- 83,966 China
- 62,944 Canada
- 51,189 Peru
- 50,509 Belgium
- 49,400 India
- 41,286 Netherlands
- 31,881 Ecuador
- 30,251 Saudi Arabia
- 30,009 Switzerland
- 25,702 Portugal
- [illegible] Mexico

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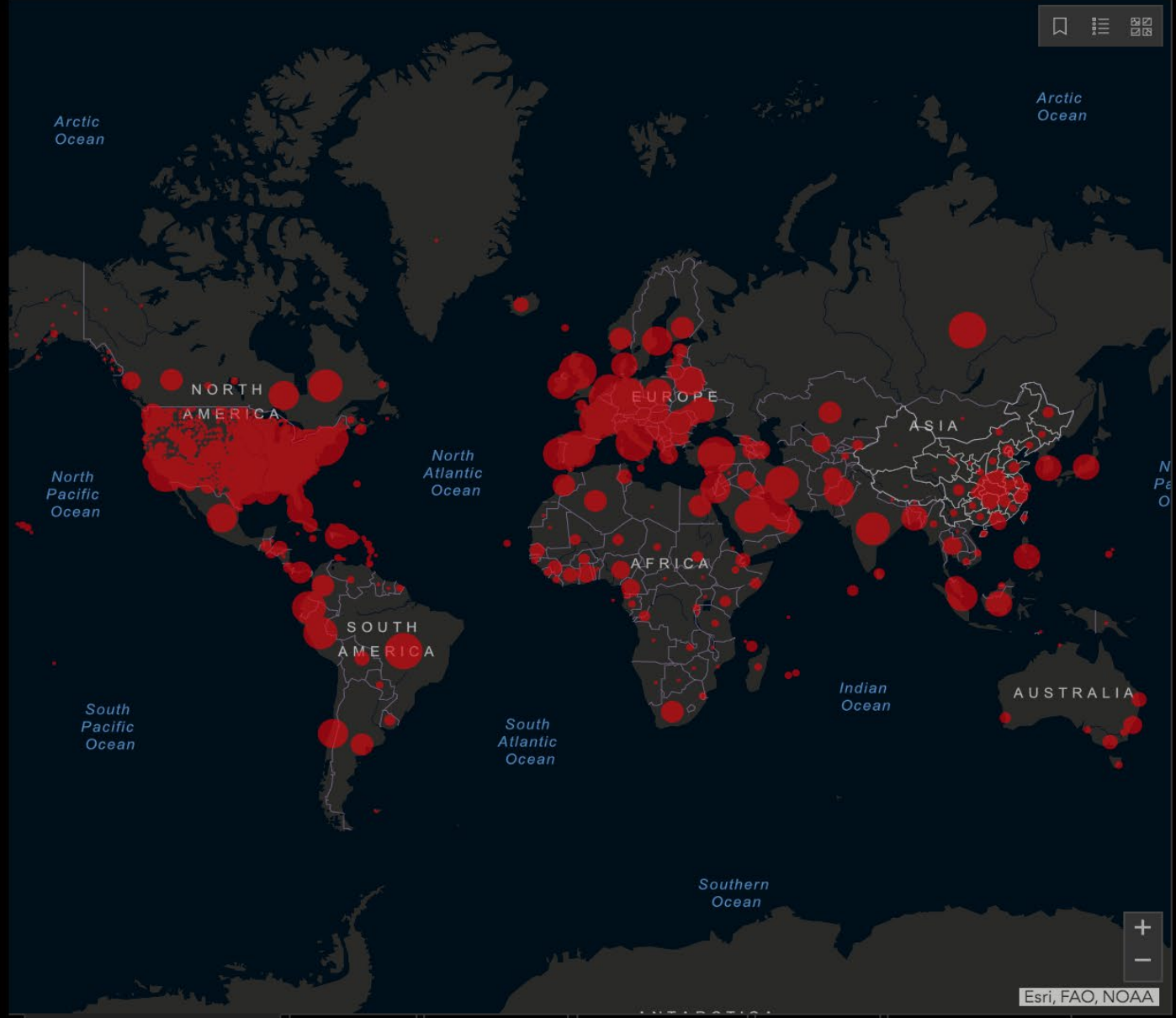


Cumulative Confirmed Cases | Active Cases | Incidence Rate | Case-Fatality Ratio | Testing Rate | Hospitalization Rate

187
countries/regions

Lancet Inf Dis Article: Here. Mobile Version: Here.
Lead by JHU CSSE. Automation Support: Esri Living Atlas team and JHU APL. Contact US. FAQ.

Data sources: WHO, CDC, ECDC, NHC, DXY, 1point3acres, Worldometers.info, BNO, the COVID Tracking Project (testing and hospitalizations), state and national government health departments, and local media reports. Read more in this blog.

Global Deaths
255,486

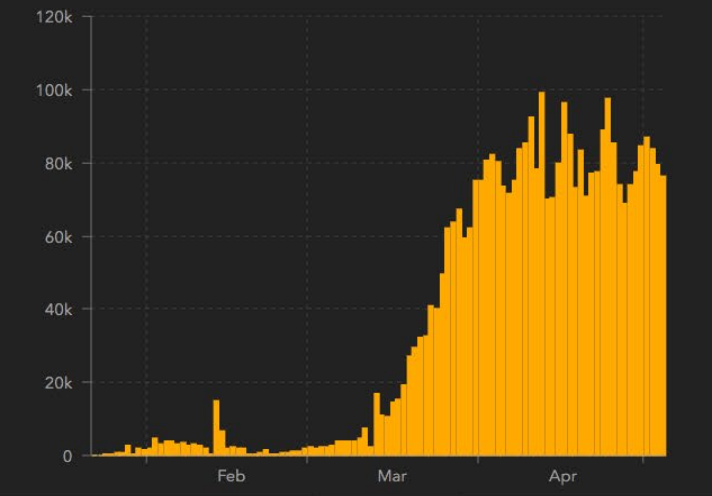
- 70,646 deaths US
- 29,502 deaths United Kingdom
- 29,315 deaths Italy
- 25,428 deaths Spain
- 25,204 deaths France
- 8,016 deaths Belgium
- 7,485 deaths Brazil
- 6,993 deaths Germany
- 6,340 deaths Iran
- 5,185 deaths Netherlands

◁ Global Deaths ▷

US State Level
Deaths, Recovered

- 25,073 deaths, 58,950 recovered New York US
- 8,244 deaths, 15,642 recovered New Jersey US
- 4,183 deaths, 15,659 recovered Michigan US
- 4,090 deaths, 0 recovered Massachusetts US
- 3,165 deaths, 0 recovered Pennsylvania US
- 2,834 deaths, 0 recovered Illinois US
- 2,633 deaths, 4,346 recovered Connecticut US
- 2,319 deaths, 0 recovered California US
- 2,115 deaths, 20,316 recovered Louisiana US
- 1,471 deaths, 0 recovered [illegible]

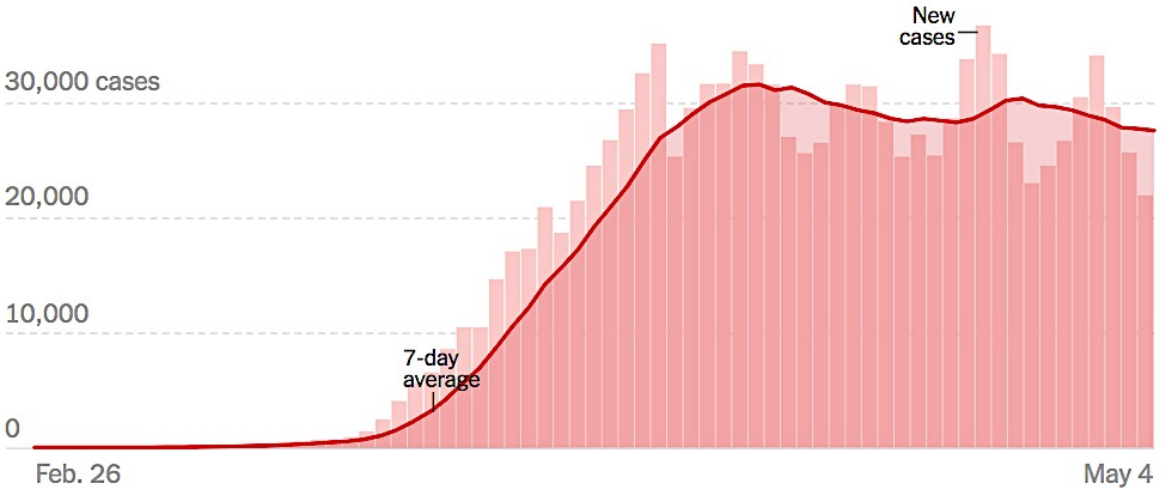
◁ US Deaths, Recovered ▷



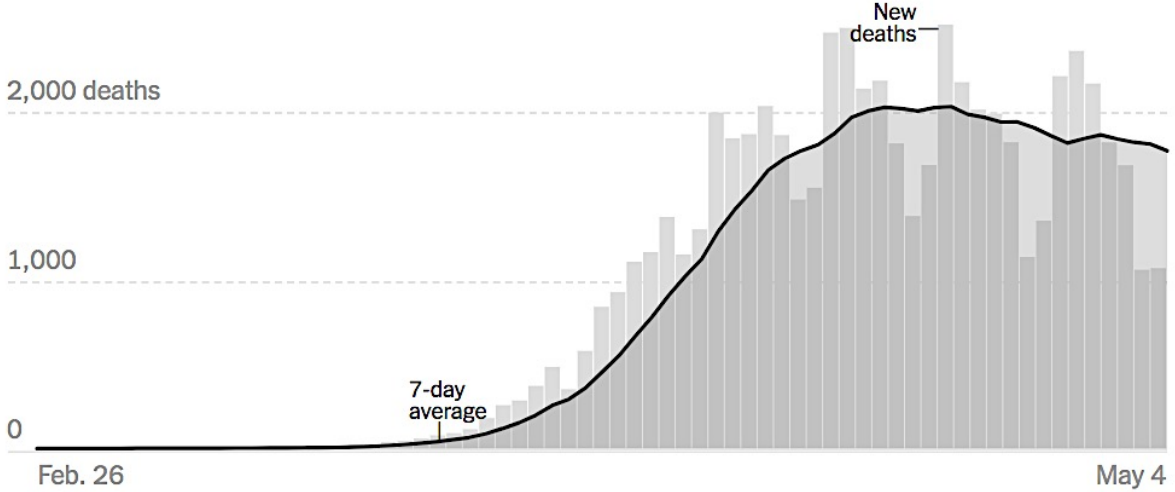
Confirmed | Logarithmic | Daily Cases

COVID-19 cases and death by day of report, United States, 2020

New reported cases by day in the United States



New reported deaths by day in the United States



Note: The seven-day average is the average of a day and the previous six days of data.

1,199,238 cases, 70,646 deaths as of May 5, 2020

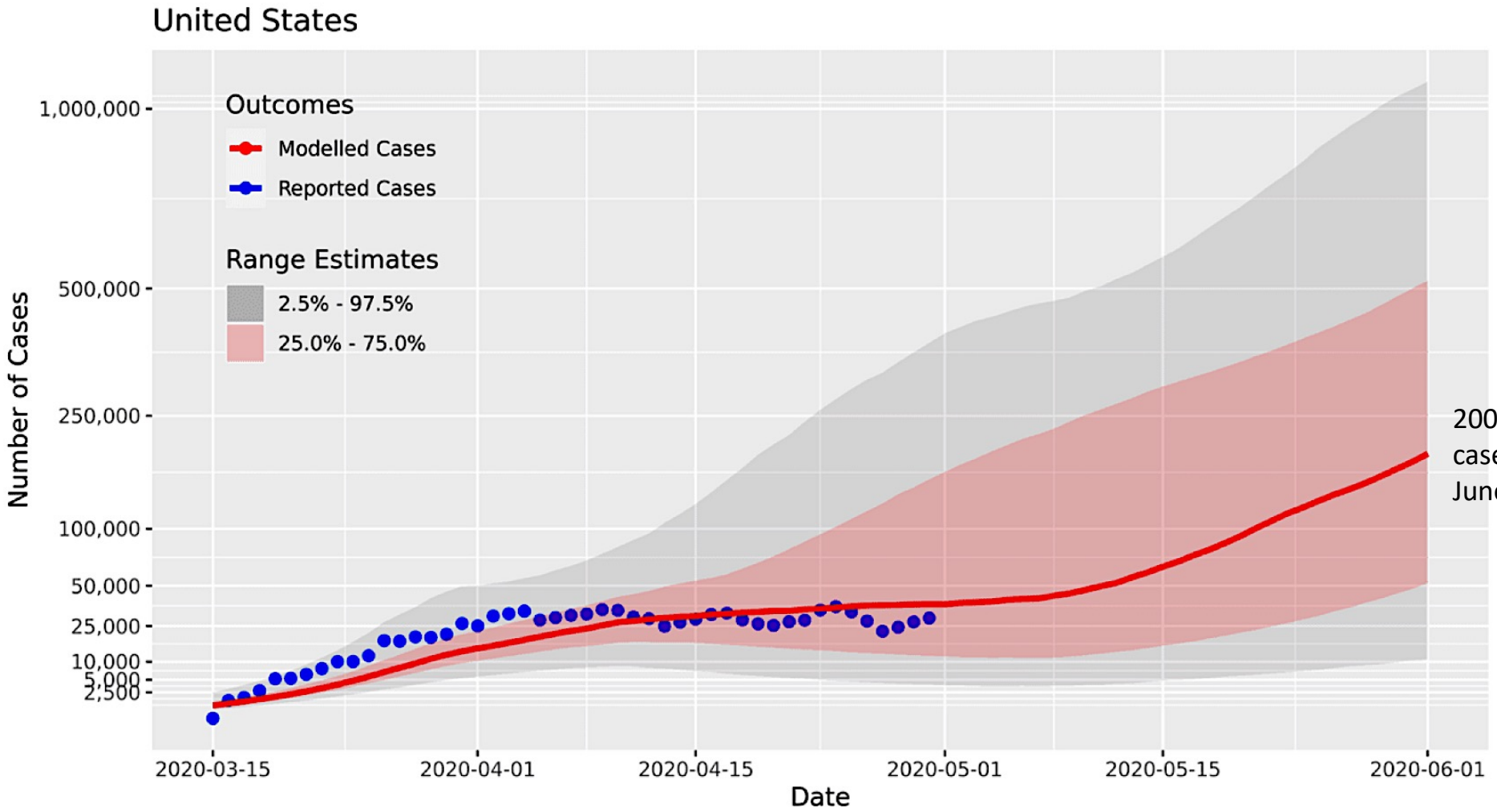
TABLE. Factors contributing to COVID-19 acceleration and corresponding public health actions — United States, January–April 2020

Factor contributing to acceleration	Examples	Public health actions
Continued travel-associated importations of the virus	Travelers arriving from countries or cruise ships with ongoing transmission	Travel health notices, traveler screening (including risk assessment, public health management and monitoring), travel restrictions, federal isolation and quarantine orders, educating travelers and clinicians regarding symptoms and evaluation
Large gatherings	Social, cultural, and professional gatherings where persons convene and then disperse over broad areas	Restricting mass gatherings; global travel restrictions and domestic travel recommendations, recommending transition to virtual events
Introductions into high-risk workplaces/settings	Long-term care facilities, hospitals, correctional facilities, and homeless shelters	Restricting visitor access, establishing cohort units or facilities for residential settings, vigorous contact tracing around persons with confirmed cases, increased infection control, environmental surface cleaning, use of recommended personal protective equipment
Crowding and high population density	Densely populated areas, crowded workplaces, schools, and public spaces	Stay-at-home orders, recommendations for hand washing and social distancing, cloth face covering guidance, school dismissals, extended telework, environmental surface cleaning
Cryptic transmission	Presymptomatic or asymptomatic spread, limited testing, co-occurrence with circulation of other respiratory viruses	Increased testing, COVID-19–specific surveillance, cloth face covering guidance, aggressive contact tracing accompanied by quarantine and/or testing of asymptomatic contacts, stay-at-home orders

Abbreviation: COVID-19 = coronavirus disease 2019.

CDC. Public health response to the initiation and spread of pandemic COVID-19 in the United States, February 24-April 21, 2020. MMWR 2020 May 1; 69 [early release].

Projected Cases per Day

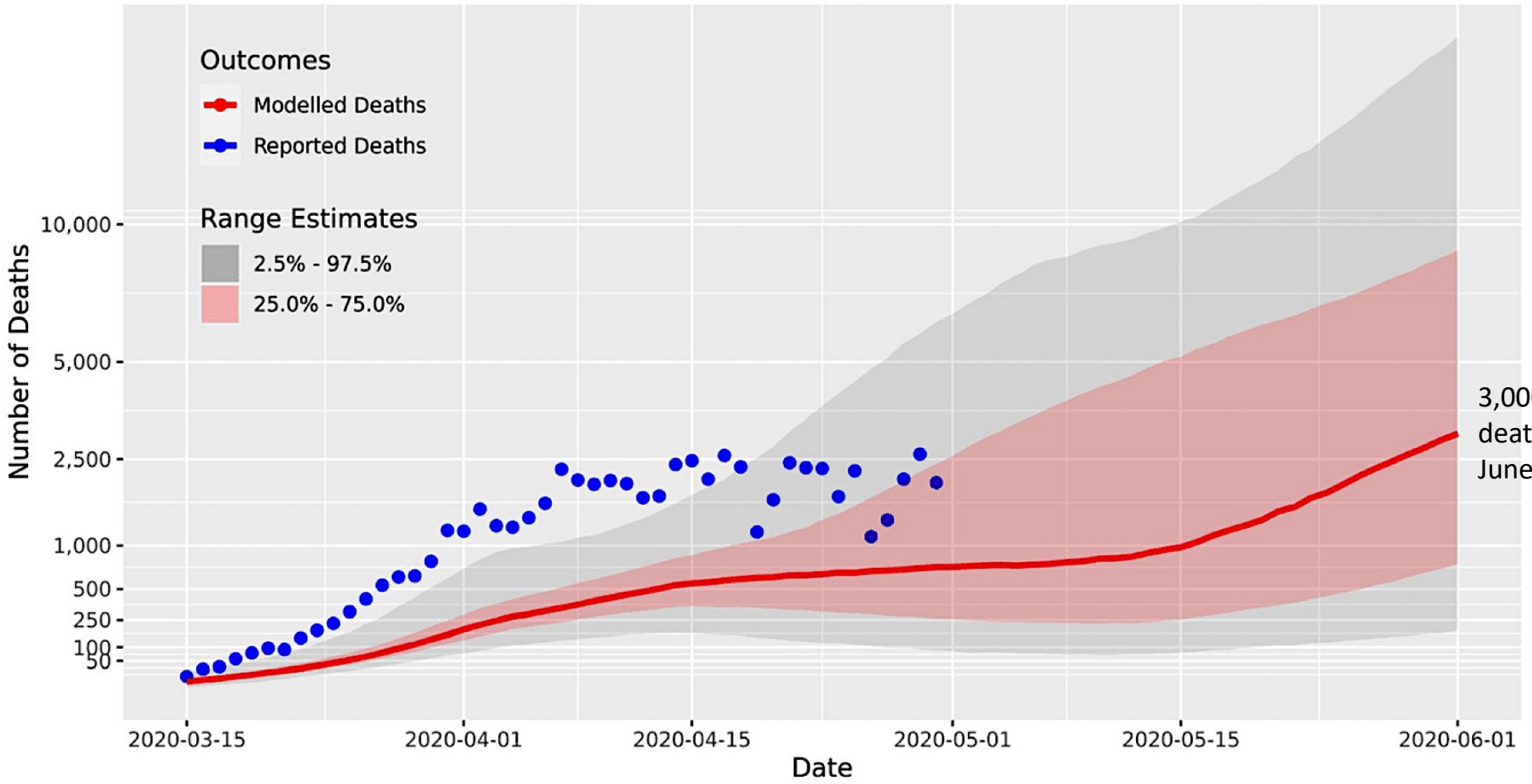


200,000 COVID-19 cases per day by June 1, 2020

NB: Run Date 2020-05-01; IDD Combined

Projected Deaths per Day

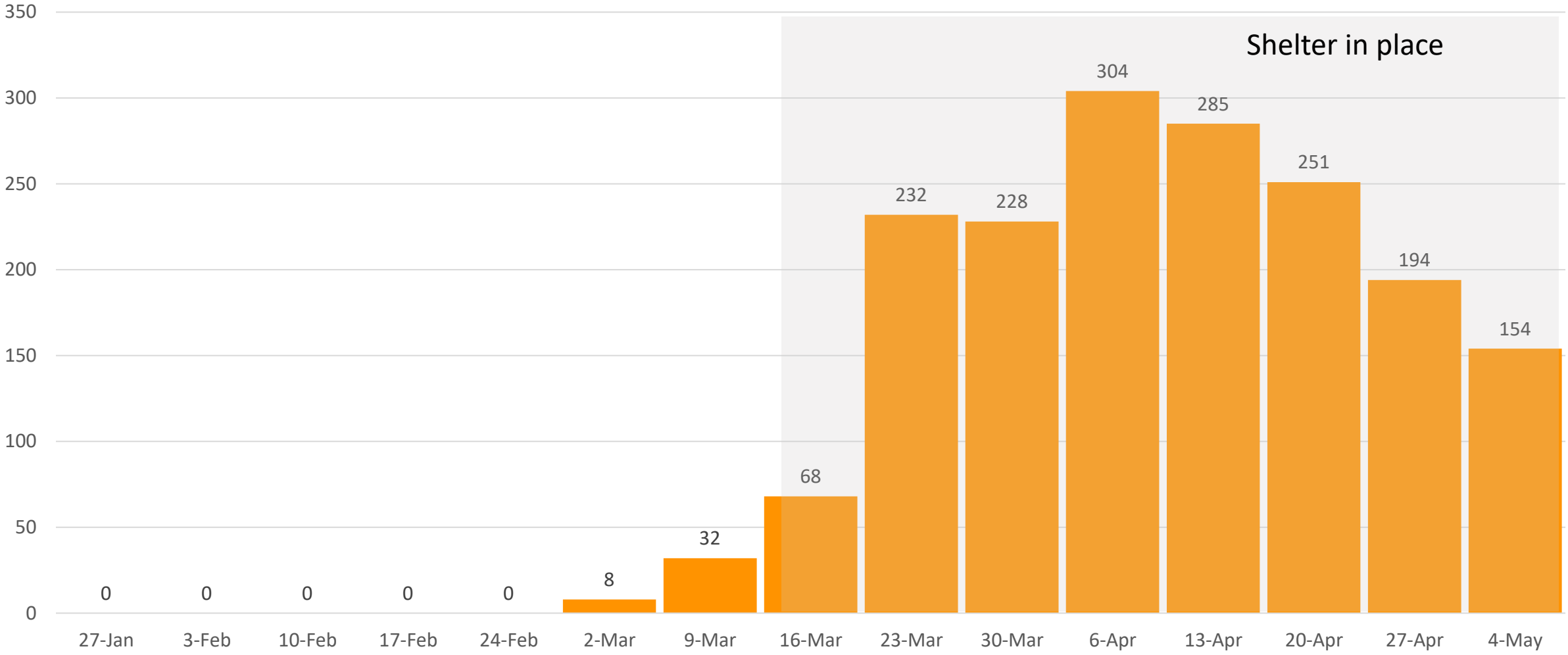
United States



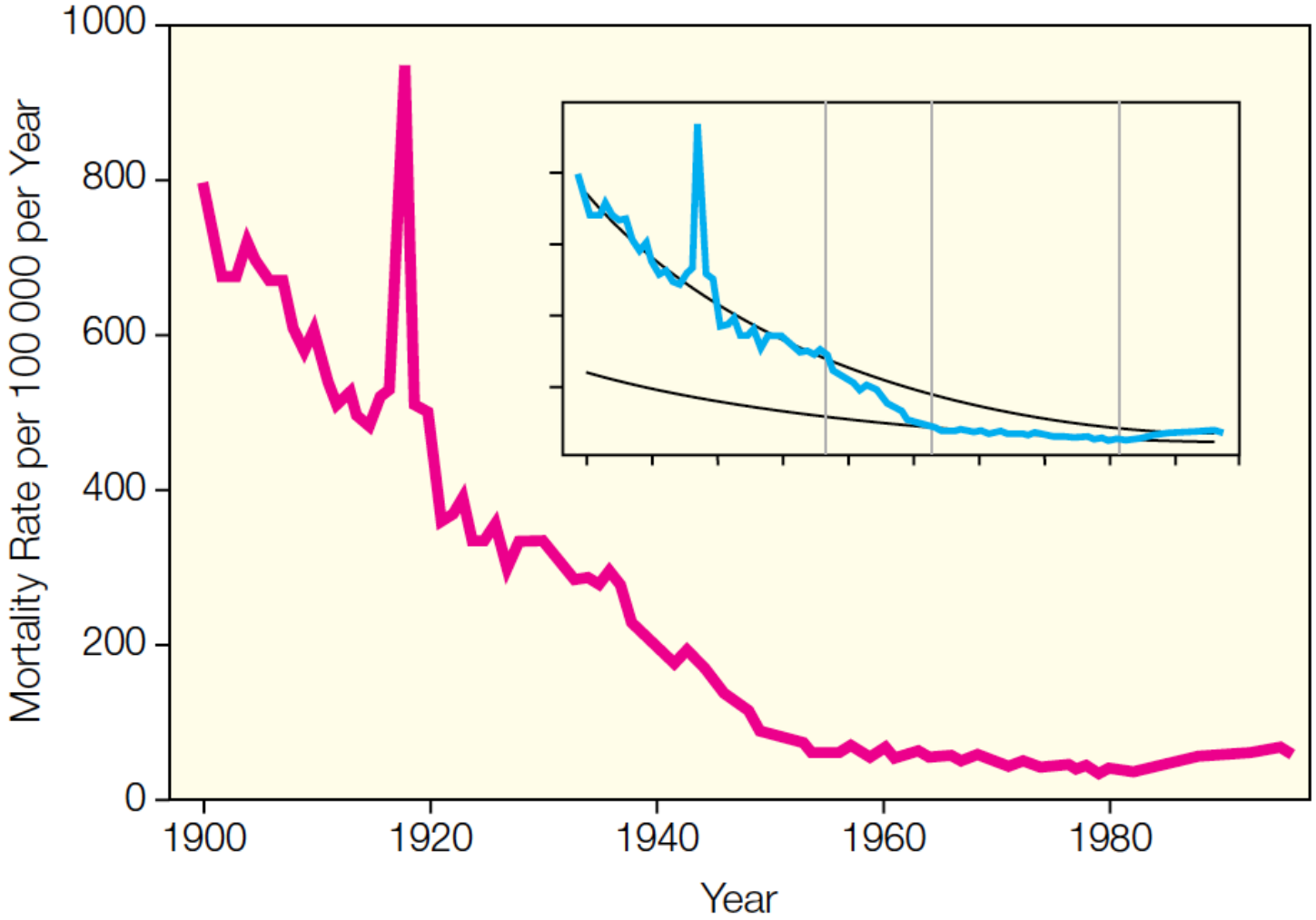
3,000 COVID-19 deaths per day by June 1, 2020

NB: Run Date 2020-05-01; IDD Combined

COVID-19 cases by week, San Francisco County



Infectious disease deaths, United States, 1900-1996



Armstrong GL, Conn LA, Pinner RW. Trends in infectious disease mortality in the United States during the 20th century. JAMA 1999; 281:61-66.

Two strategic goals

- Limit new cases by decreasing R_e, the effective reproductive number
- Flatten and prolong the outbreak to (1) assure adequacy of health care resources and (2) buy time for antivirals and eventually vaccine

Effective reproductive number

Figure 1. Concepts of the Effective Reproduction Number

The effective reproduction number (R_t) of a viral infection is the mean number of additional infections caused by an initial infection in a population at a specific time.

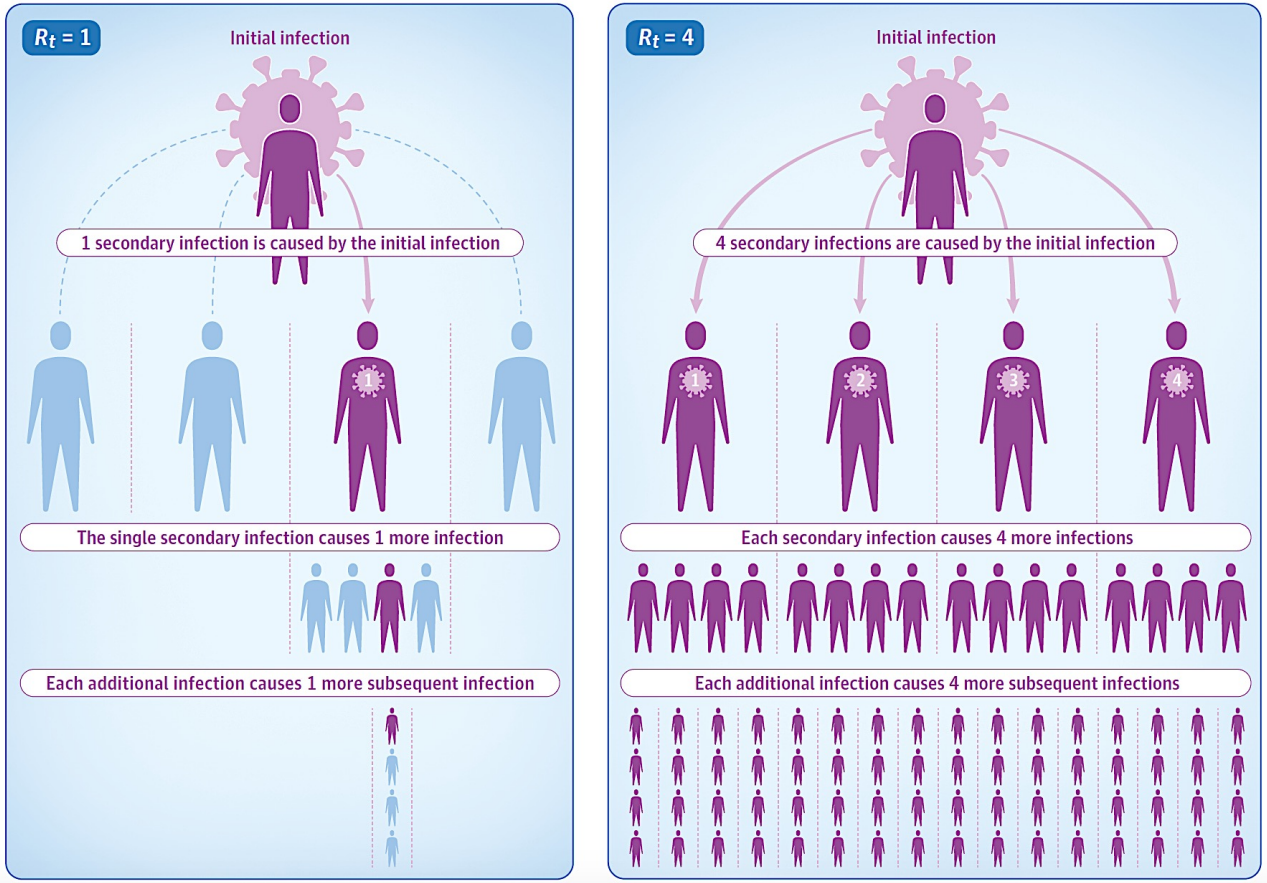
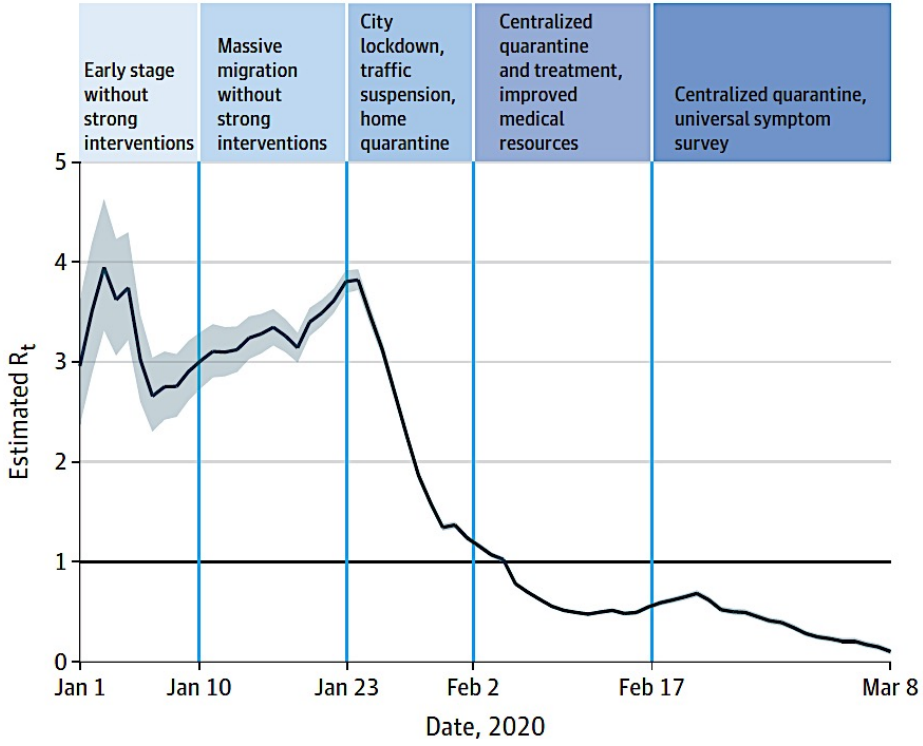


Figure 2. The Effective Reproduction Number (R_t) Estimates Based on Laboratory-Confirmed Coronavirus Disease 2019 (COVID-19) Cases in Wuhan, China



Herd immunity = R_e-1/R_e

If Re = 4, herd immunity occurs at 75%

If Re = 3, herd immunity occurs at 67

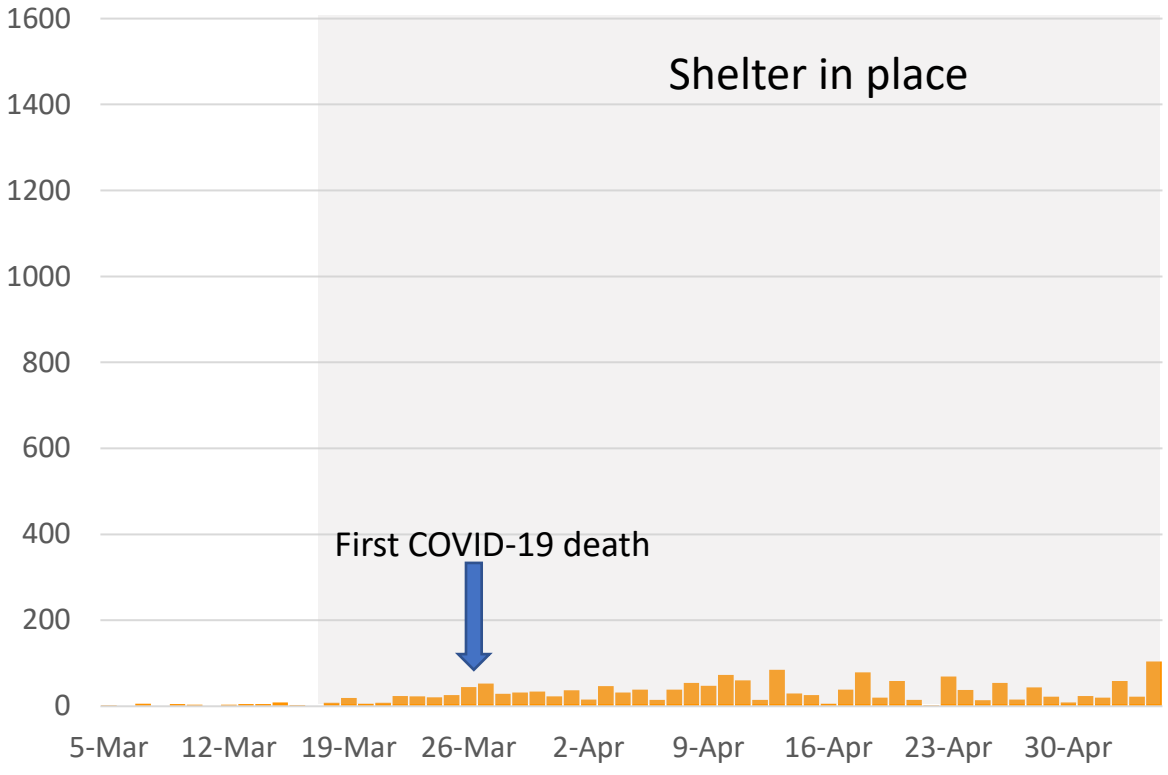
What does the immediate future hold?

- Long tail of cases into the early summer
- Occasional outbreaks in congregate living facilities – skilled nursing homes, homeless shelters, jails, etc.
  - Identifying and suppressing these will be our biggest challenge this summer
- Possible very large second wave when children return to school, but …

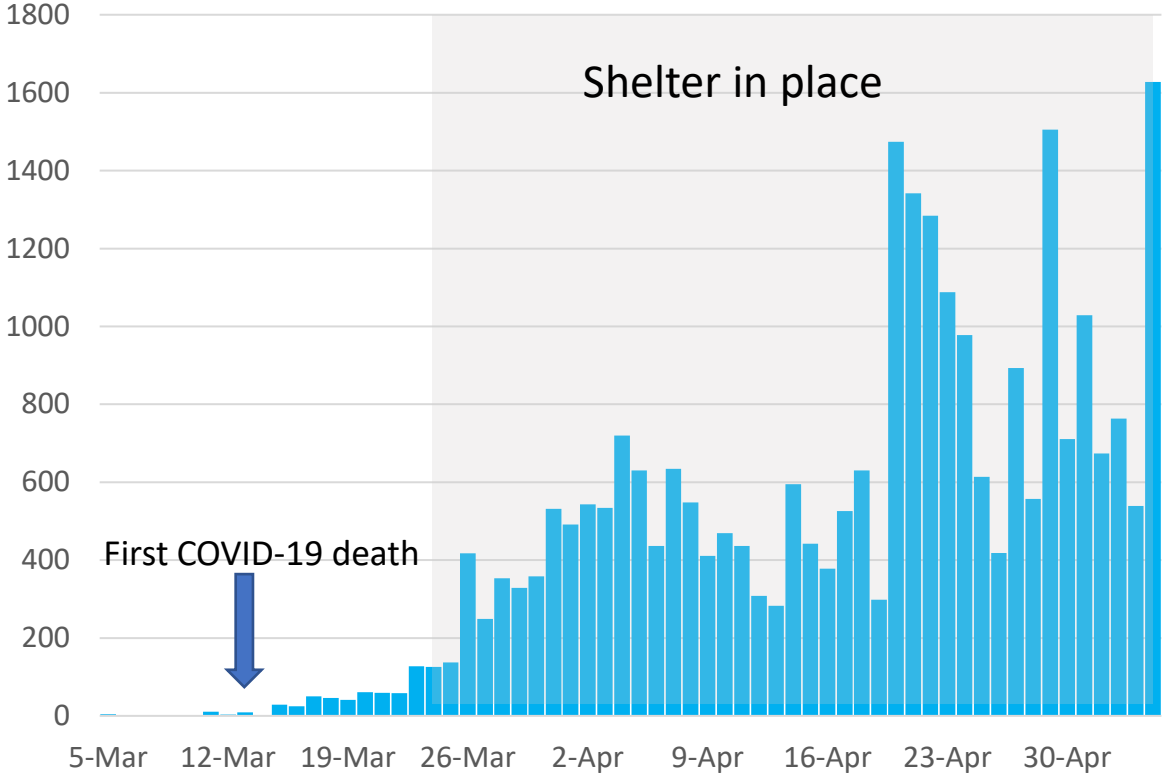
Is social distancing working in San Francisco?

COVID-19 cases by day, San Francisco and Los Angeles, March-April, 2020

San Francisco



Los Angeles



Children are underrepresented among reported COVID-19 cases

- Case series have shown consistently <10% of reported patients are in children and adolescents
  - In the United States 2.1% are <18 years old
  - In Italy 1.8% are ≤18 years old
  - Only sparse data on COVID-19 prevalence

- In review of 1,065 patients (from 18 studies, all but one patient from China), Castagnoli found:
  - Ages ranged from 30 hours to 17 years
  - Most had mild symptoms without pneumonia (fever, dry cough, fatigue)
  - One death (13 month old)

COVID-19 prevalence in children, Iceland

- Two samples
  - High-risk – symptoms, contact with diagnosed patient, foreign travel
  - Community-based
- Nasopharyngeal and oropharyngeal swabs tested by RT-PCR for viral RNA

Age group	High-risk	Community
0-9	6.7%	0%
10-19	13.7%	0.8%
All	13.3%	0.8%

- Suggests little transmission among young children (different from influenza A)

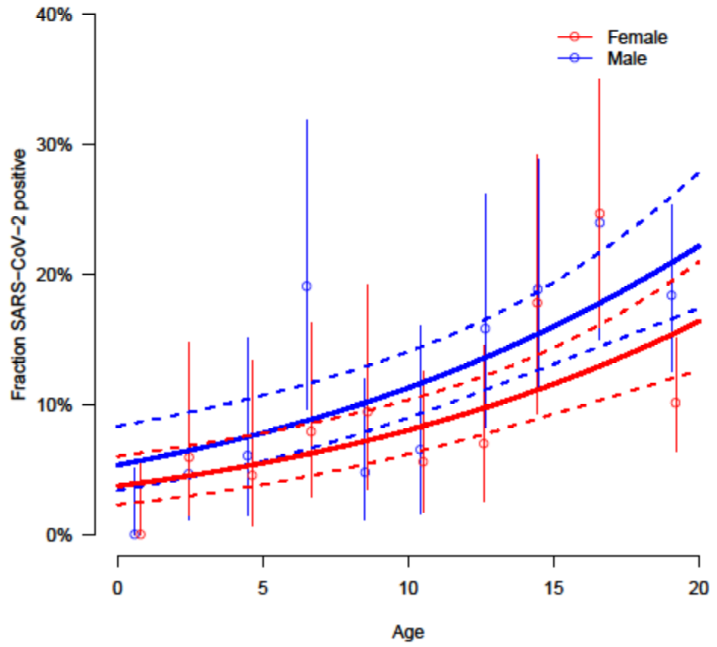


Figure S5 The fraction of individuals that tested positive before age 20 in the targeted testing stratified by age and sex. The results for males are shown in blue and females in red. Vertical bars indicate 95% confidence intervals. The solid curves indicate logistic regression fits of a model with a sex effect and an age effect. The dashed lines indicate 95% confidence intervals for the male and female logistic regression fits. The age odds ratio is 1.08 per year (95% CI: 1.05-1.12) and the male sex odds ratio is 1.45 (95% CI: 1.04-2.0).

COVID-19 transmission in households and schools?

In Asia, early (Jan-Feb) household clusters/infections, driven by children low (<10% have pediatric index case)

In contrast to influenza (54%)

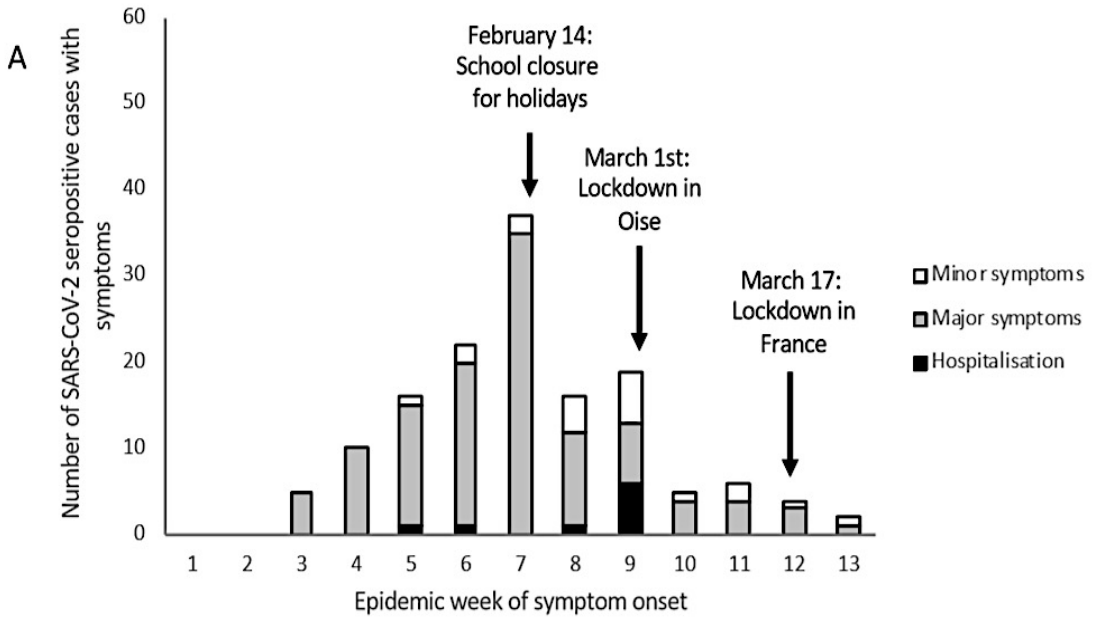
However, schools closed (Lunar New Year) during exponential phase

In France, retrospective 40% seropositivity amongst 15-17 year olds where **school closed 2-3 weeks after first cases.** 11% of household contacts were seropositive suggesting spread amongst **high school students first.**

However**,** in France one PCR+ symptomatic pediatric case with 112 school contacts, **no subsequent transmission**. In Australia, 18 primary and high school cases (9 students, 9 teachers) found 2 subsequent cases in students amongst 863 close contacts

Children are unlikely to have been the primary source of household SARS-CoV-2 infections

Yanshan Zhu[1], Conor J. Bloxham[2], Katina D. Hulme[1], Jane E. Sinclair[1], Zhen Wei Marcus Tong[1], Lauren E. Steele[1], Ellesandra C. Noye[1], Jiahai Lu[3], Keng Yih Chew[1], Janessa Pickering[4], Charles Gilks[5,6], Asha C. Bowen[4] & Kirsty R Short[1,5*]

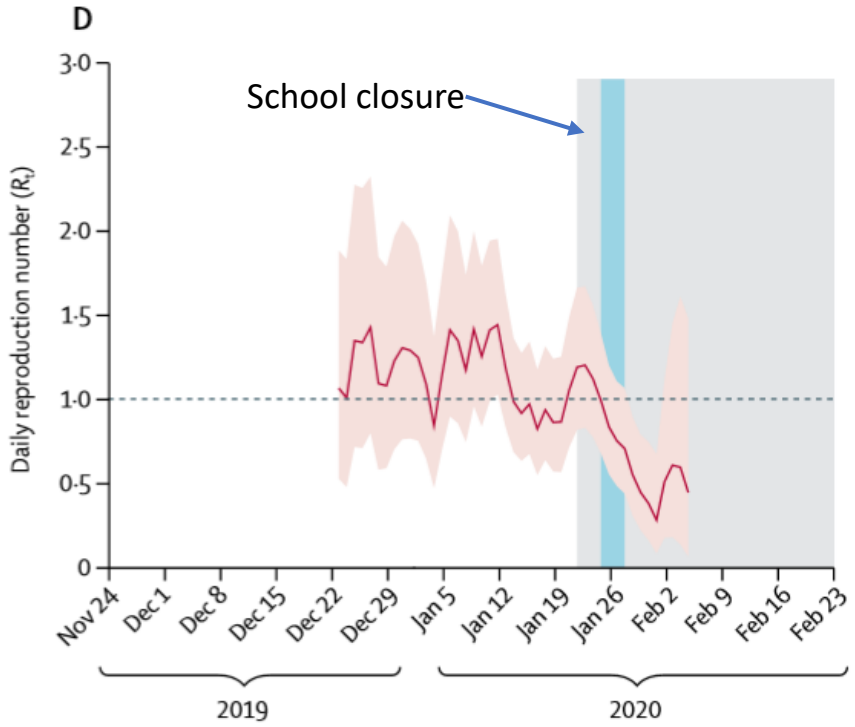


Fontanet A, Tondeur L, Madec Y, et al. Cluster of COVID-19 in northern France: a retrospective closed cohort study. medRxiv 2020 Apr 23. 83/242 (34%) students PCR positive

Why were schools closed?

- Analogy with influenza A outbreaks
  - School children are clear vectors of influenza A with community-wide spread and childhood influenza immunization is associated with lower rates of influenza in communities
    - Children have higher influenza A attack rates than adults and are infectious longer
    - Contributes to school absenteeism and parental absence from work
    - Presence of a child with influenza in a household is a risk factor for influenza infection in families
    - Changes social mixing patterns
- No clear evidence from SARS or MERS

- Ecological data from Hong Kong on declining R_0 of SARS-CoV-2 following school closure

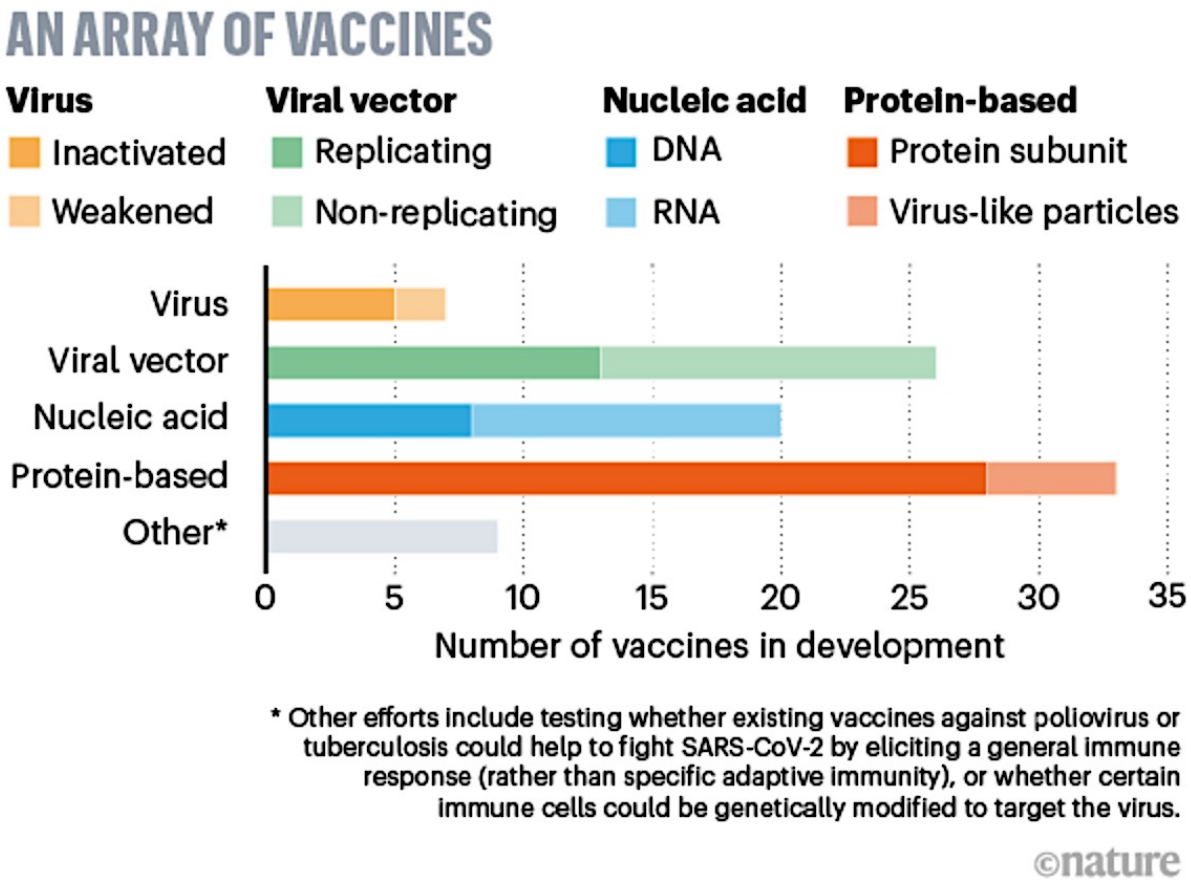


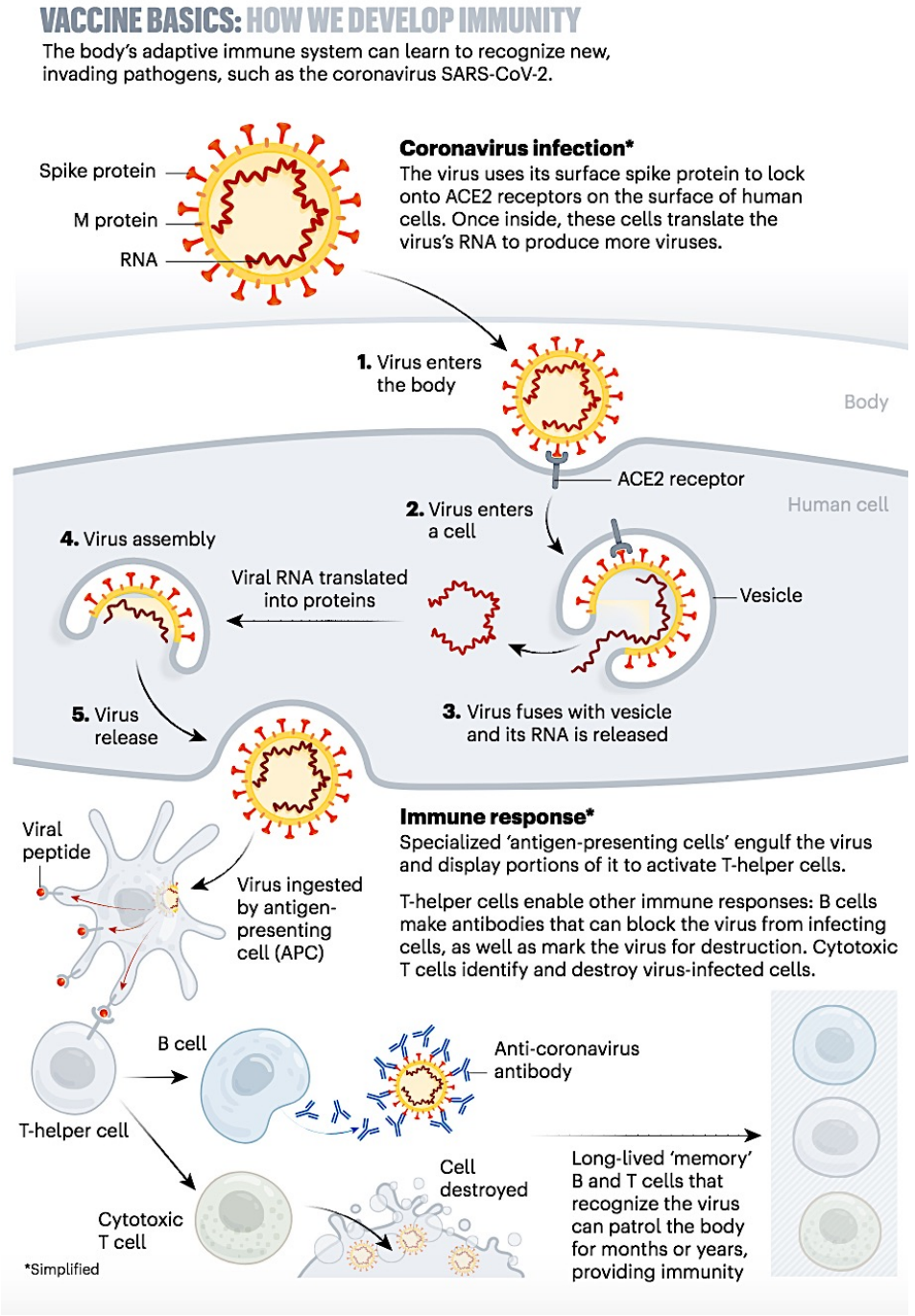
When can schools reopen?

	South Korea	Germany	Japan	China	Australia (NSW)	UK
Planned reopening date	Next year	May 4 (April 27 in Berlin)	Unclear	April (now)	May 11	Unclear
Staged plan	Yes	Yes	Unclear	Unclear	Yes	Unclear
Criteria	Unclear	Qualitative	Unclear	Quantitative	Unclear	Qualitative

- Long et al calculate risk of student being infected by teacher in first week of reopening = 0.5% in China outside of Hubei if ≤3 cases in prior two weeks
- Considerations:
  - Maintaining social distancing
  - Mixing patterns
  - Surveillance for new disease (absenteeism)
  - Rapid outbreak investigation with isolation and quarantine

Vaccine development





Resilience Roadmap Stages

STAGE 1: Safety and Preparedness

Making essential workforce environment as safe as possible.

STAGE 2: Lower Risk Workplaces

Creating opportunities for lower risk sectors to adapt and re-open.

Modified school programs and childcare re-open.

STAGE 3: Higher Risk Workplaces

Creating opportunities for higher risk sectors to adapt and re-open.

STAGE 4: End of Stay-At-Home Order

Return to expanded workforce in highest risk workplaces.

Requires Therapeutics.

Stage 2: Lower Risk Workplaces

Gradually opening some lower risk workplaces with ADAPTATIONS:

- Retail (e.g. curbside pickup)
- Manufacturing
- Offices (when telework not possible)
- Opening more public spaces

Expanded Workforce Safety Net:

- Wage replacement so workers can stay home when sick

Stage 2: Lower Risk Workplaces

Schools and Childcare Facilities with Adaptations:

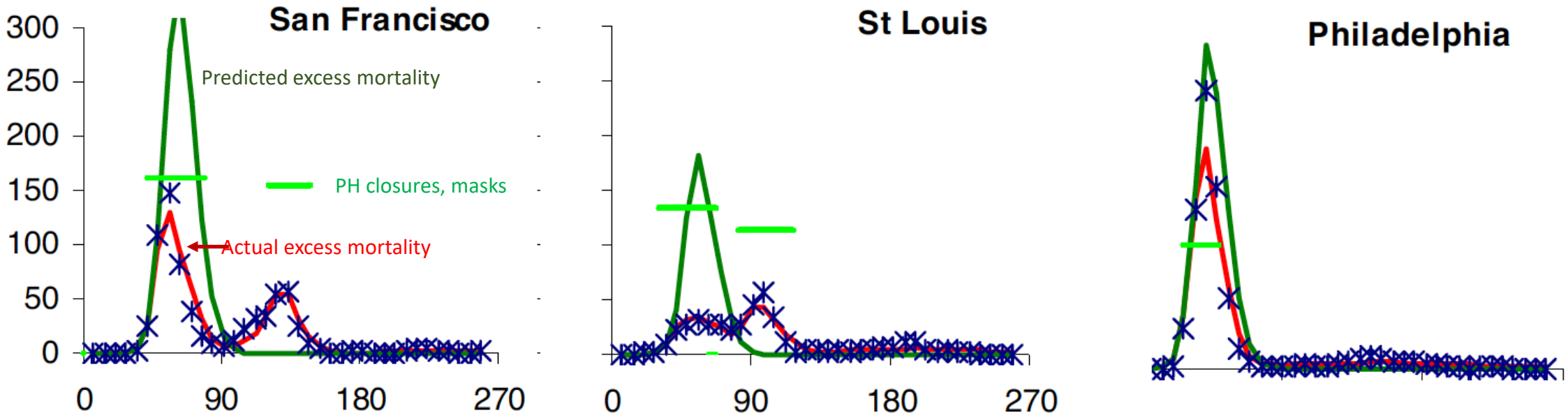
- Summer programs and next school year potentially starting sooner (July/August)
- Childcare facilities to provide more care
- Address learning gaps
- Ensure students and staff are protected
- Allow broader workforce to return to work

San Francisco and the 1918-19 influenza epidemic

A family wearing masks in San Francisco on November 21, 1918. San Francisco History Center, San Francisco Public Library

A family with their masks off in San Francisco on November 21, 1918. San Francisco History Center, San Francisco Public Library

Comparative excess mortality per 100 000 by days since 7 September 1918, United States



Bootsma MCJ, Ferguson MN. The effect of public health measures on the 1918 influenza pandemic in U.S. cities. Proc Natl Acad Sci 2007; 104:7488-93.