COVID-19: what we have learned
Osher Mini-Medical School for the Public

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What we'll discuss this evening

- Human coronaviruses in general, SARS, MERS and the novel coronavirus, SARS-CoV-2

- The emergence of SARS-CoV-2 and its associated disease (COVID-19) in Wuhan, China

- Individual-level prevention

- Population-level prevention

- Impact and the future
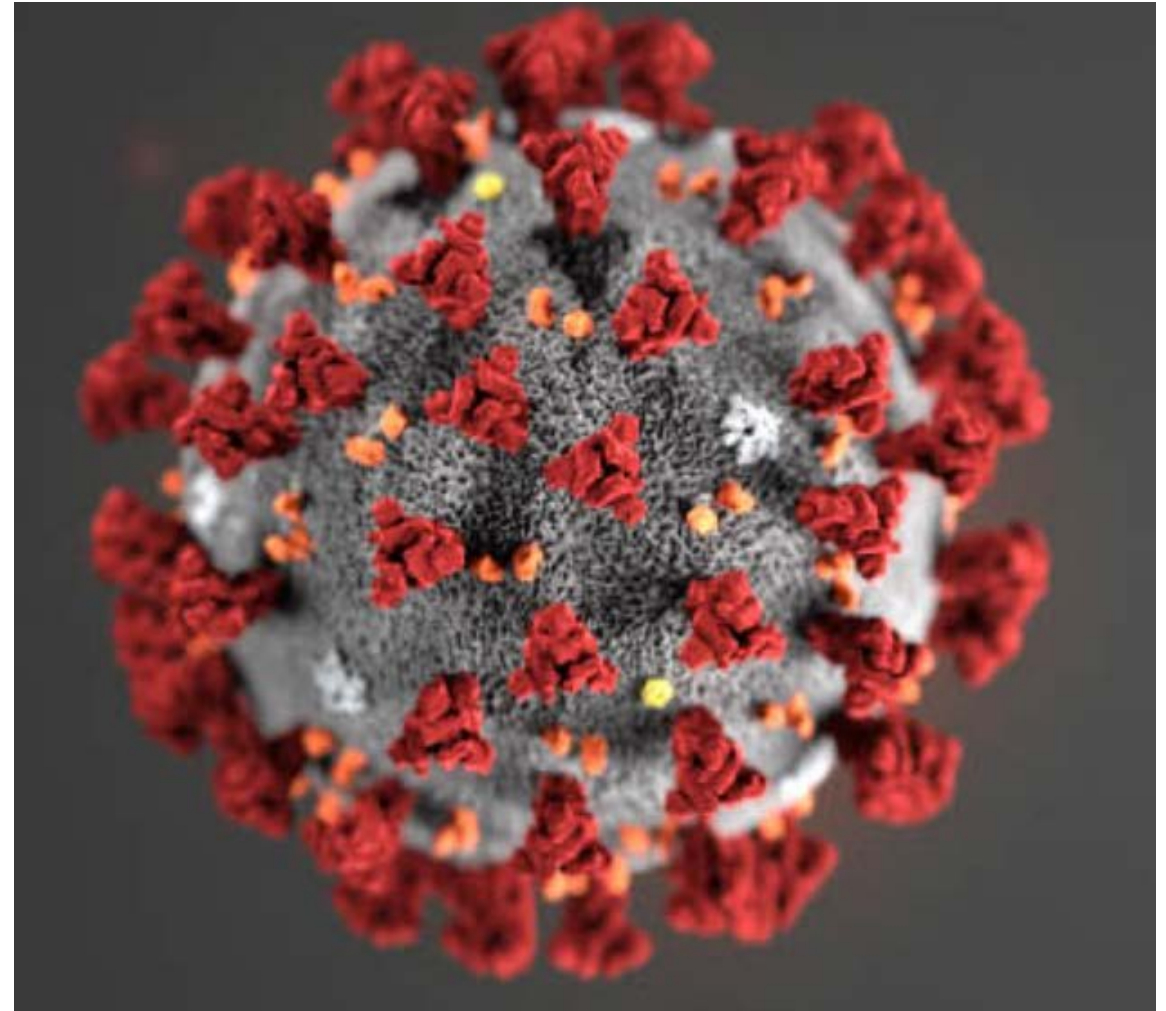
Human coronaviruses, severe acute respiratory syndrome (SARS), Middle East respiratory syndrome (MERS) and the novel 2019 coronavirus

Coronaviruses

- Before SARS (2002), coronaviruses were considered relatively inconsequential pathogens that caused common colds
  - Four human coronaviruses are endemic globally and cause 10-30% of upper respiratory tract infections in adults (alpha coronaviruses HCoV 2229E, NL 63, OC 43, HKU 1)
- Widely distributed in mammals and birds
- Since 2002 we've recognized two highly pathogenic strains that causes severe acute respiratory syndrome (SARS) and Middle East respiratory syndrome (MERS)

SARS and MERS

- As opposed to the human coronaviruses that are associated with upper respiratory tract infections, SARS and MERS are caused by beta coronaviruses

- Primarily cause lower respiratory tract infection (pneumonia)

- Relatively high case fatality rates

	SARS	MERS
Cases	8098	2494
Deaths	774	858
Case fatality rate	9.5%	34.4%
Controlled	Yes after reached pandemic	No, continued transmission
Other features	58% from nosocomial transmission	70% of cases from nosocomial transmission

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
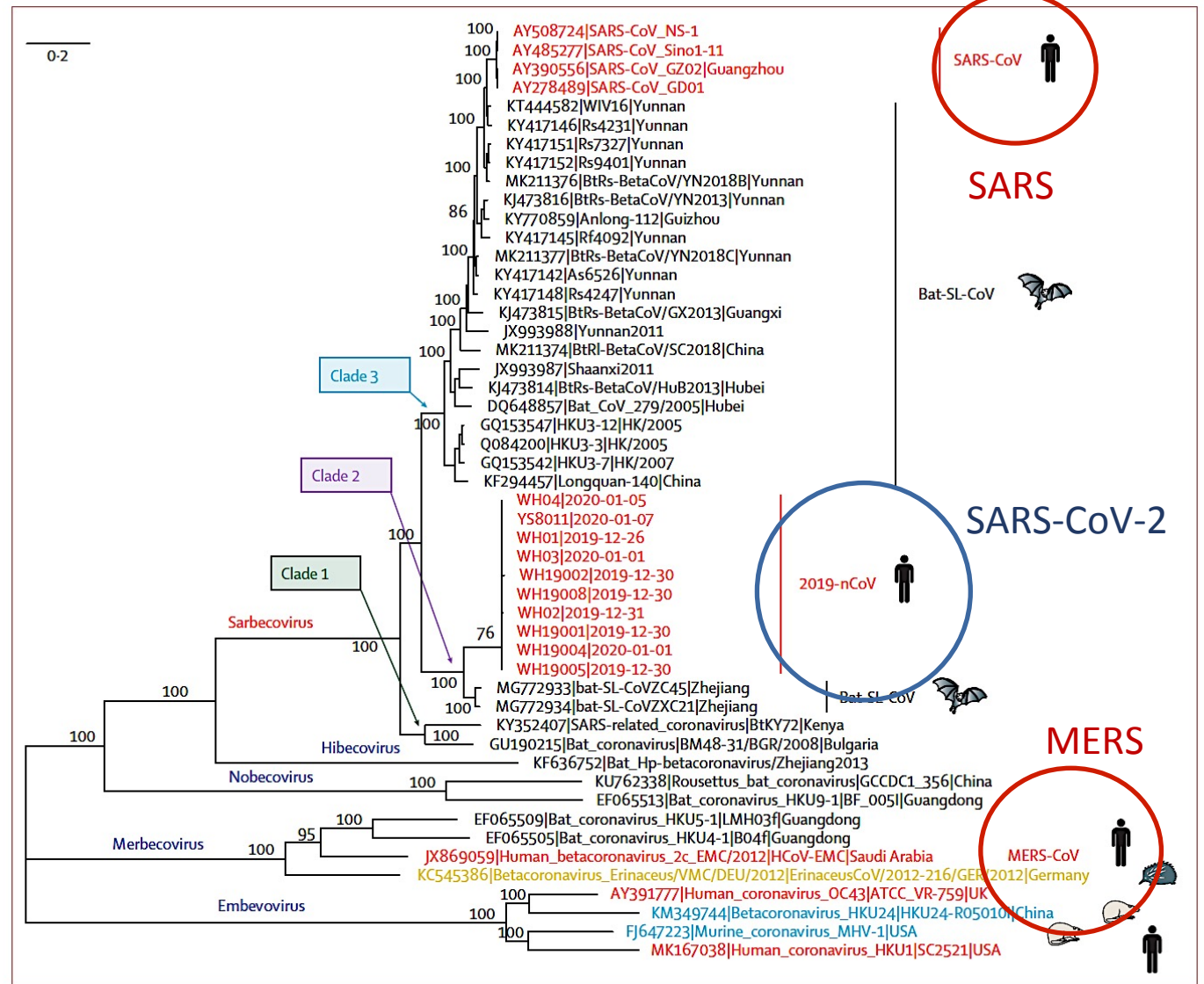 - 26 countries
  - $10-$30B economic damage

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].

SARS-CoV-2

- Spike (S) protein binds to angiotensin-converting enzyme 2 (ACE2) on the membranes of lung alveolar cells, upper airway epithelial cells and glandular cells of the GI tract

Viral membrane
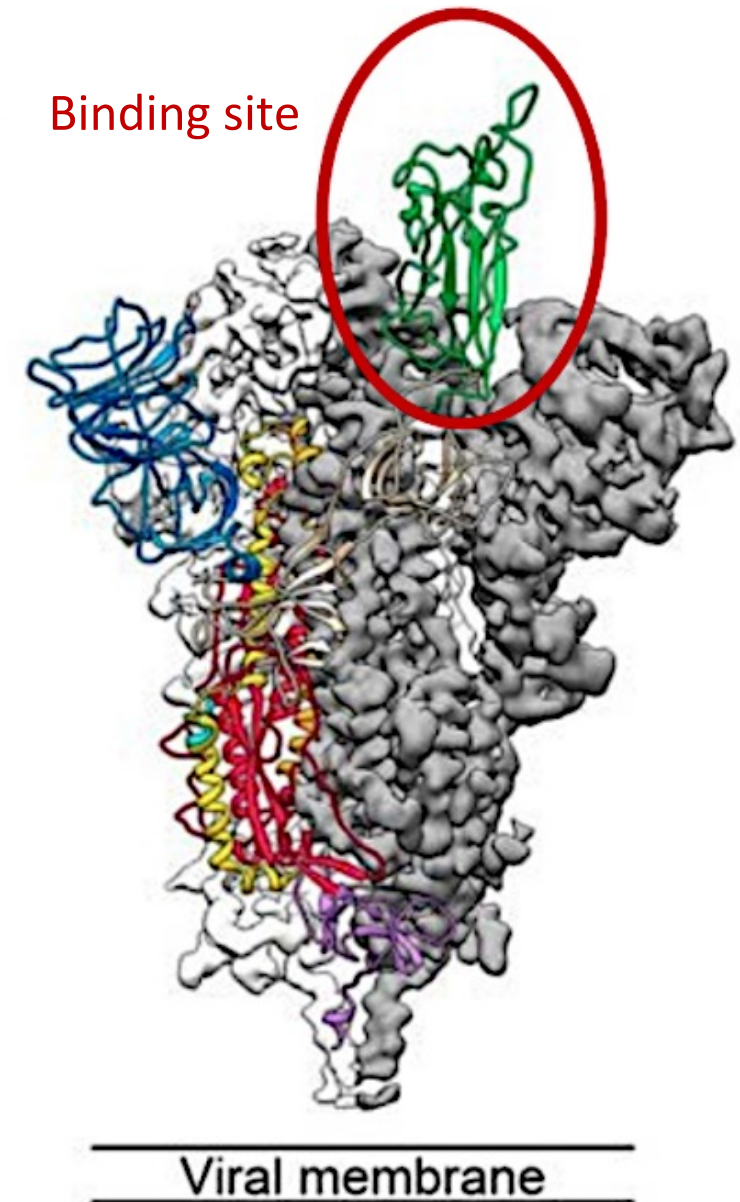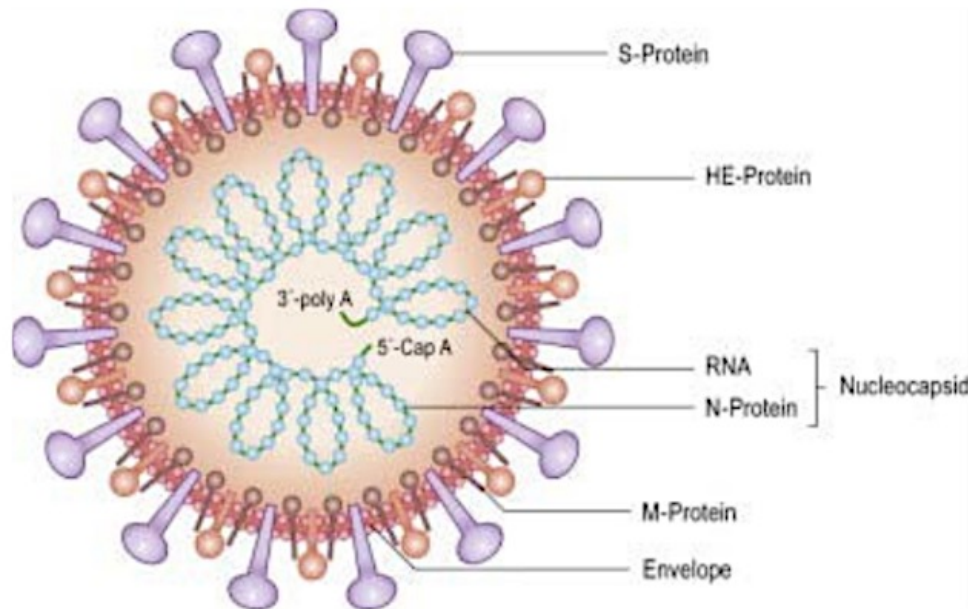
Emergence and recent epidemiology of SARS-CoV-2

Emergence of the 2019 novel coronavirus (SARS-CoV-2)

- First case (COVID-19) hospitalized 17 December 2019
- Cluster reported on 30 December
- Huanan Wholesale Seafood Market closed 1 January
- COVID-19 isolated 7 January
- COVID-19 sequenced 10 January
- Rapid diagnostic tests developed and distributed
- *Cordon sanitaire* implemented in Wuhan and surrounding cities on 23 January – 59 million people quarantined
- WHO declared Public Health Emergency of International Concern 30 January

Respiratory spread

- Data suggest similar transmission as seasonal influenza
  - Droplet - primary, large virus-laden nuclei, <6 feet (OSHA) or <1 m (WHO), don't stay in air
  - Hands
  - Fomites (surfaces)
  - Possible: gastrointestinal
  - While theoretically possible, aerosol transmission unlikely

- Infection control needs to focus on *droplet spread*, which is far and away the most common route of transmission, followed by fomite and possibly GI

The story starts in Wuhan in Hubei Province, China

- A major commercial city in central China on the Yangtze River

- Capitol of Hubei Province

- Population 11 million
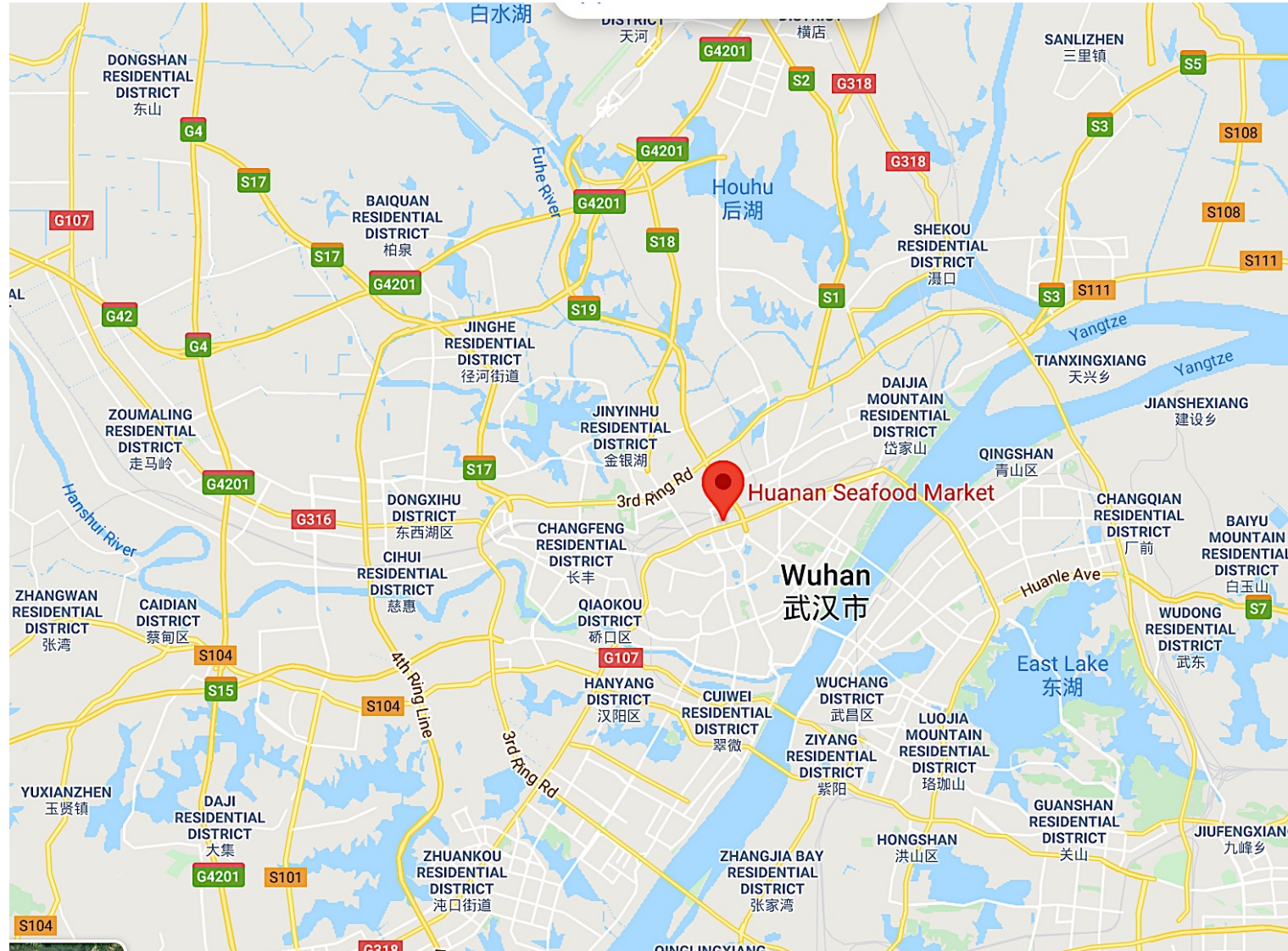
Epizoology of COVID-19

- 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
2,982,933

Confirmed Cases by Country/Region/Sovereignty

965,933	US
226,629	Spain
197,675	Italy
162,220	France
157,770	Germany
154,037	United Kingdom
110,130	Turkey
90,481	Iran
87,147	Russia
83,912	China
63,100	Brazil
47,147	Canada
46,687	Belgium
38,040	Netherlands
29,061	Switzerland
27,977	India
27,517	Peru
23,864	Portugal
22,719	Ecuador
19,262	Ireland
18,640	Sweden

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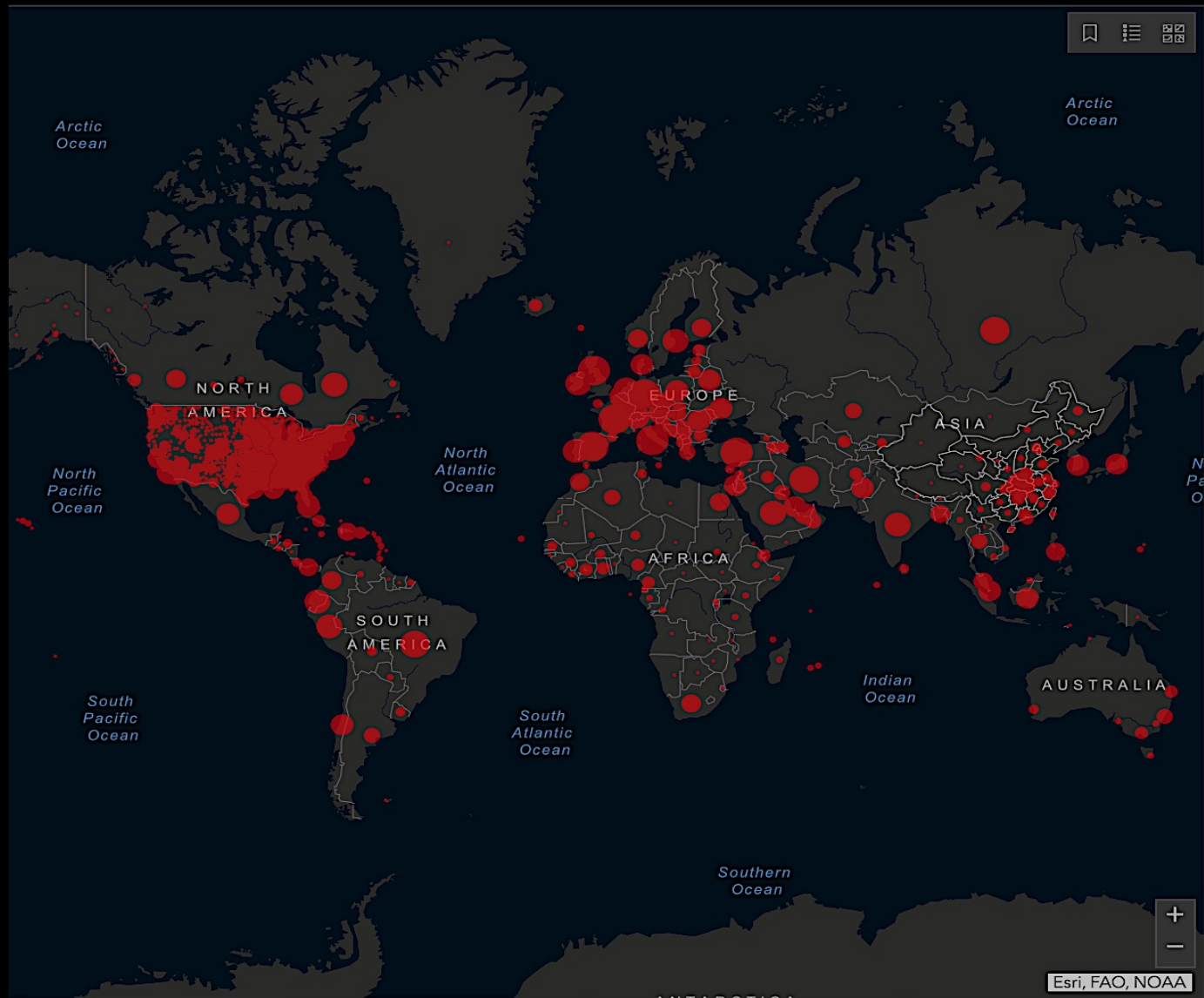
Last Updated at (M/D/YYYY)
4/27/2020, 3:31:20 AM

185 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.

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

Esri, FAO, NOAA

Total Deaths
206,811

26,644 deaths	Italy
23,190 deaths	Spain
22,856 deaths	France
20,732 deaths	United Kingdom
17,280 deaths	New York City **New York** US
7,207 deaths	Belgium
5,976 deaths	Germany
5,710 deaths	Iran
4,512 deaths	**Hubei** China
4,475 deaths	Netherlands

Deaths | Recovered

Total Test Conducted in U.S.
5,441,079

805,350 tested	New York US
526,084 tested	California US
344,613 tested	Florida US
276,021 tested	Texas US
236,100 tested	Massachusetts US
223,144 tested	New Jersey US
214,952 tested	Illinois US
198,593 tested	Pennsylvania US
193,879 tested	Michigan US
170,594 tested	Washington US

◁ US Tested ▷

120k
100k
80k
60k
40k
20k
0
Feb   Mar   Apr
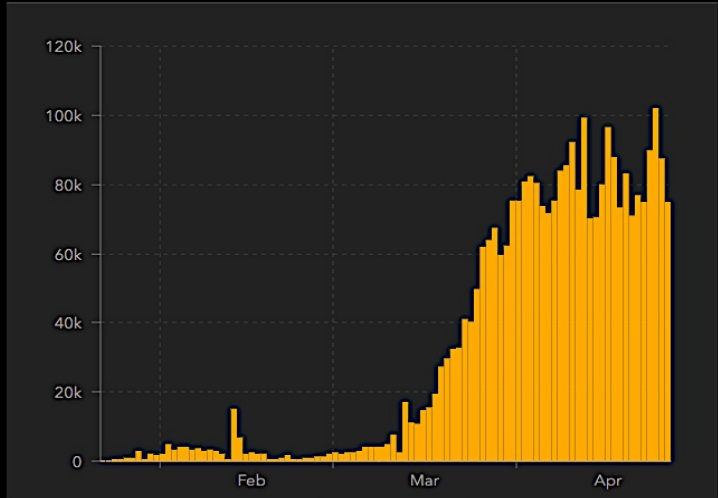
Confirmed | Logarithmic | Daily Cases

COVID-19 cases by date of onset and date of report, China 2018-2019*
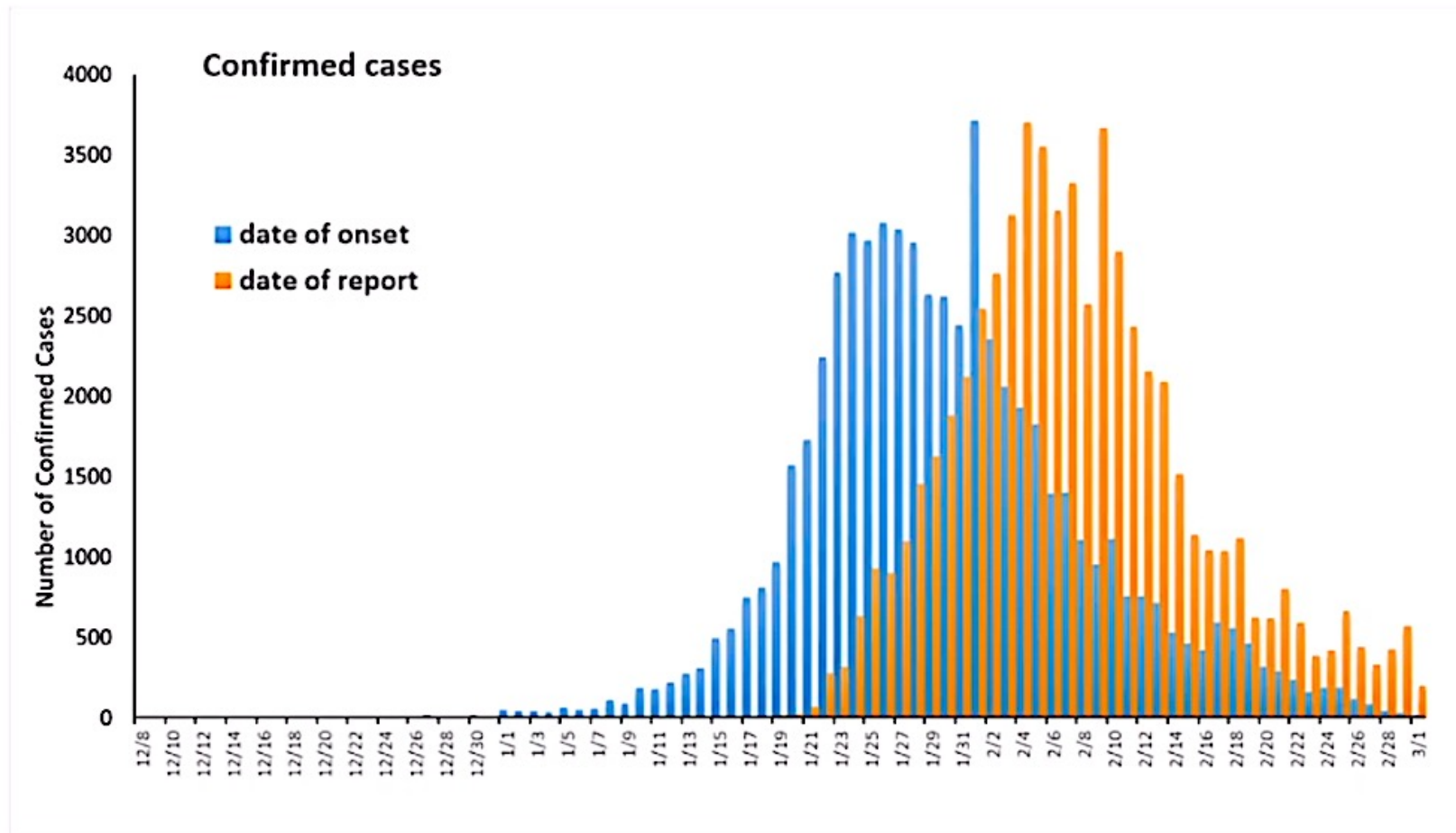

*Through 1 March 2020

# Transmission dynamics of COVID-19, China

- The majority of cases arise from close contacts of symptomatic cases
  - 1.5% of close contacts in China developed COVID-19
- Transmission is driven by family clusters (75-85% of infected contacts)
- Secondary household attack rates with ~10% early in the outbreak and fell to 3% with faster isolation
- Transmission in closed settings happened but was not a major driver in China (health facilities, nursing homes, prisons)
- Transmission in schools was not been observed in China; this may simply be because of the closure of schools during most of the outbreak
- Is China underreporting deaths, especially in the waning days of the epidemic?

COVID-19 by WHO region and date of report, 2020

2 982 933 cases worldwide
206 811 deaths worldwide

As of 26 April 2020
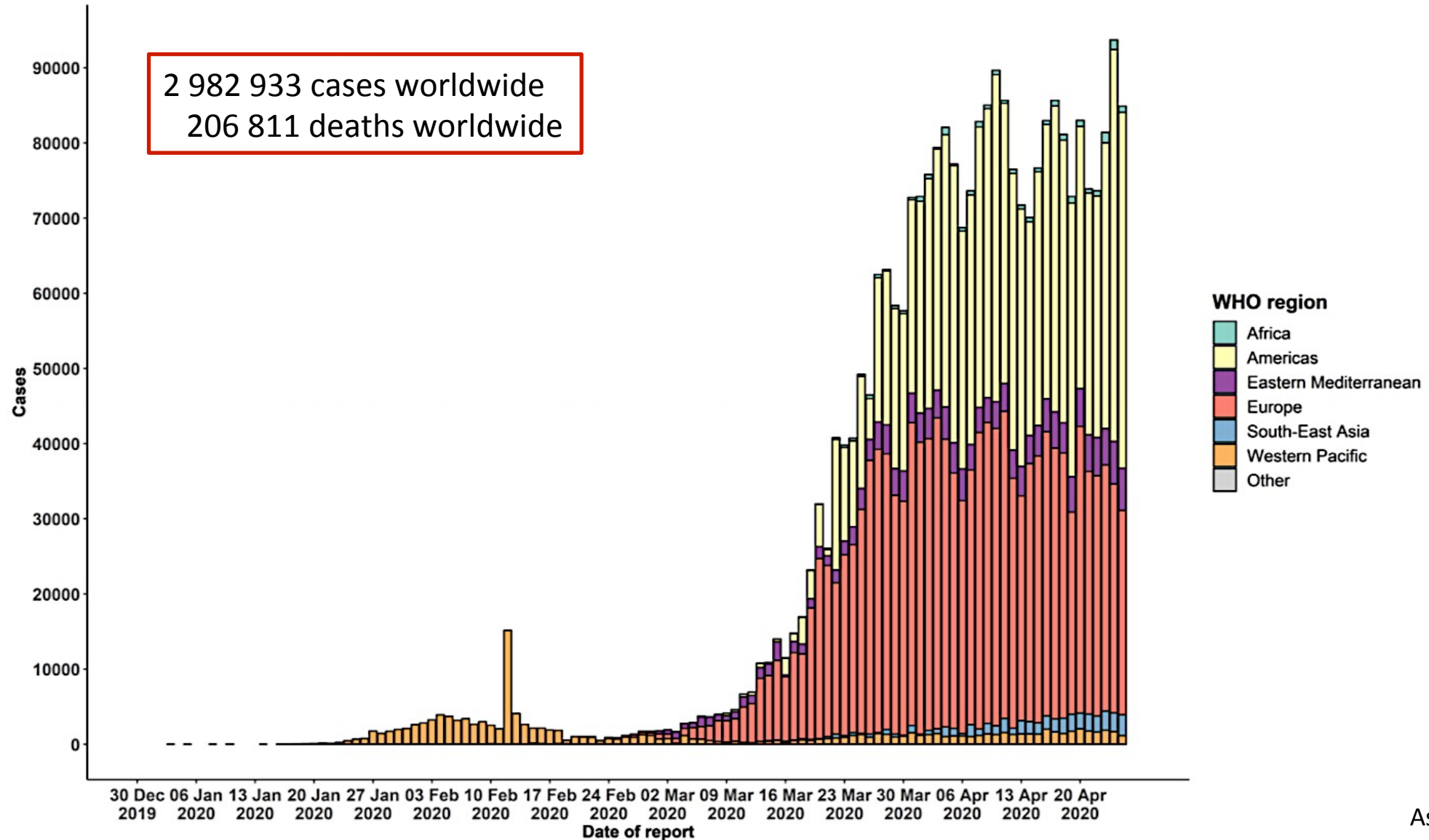
Sustained transmission outside of China – South Korea

- 10 683 cases and 237 deaths centered among members of a Christian sect in the southeastern city of Daegu (>5 000 cases, 60% of total)

- Assemblies banned, school re-openings delayed, massive testing
  - 270,000 tests as of 17 March (5200/million inhabitants)

- Focus is on massive isolation of cases, contact tracing and quarantine of contacts
  - People in quarantine have temperature taken twice a day by monitoring team
  - Fines for violating quarantine (up to US$ 2500)

- Epidemic starting to wane, note CFR is 2.2% - Early diagnosis? Finding asx?

- Small second wave (239 cases on 20 March centered in call center in Seoul)
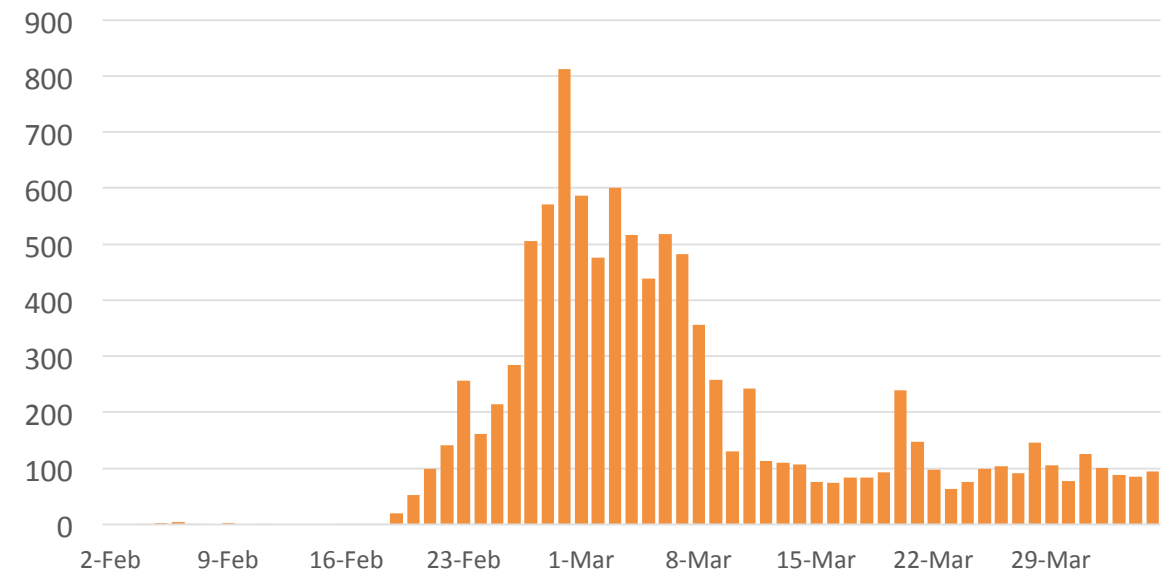
Sustained transmission outside of China - Europe

- Europe became the most affected region in the world on 19 March 2020 surpassing China and is now one of the three new centers of the COVID-19 epidemic
  - Now 49% of World's cases and 65% of deaths
- Most impacted countries – Italy, Spain, France, Germany, UK all with >100 000 cases
- All have moved to shelter in place with widespread business closures on Italian model
- European Commission has banned all non-essential travel into EU for 30 days

Las Ramblas, Barcelona, Spain, 19 March 2020

Sustained transmission outside of China - Italy

- 183 957 cases and 25 085 deaths (13.6%) concentrated in Lombardy region and Italy's elderly
- Entire country placed in cordon sanitaire on 9 March – only groceries, pharmacies, banks and public transit can stay open
- ICU capacity severely strained in Lombardy – on the edge of austere care – critical care patients being transferred to other regions
- Chinese experts say restrictions in Lombardy are not "strict enough" (no masks, transit open)

- Italy moved in military to enforce lockdown
- Now slowly moving away from shelter in place – bookstores and stationary stores first
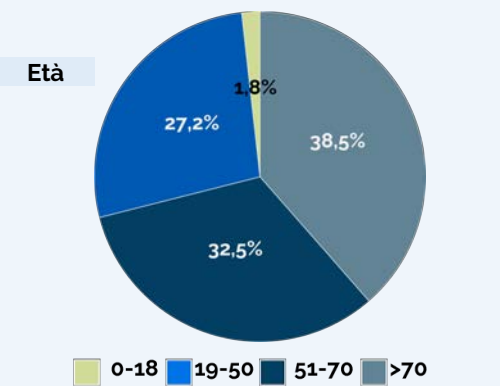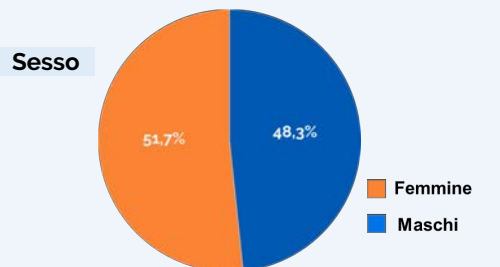
183.269 casi di COVID-19* di cui:

19.942 operatori sanitari $

23.576 deceduti

Sorveglianza Integrata COVID-19 in Italia

(Ordinanza n. 640 del 27/02/2020)

AGGIORNAMENTO 24 aprile 2020

Età

27,2%   38,5%   1,8%   32,5%

0-18   19-50   51-70   >70

Età mediana dei casi: 62 anni

Sesso

51,7%   48,3%

Femmine
Maschi

Nota: i dati più recenti (riquadri grigi) devono essere considerati provvisori sia per il ritardo di notifica dei casi più recenti sia perché i casi non ancora diagnosticati riporteranno in parte la data di inizio sintomi nei giorni del riquadro grigio.

Data diagnosi/prelievo (179451 casi)   Data inizio sintomi (109766 casi)

Sono risultati positivi il **99%** dei campioni processati dal Laboratorio nazionale di riferimento presso l'Istituto Superiore di Sanità

CRITICO: 2%
ASINTOMATICO: 13,4%
SEVERO: 17,8%
SINTOMATICO (NON SPECIFICATO): 14,5%
PAUCI-SINTOMATICO: 17,3%
LIEVE: 35%

Dato disponibile per 57.078 casi

Numero totale di casi di COVID-19 diagnosticati dai laboratori regionali di riferimento

Fascia d'età (anni)	Deceduti [n (%)]	Letalità (%)
0-9	2 (0%)	0,1%
10-19	0 (0%)	0%
20-29	7 (0%)	0,1%
30-39	49 (0,2%)	0,4%
40-49	213 (0,9%)	0,9%
50-59	870 (3,7%)	2,6%
60-69	2612 (11,1%)	9,9%
70-79	6951 (29,5%)	24,5%
80-89	9544 (40,5%)	30%
>=90	3328 (14,1%)	25,6%
Non noto	0 (0%)	0%
Totale	23576 (100%)	12,9%

1-500
501-1000
1001-5000
5001-10000
10001-20000
>20000

per Regione/PA di diagnosi

(dato disponibile per 183.269)

1-500
501-1000
1001-5000
5001-10000
10001-20000
>20000

per Provincia di domicilio/residenza

(dato disponibile per 178.241)

*La definizione internazionale di caso prevede che venga considerata caso confermato una persona con una conferma di laboratorio del virus che causa COVID-19 a prescindere dai segni e sintomi clinici

https://www.ecdc.europa.eu/en/case-definition-and-european-surveillance-human-infection-novel-coronavirus-2019-ncov

*Il flusso ISS raccoglie dati individuali di casi con test positivo per SARS-COV-2 diagnosticati dalle Regioni/PPAA. I dati possono differire dai dati forniti dal Ministero della Salute e dalla Protezione Civile che raccolgono dati aggregati. $ Dato non riferito al luogo di esposizione ma alla professione.
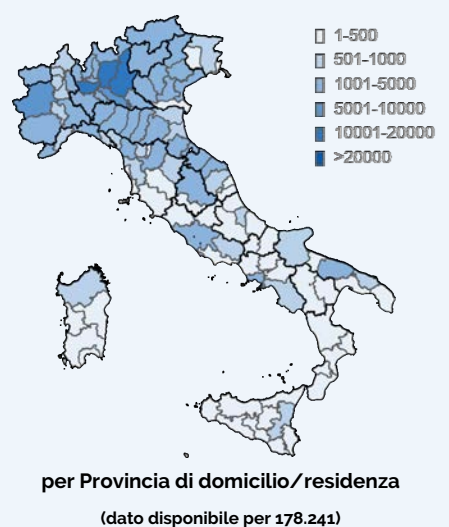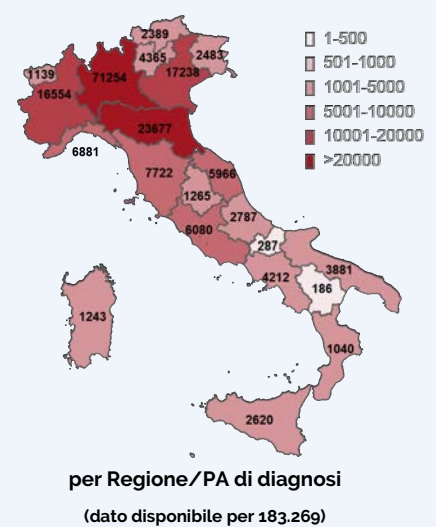
A cura di: Task force COVID-19 del Dipartimento Malattie Infettive e Servizio di Informatica
Istituto Superiore di Sanità

Is health-care resource availability associated with COVID-19 mortality?
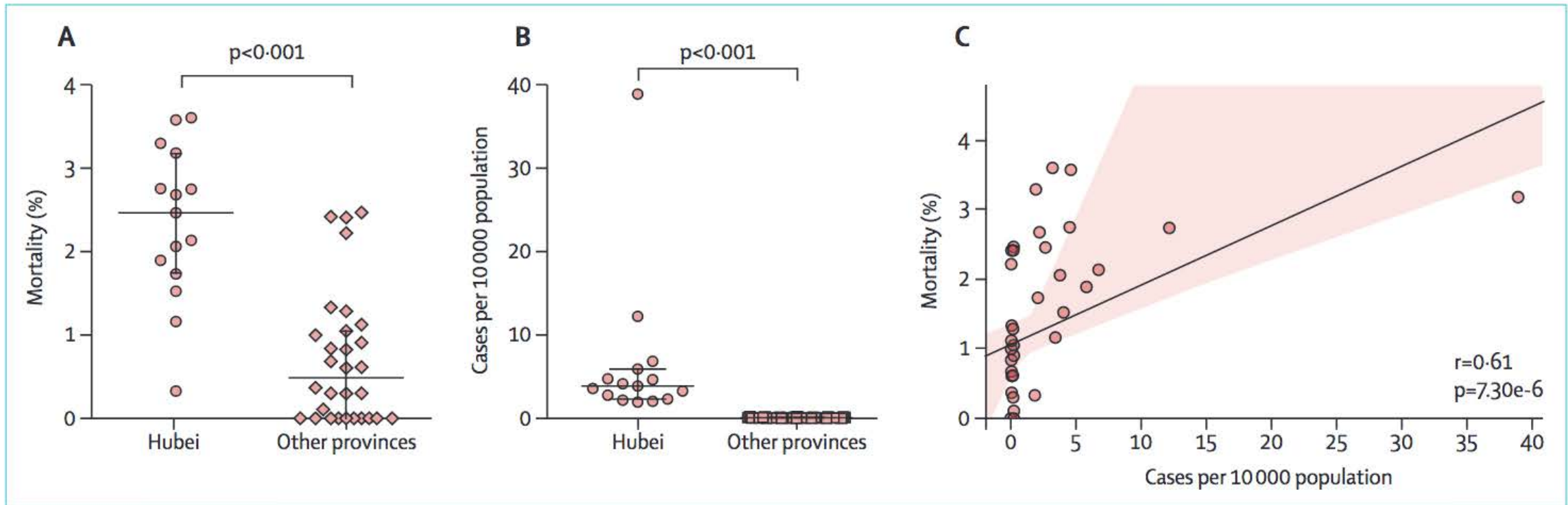

Figure: Mortality and incidence of COVID-19 in Hubei and other provinces of China

Mortality (A) and cumulative number of confirmed cases of COVID-19 since the start of the outbreak per 10 000 population (B) in Hubei and other provinces of China. Horizontal lines represent median and IQR. p values were from Mann-Whitney U test. (C) Correlation between mortality and number of cases per 10 000 population (Spearman method). Data were obtained from the Chinese Center for Disease Control and Prevention to Feb 16, 2020. COVID-19=coronavirus disease 2019.

Ji Y, Ma Z, Peppelenbosch MP, Pan Q. Potential association between COVID-19 mortality and health-care resource availability [Letter]. Lancet Global Health 2020 Feb 25 [E pub ahead of print].

COVID-19 Dashboard by the Center for Systems Science and Engineering (CSSE) at Johns Hopkins University (JHU)

Total Confirmed
965,933

Confirmed Cases by Province/State/Dependency

288,045 confirmed
New York US

109,038 confirmed
New Jersey US

54,938 confirmed
Massachusetts US

43,903 confirmed
Illinois US

43,720 confirmed
California US

42,616 confirmed
Pennsylvania US

37,778 confirmed
Michigan US

31,532 confirmed
Florida US

26,773 confirmed
Louisiana US

25,269 confirmed
Connecticut US

24,968 confirmed
Texas US

23,481 confirmed
Georgia US

18,581 confirmed
Maryland US

15,972 confirmed
Ohio US

15,012 confirmed
Indiana US

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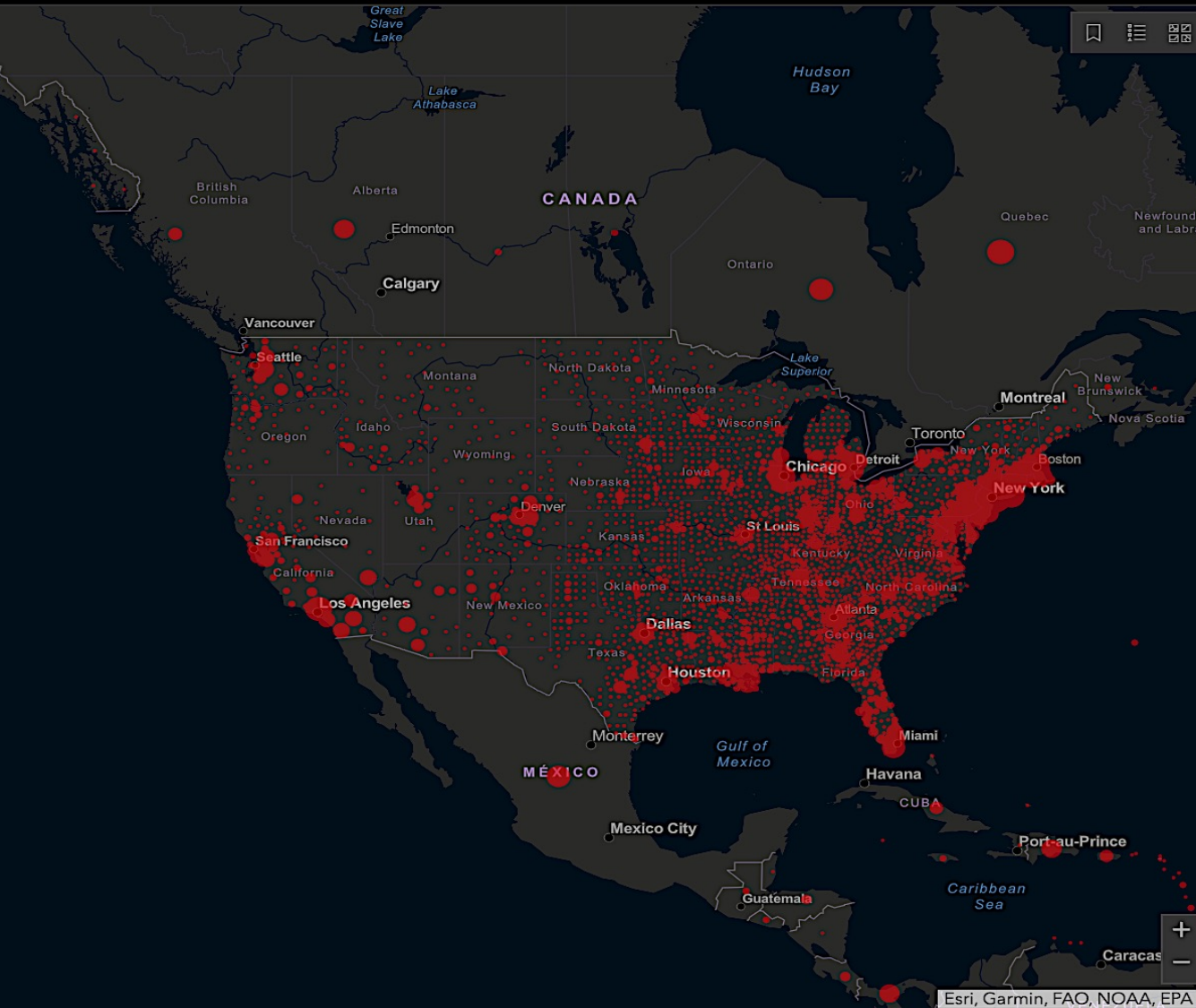
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185 countries/regions

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

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.

Total Deaths
54,877

17,280 deaths
New York City **New York** US

1,587 deaths
Nassau **New York** US

1,580 deaths
Wayne **Michigan** US

1,313 deaths
Cook **Illinois** US

1,070 deaths
Suffolk **New York** US

1,023 deaths
Essex **New Jersey** US

955 deaths
Bergen **New Jersey** US

946 deaths
Westchester **New York** US

916 deaths
Los Angeles **California** US

707 deaths
Fairfield **Connecticut** US

Deaths   Recovered

Total Test Conducted in U.S.
5,441,079

805,350 tested
New York US

526,084 tested
California US

344,613 tested
Florida US

276,021 tested
Texas US

236,100 tested
Massachusetts US
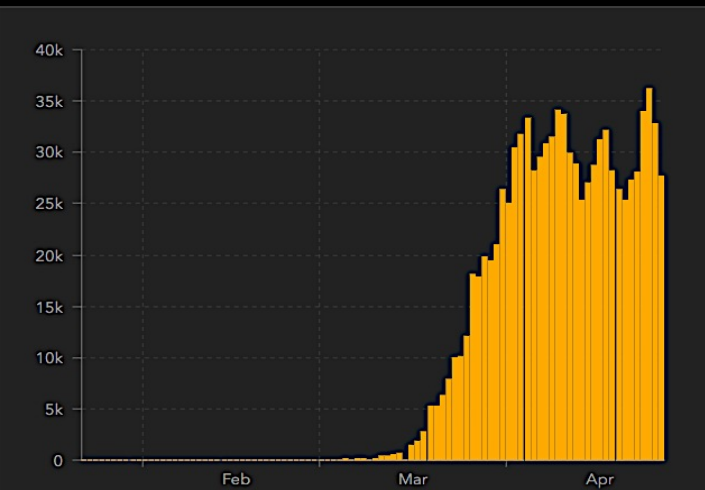
223,144 tested
New Jersey US

214,952 tested
Illinois US

198,593 tested
Pennsylvania US
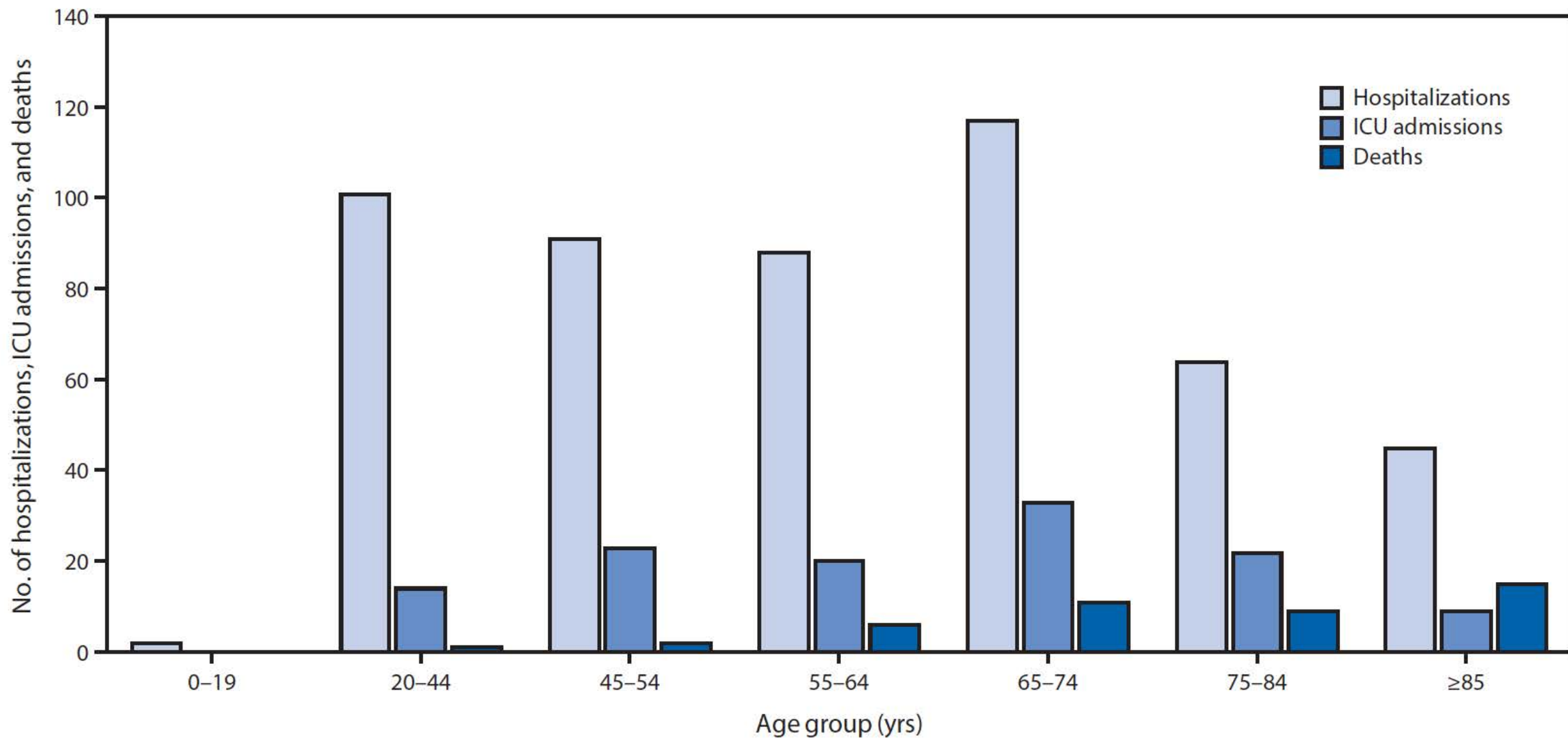
193,879 tested
Michigan US

170,594 tested
Washington US

◄   US Tested   ►

Confirmed   Logarithmic   Daily Cases

Esri, Garmin, FAO, NOAA, EPA

FIGURE 2. COVID-19 hospitalizations,* intensive care unit (ICU) admissions,† and deaths,§ by age group — United States, February 12–March 16, 2020

COVID-19 cases and deaths, California, 2020

California COVID-19 By The Numbers
April 26, 2020
Numbers as of April 25, 2020

CALIFORNIA COVID-19 SPREAD

42,164
Total Cases

Ages of Confirmed Cases
- 0-17: 1,039
- 18-49: 20,379
- 50-64: 11,139
- 65+: 9,512
- Unknown/Missing: 95

Gender of Confirmed Cases
- Female: 20,908
- Male: 20,957
- Unknown/Missing: 299

Hospitalizations

Confirmed COVID-19
3,324/1,184
Hospitalized/in ICU

Suspected COVID-19
1,604/289
Hospitalized/in ICU

1,710
Fatalities

For county-level data:
data.chhs.ca.gov

COVID-19 cases and deaths by race/ethnicity, California

Race/ ethnicity	Cases N (%)	Deaths N (%)	% CA population
Latino	9701 (41)	364 (31)	38.9
White	6982 (30)	417 (36)	36.6
Asian	3020 (13)	206 (18)	15.4
African American/ Black	1630 (7)	138 (12)	6.0
Multi-race	189 (1)	3 (0.3)	2.2
American Indian/ Alaska Native	50 (<1)	4 (0.3)	0.5
Native Hawaiian or Pacific Islander	336 (1)	14 (1.2)	0.3
Other	1735 (7)	24 (2.1)	0

12 672 (34%) of cases and 129 (9%) of deaths missing race/ethnicity

COVID-19 deaths by race/ethnicity, 18-49 year olds, California 2020

Disparities found in COVID-19 death rates

In California, black and Latino patients ages 18 to 49 are dying of COVID-19 more often relative to their share of the population than other racial groups and their older counterparts.
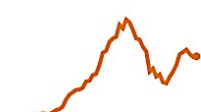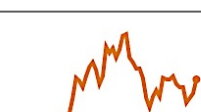
■ Percent of population ■ Percent of deaths
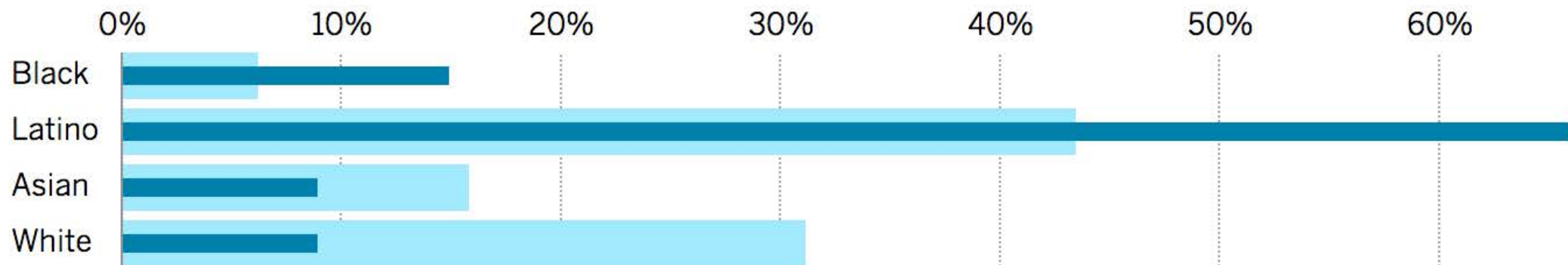
NOTE: Figures as of April 23.
California Department of Health

Ben Poston

COVID-19 cases by county, San Francisco Bay Area, as of 27 April 2020

County	Total deaths	Total cases	New cases curve	Weekly change in new cases
Santa Clara	100	2,084	March 1 April 26	-46 (-25%)
Alameda	52	1,468		-45 (-14%)
San Francisco	22	1,408		-74 (-30%)
San Mateo	41	1,019		44 (+33%)
Contra Costa	25	817		-35 (-23%)
Marin	12	224		-2 (-6%)

Cases per 100,000 people

0   7.8   64.3   500+
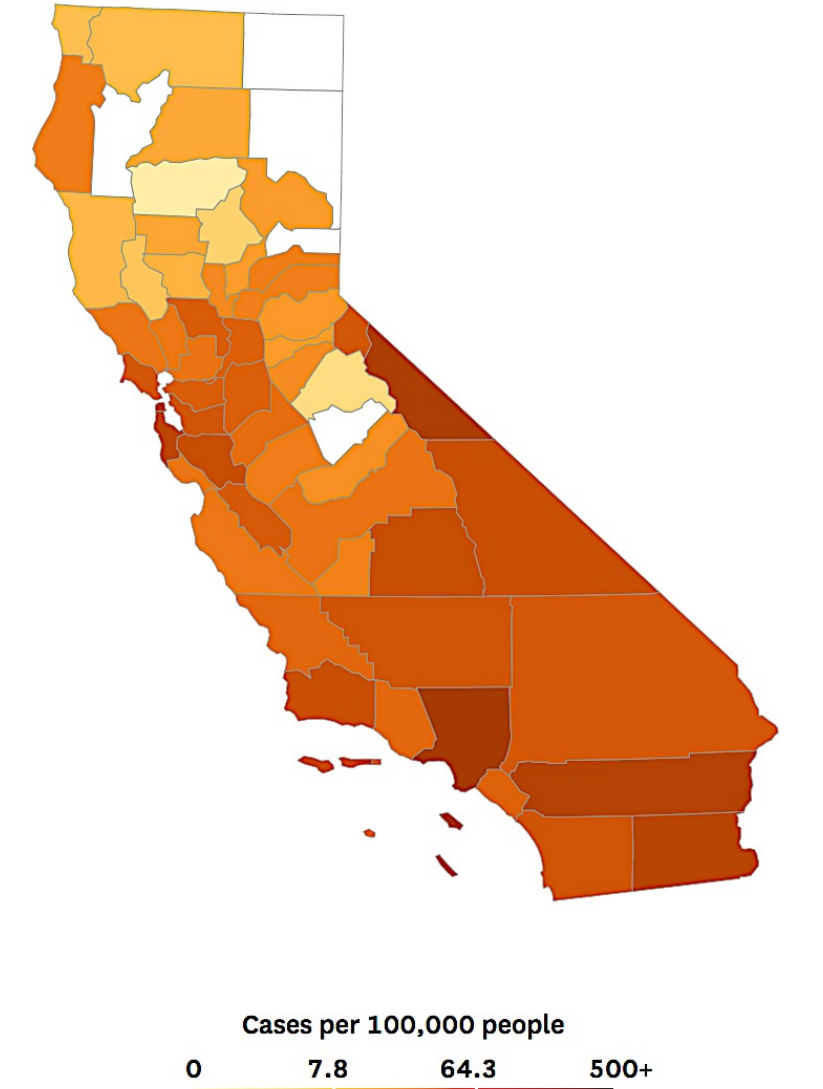
Total beds, COVID-19 patients by county and date, San Francisco Bay Area, April 2020
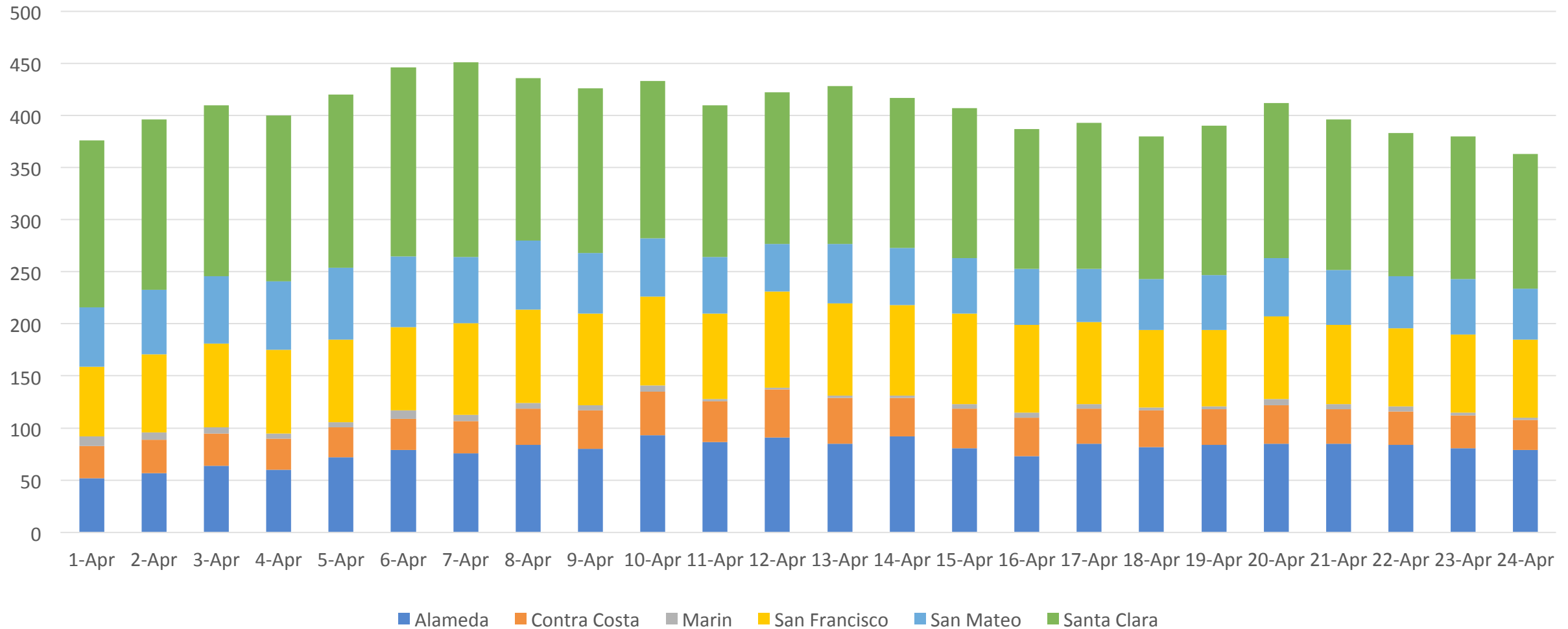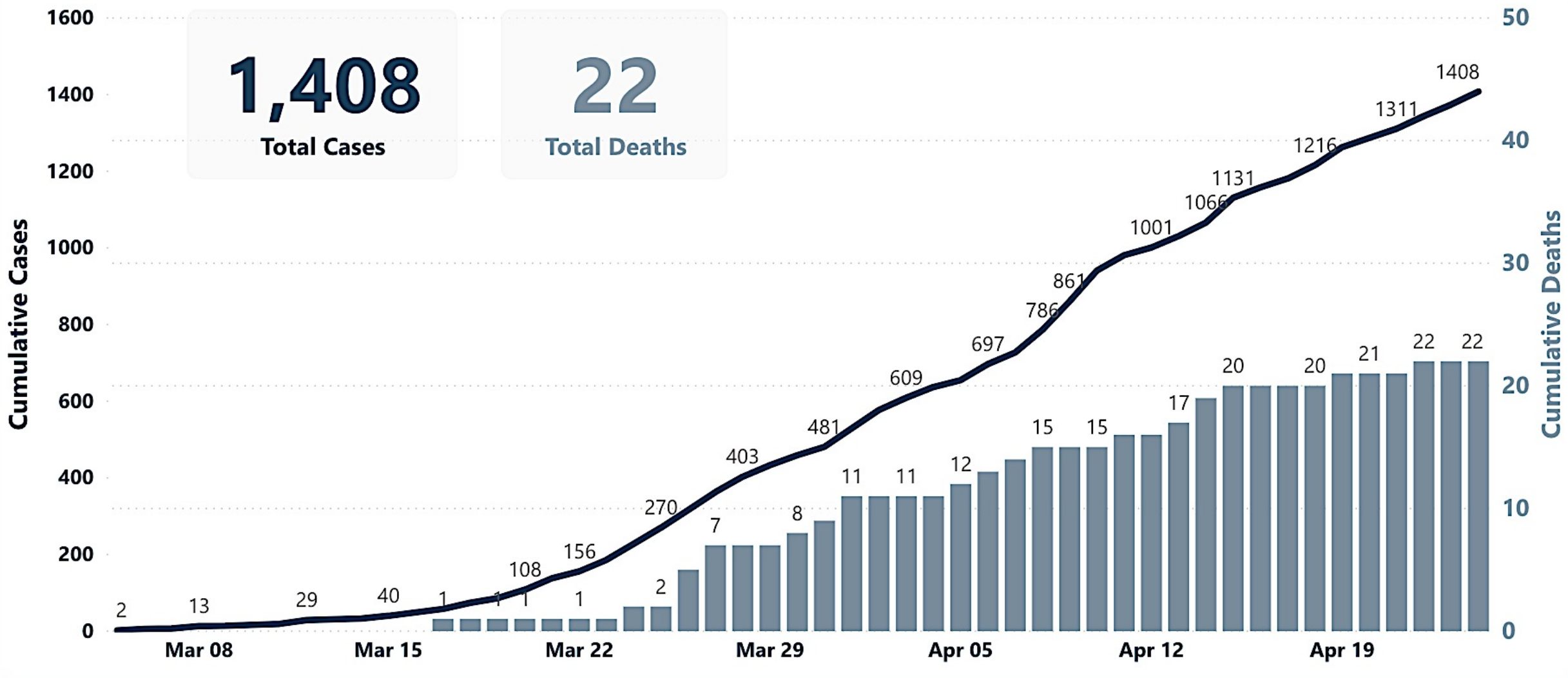
Incidence of COVID-19 cases by date of report, San Francisco, March-April 2020
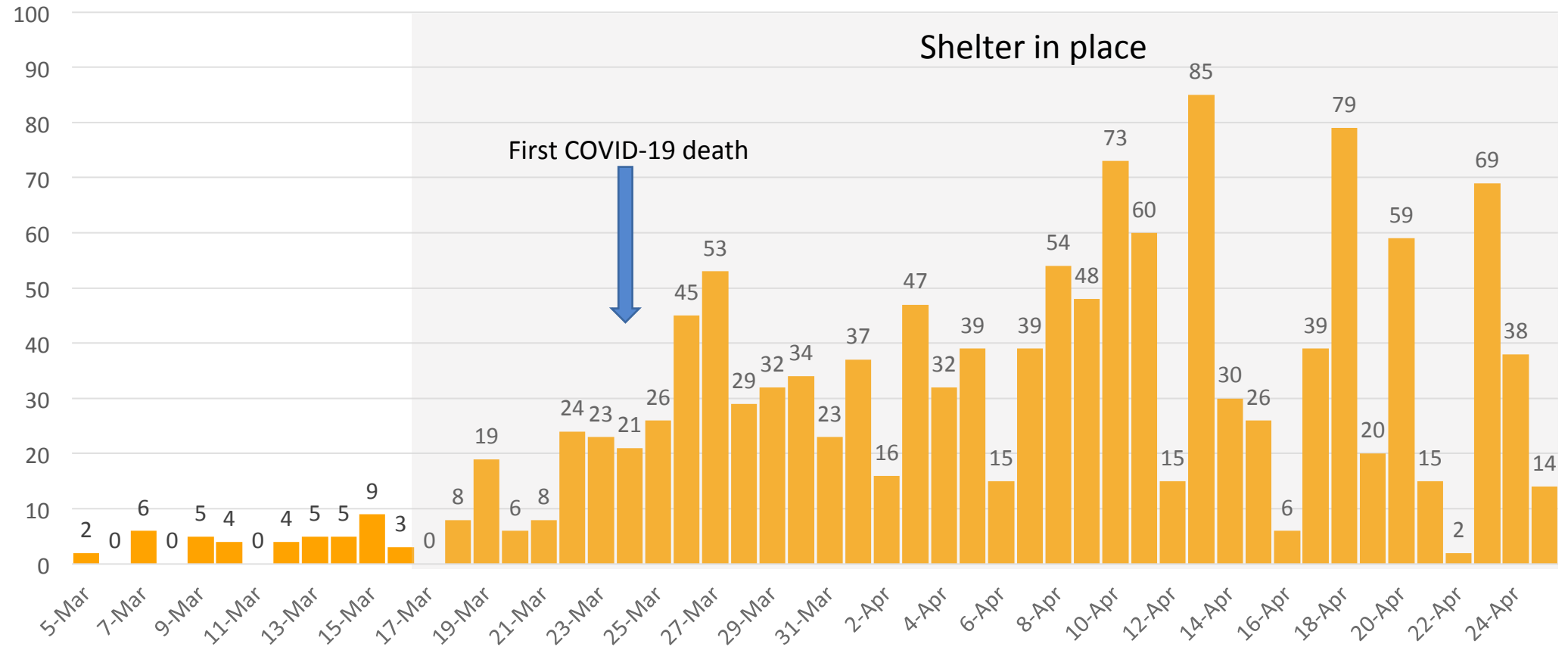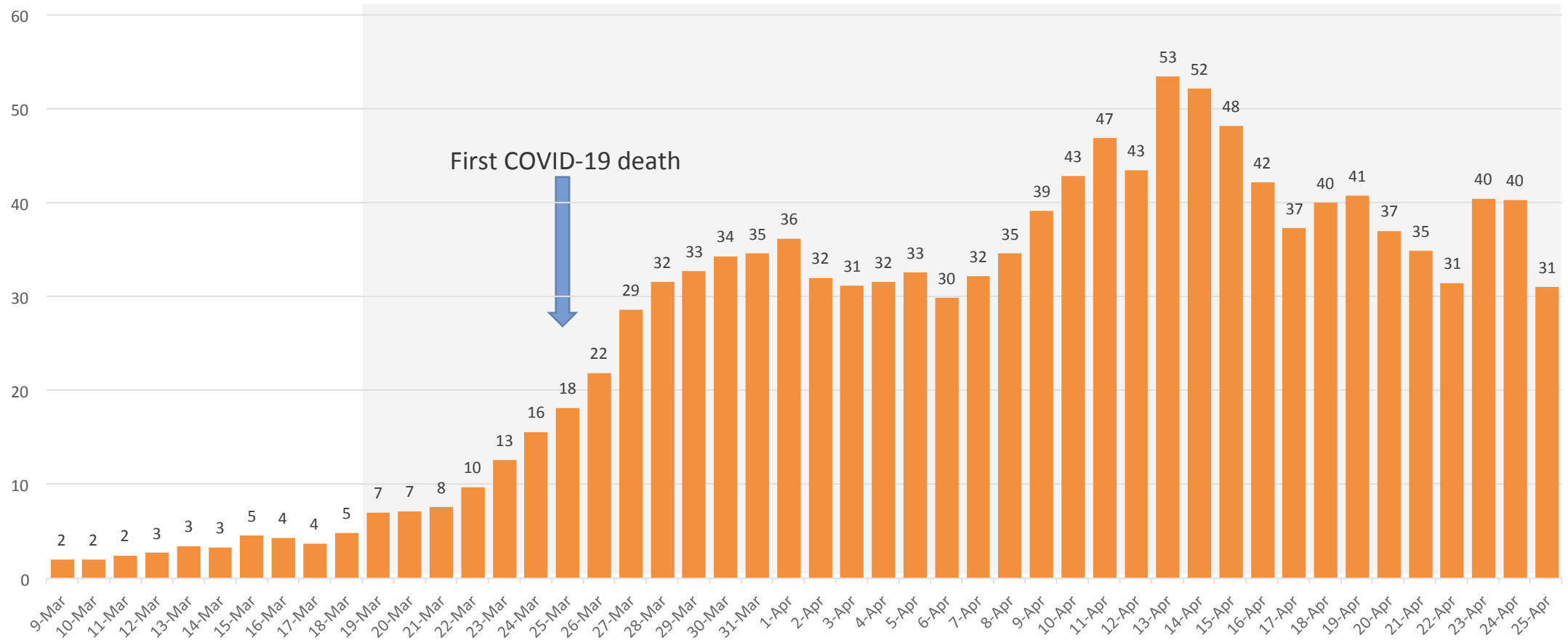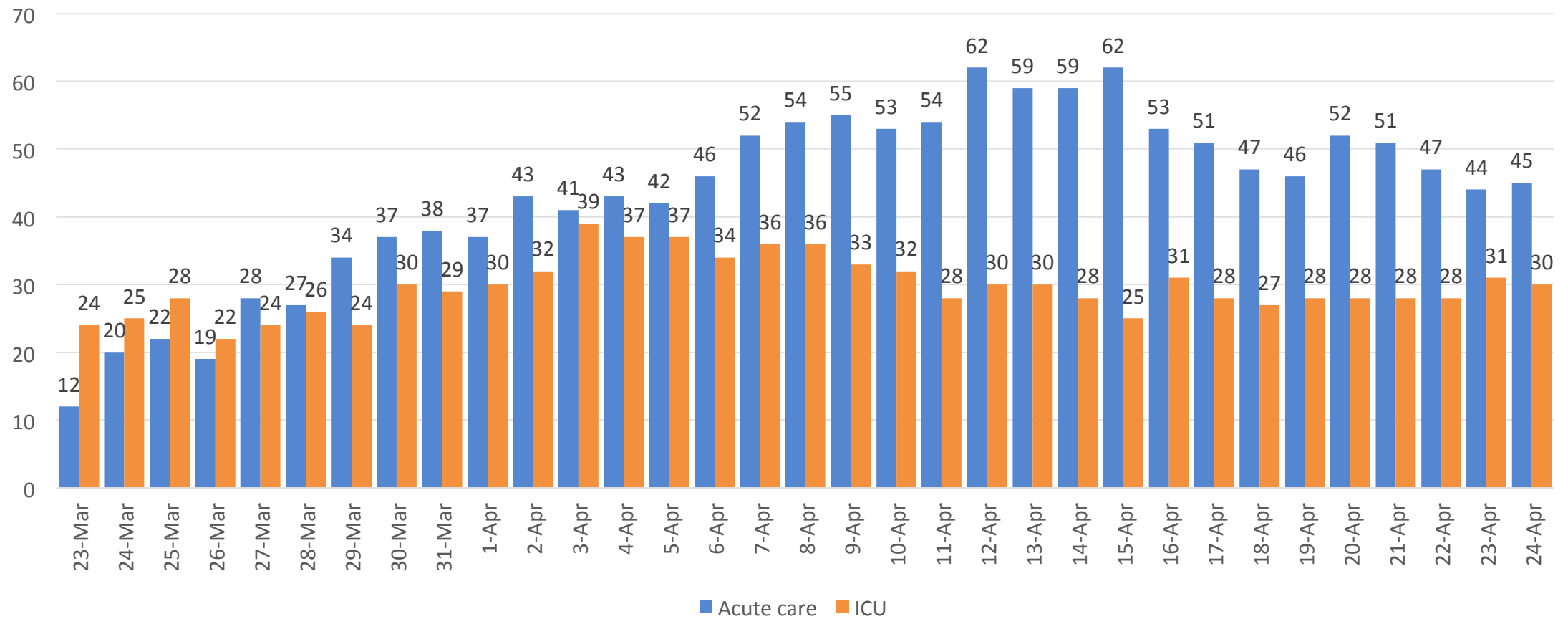
Incidence of COVID-19 cases by seven-day moving average, San Francisco, March-April 2020

Acute care and ICU beds by county and date, COVID-19 patients, San Francisco County, March-April 2020
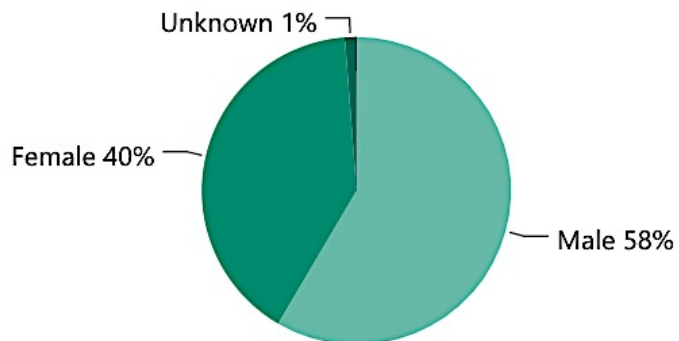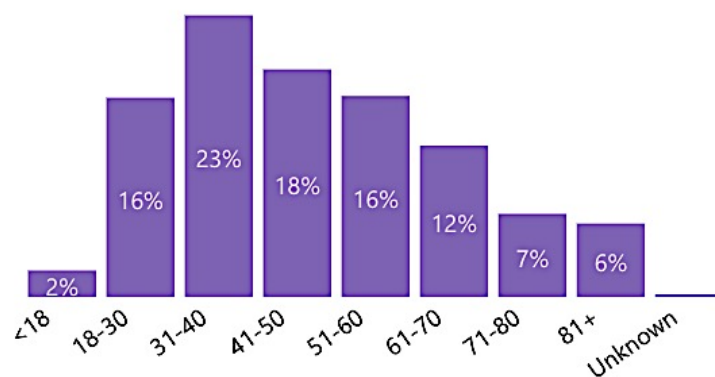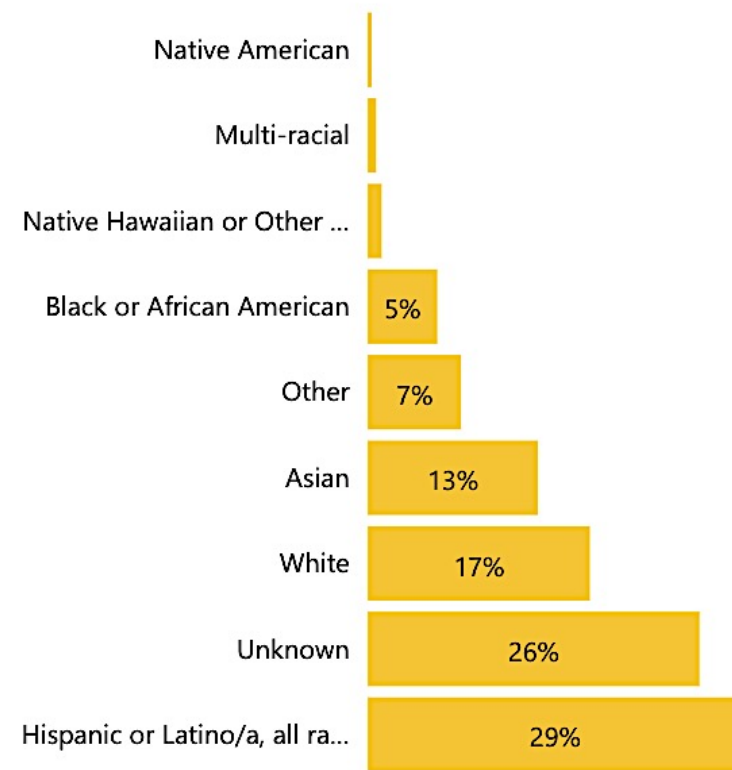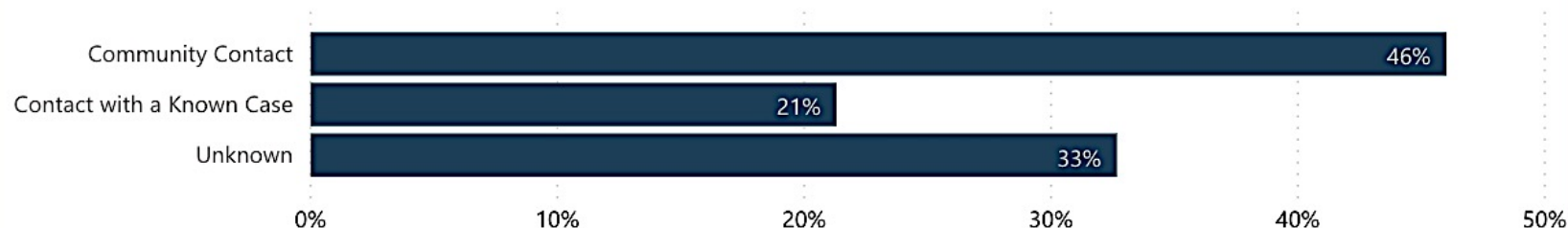
Where are COVID-19 cases in San Francisco?

Cases per 10,000 residents

- 5-10
- 10-15
- 15-20
- 20-25
- 30-35
- 40-45
- No Value (fewer than 10 cases)

© Mapbox © OpenStreetMap **Improve this map**

Legend ✕
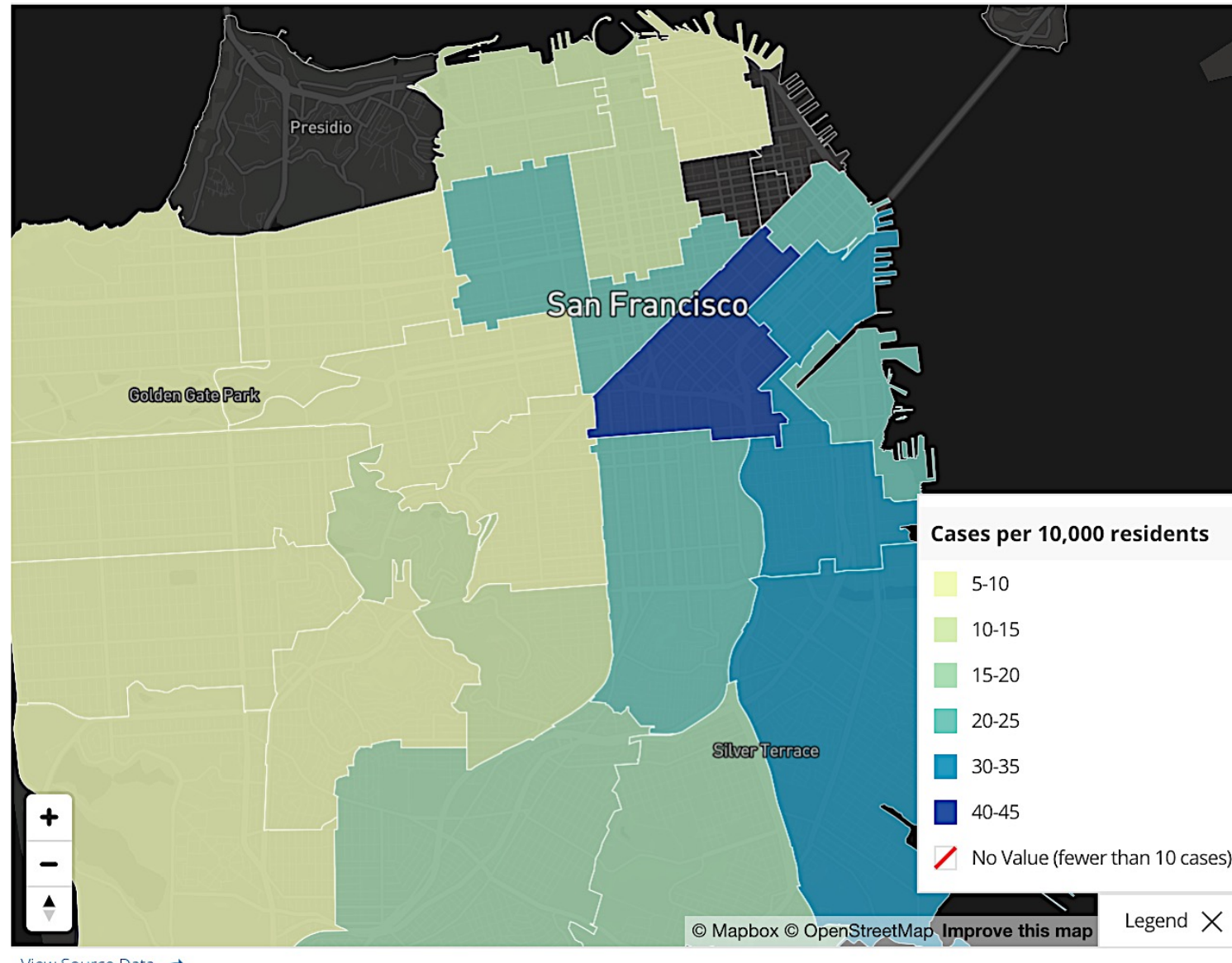
Post-mortem diagnoses of COVID-19, Santa Clara County, February-March 2020

- Three COVID-19 deaths from earlier in the year diagnosed from pathology specimens on April 22
  - February 6 (57-year-old woman), February 17 (69-year-old man) and March 6 (70-year-old man)
  - Occurred week's before the County's first recognized case of community transmission (February 28)
- No travel history
- Unconnected to each other
- Indicates that SARS CoV-2 was circulating in Santa Clara County in mid-late January (first US case January 21 in Washington, first Bay Area case on January 31, both returned from Wuhan)

Seroprevalence, Santa Clara County, April 2020

- Santa Clara County residents
- 3 300 participants recruited by Facebook ads
- Used Premier Biotech serological test
- No confirmatory test
- 50 positive tests (1.5% crude prevalence)
- Adjusted prevalence 2.49%-4.16% after adjustments for sample, test performance
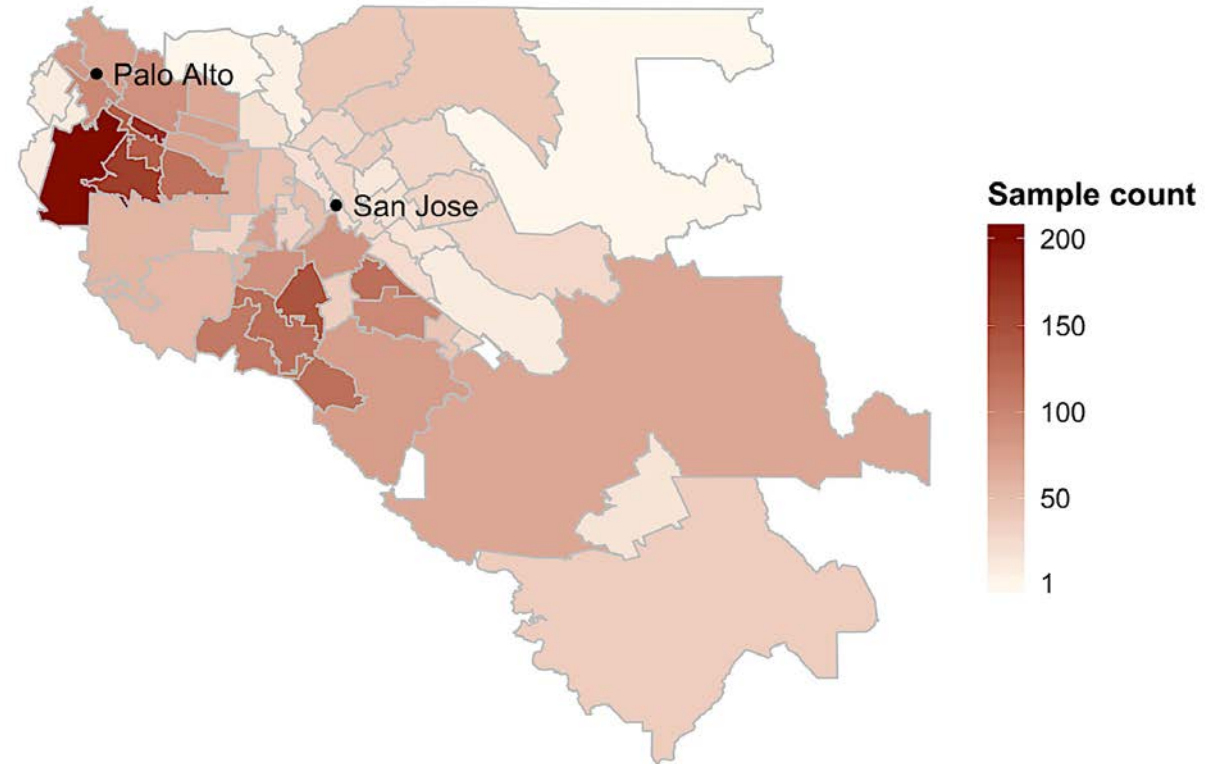
Bayes' theorem

$$PPV = \frac{\text{sensitivity x prevalence}}{(\text{sensitivity x prevalence})+[(1-\text{specificty})\text{x}(1-\text{prevalence})]}$$

Test result	Disease		
	Present	**Absent**	**Total**
Positive	a (TP)	b (FP)	a+b
Negative	c (FN)	d (TN)	c+d
Total	a+c	b+d	N

$$\text{Odds} = \frac{\text{probability}}{1\text{-probability}}$$

$$\text{Probability} = \frac{\text{odds}}{\text{odds} + 1}$$

Thomas Bayes, FRS, 1701-1761

Prior odds = (a+c)/(b+d)   All with disease/all without disease
Prior probability = (a+c)/N   Prevalence of disease in study population
Posterior odds = a/b   Odds of disease among those with a + test
Posterior probability = a/(a+b)   Proportion with disease of those with + test (PPV)
Negative probability = d/c+d   Proportion without disease with a − test (NPV)
Sensitivity = a/a+c   Proportion of those with disease who have a + test
Specificity = d/b+d   Proportion of those without disease who have a - test
LR = P(result|disease)/P(result|no disease
LR+ = sensitivity/(1-specificity)   Ratio of positive test results among those with and without disease
LR- = 1-sensitivity/specificity   Ratio of negative test results among those with and without disease
Remember that prior odds x LR = posterior odds

For dichotomous variables only

Baye's theorem as applied to Santa Clara County data

Manufacturer's values

Sens=91.8%, Spec=99.5%, prevalence=1-2%

Test results	Infection present	Infection absent	Total
Positive	9.18	4.9	14.08
Negative	0.82	985.1	985.92
Total	10	990	1000

Positive predictive value = 9.18/14.08 = 65.2%
If 50 positive tests, 32 true positives, 18 false positives

Test results	Infection present	Infection absent	Total
Positive	18.36	4.9	23.26
Negative	1.64	975.1	976.74
Total	20	980	1000

Positive predictive value = 18.36/23.26 = 78.6%
If 50 positive tests, 40 true positive, 10 false positives

Blended values

Sens=80.3%, Spec=99.5%, prevalence=1-2%

Test results	Infection present	Infection absent	Total
Positive	8.03	4.9	12.93
Negative	1.97	985.1	987.07
Total	10	990	1000

Positive predictive value = 8.03/13.03 = 62.1%
If 50 positive tests, 30 true positives, 20 false positives

Test results	Infection present	Infection absent	Total
Positive	16.06	4.9	20.96
Negative	3.94	975.1	979.04
Total	20	980	1000

Positive predictive value = 16.06/20.96 = 76.6%
If 50 positive cases, 38 true positives, 12 false positives

Syndromic surveillance, COVID-19 Citizen Scientist, San Francisco, March-April 2020
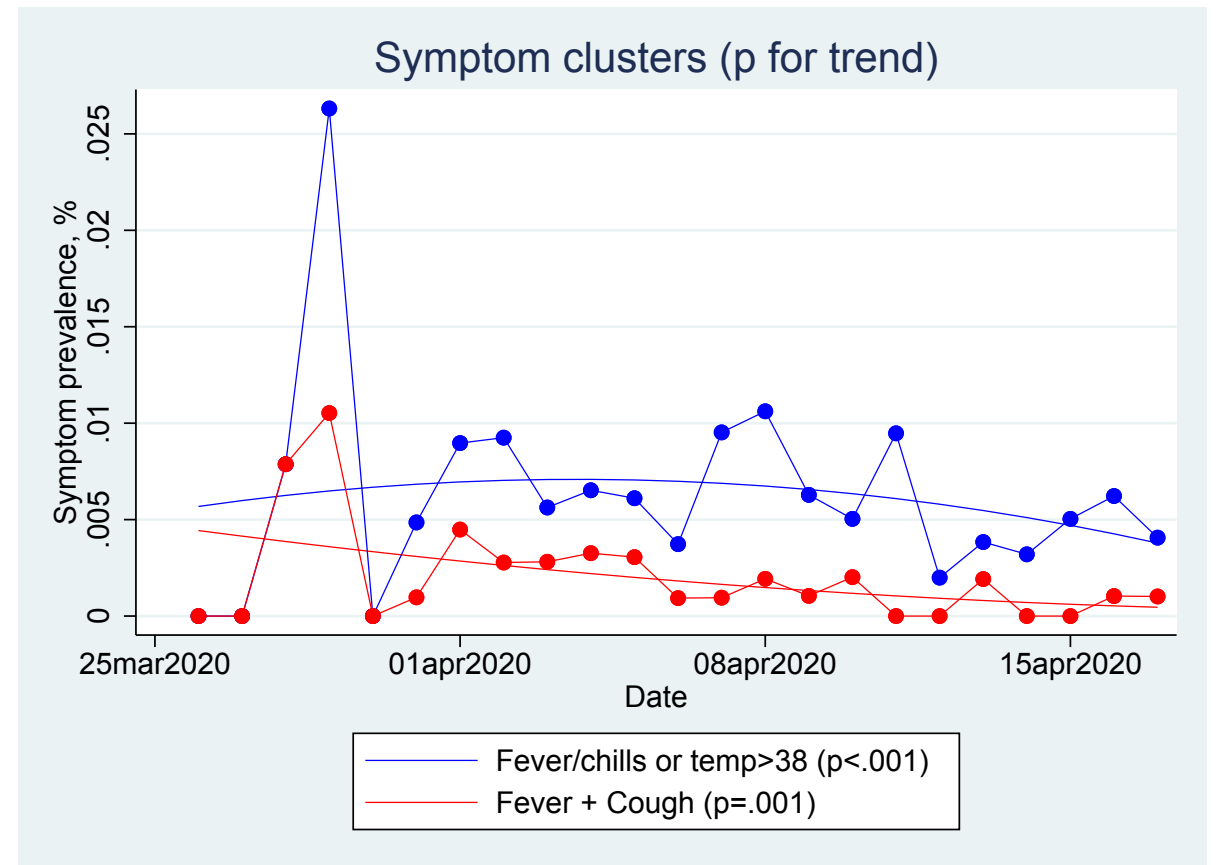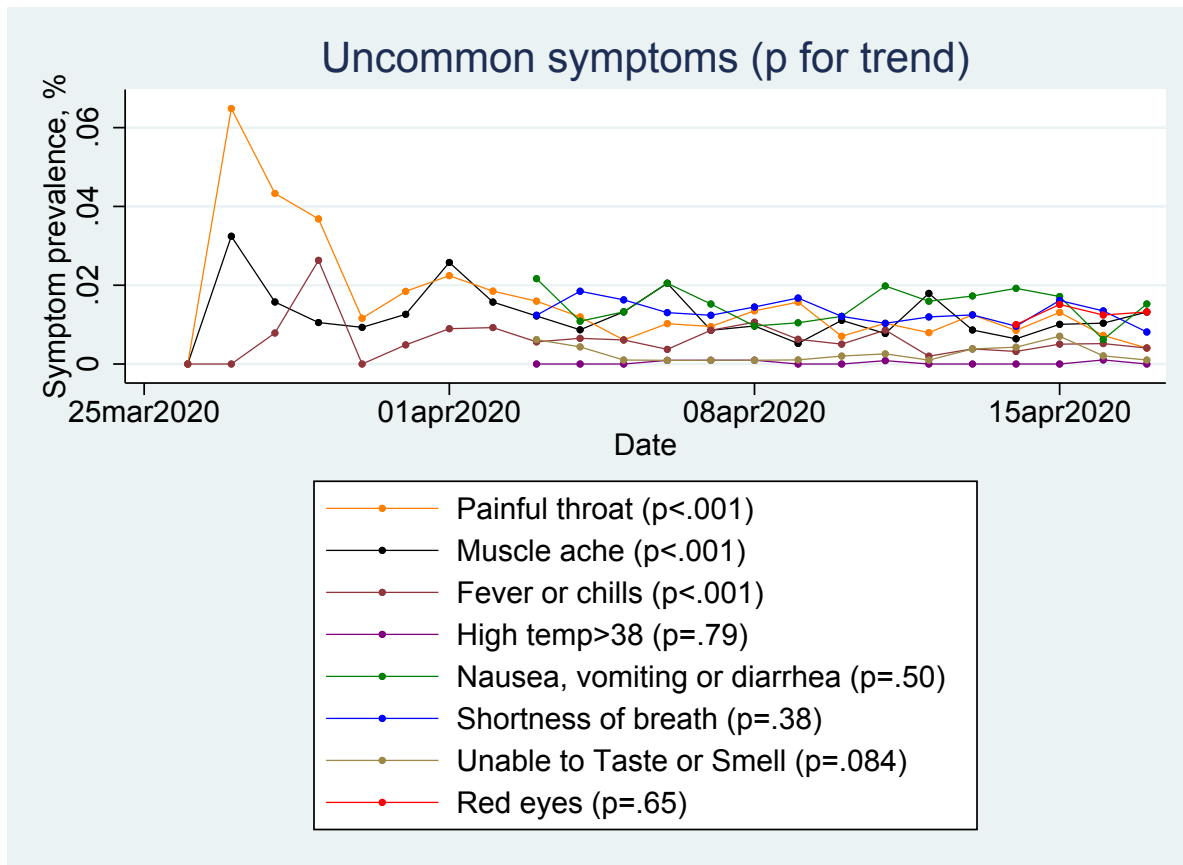
Percentage of People With Symptoms

| 0% | 1.24% | 1.35% | 1.49% | 1.59% | 1.96% | >2.4% |

April 12, 2020

California

Containment strategy ⓘ

After May 18, 2020, relaxing social distancing may be possible with containment strategies that include testing, contact tracing, isolation, and limiting gathering size.
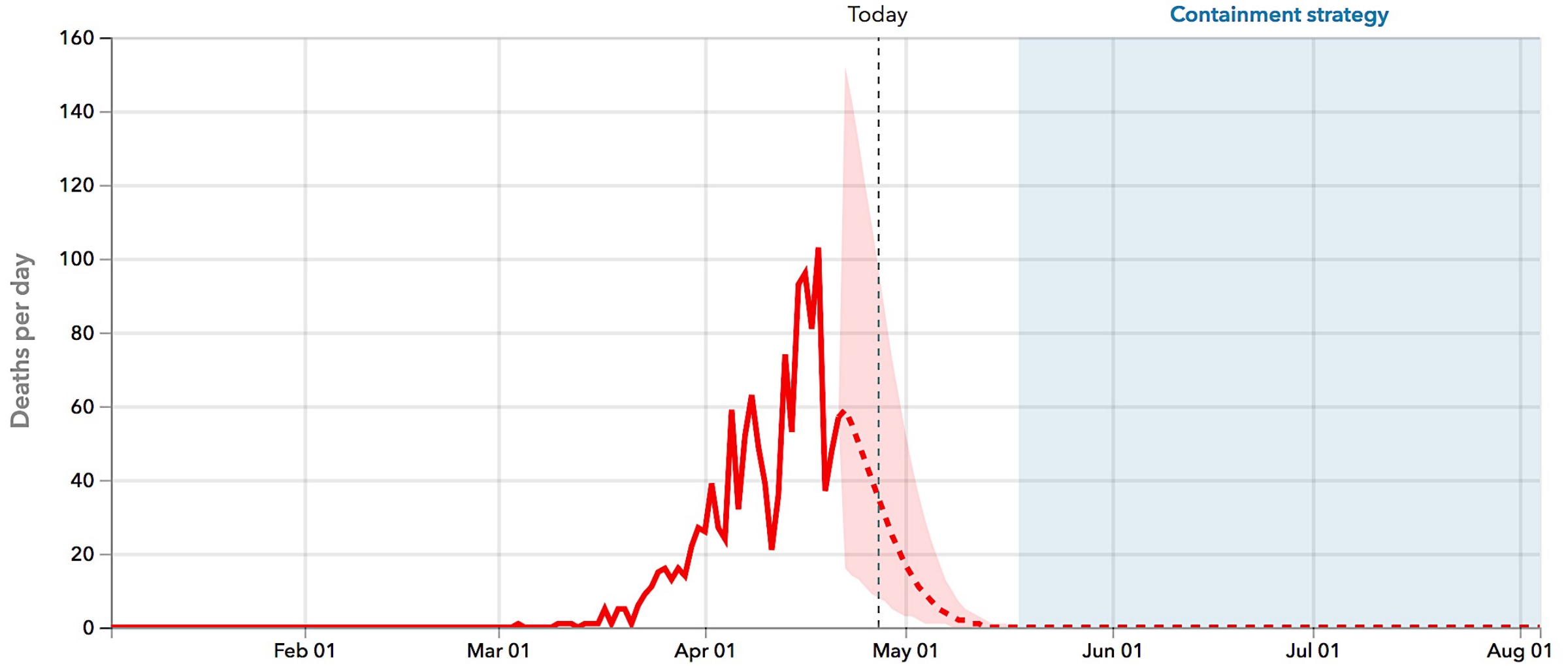
Individual- and community-level prevention

Infectious disease deaths, United States, 1900-1996
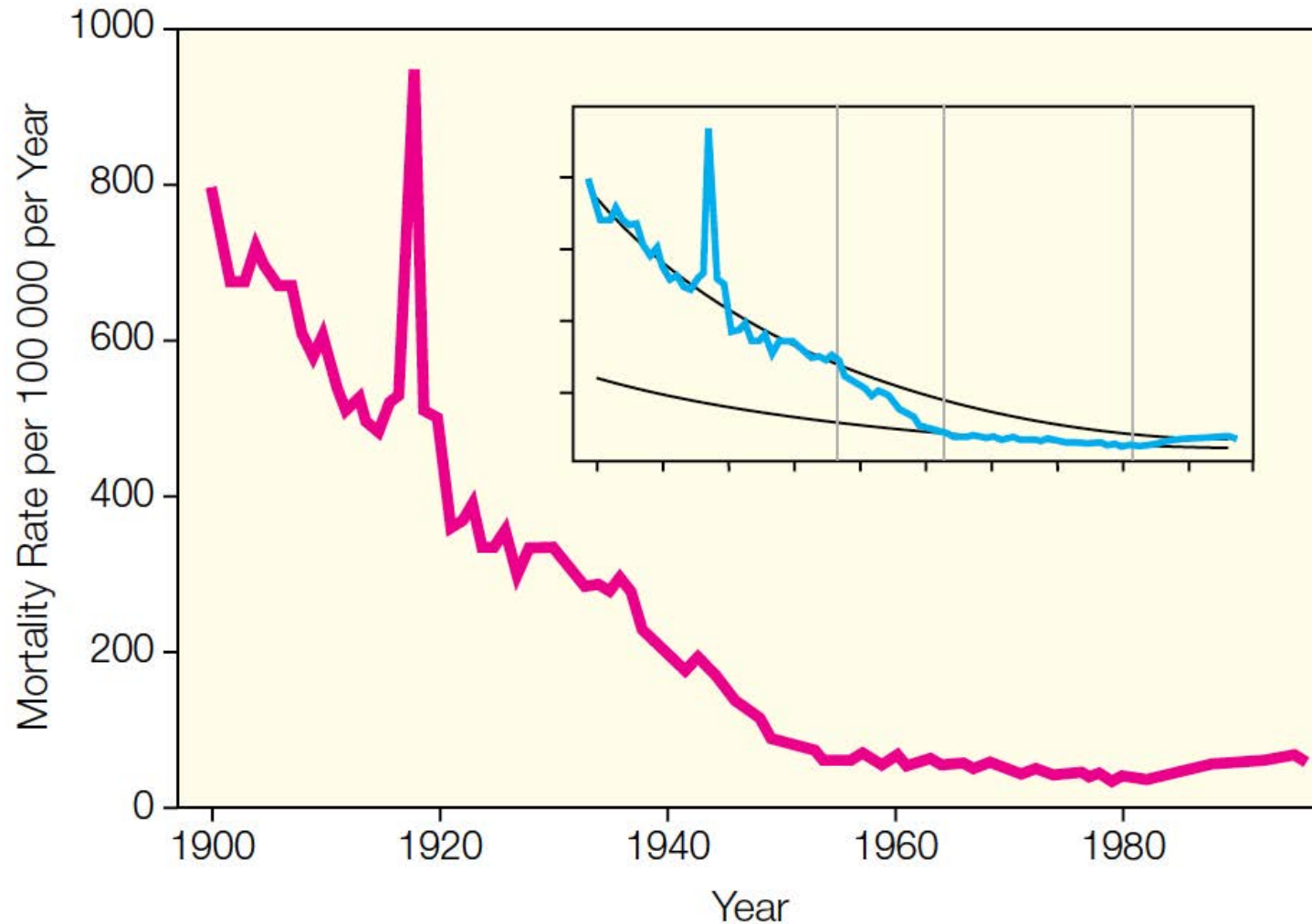
Armstrong GL, Conn LA, Pinner RW. Trends in infectious disease mortality in the United States during the 20th century. JAMA 1999; 281:61-66.

What are our goals?

- Minimize transmission of SARS-CoV-2
  - Measured by R_e
- Avoid overwhelming the medical care system
- Return to the "life we aspire to"
- Contain transmission until a vaccine is available

What are our intervention options?

Containment

- Case management - isolation
- Contact management – quarantine (voluntary and involuntary)
- Hospital/facility infection control
- Basic activities
  - Public information and education
  - Promote "respiratory hygiene" and hand washing
- Individual measures to increase social distance

Mitigation

- Community-wide measures to increase social distance
  - Telecommuting
  - Banning large gatherings
  - Business, school and transit closures
  - Widespread community quarantine – shelter in place
  - Border closures
    - All U.S. borders now closed except for essential travel
    - Hawai'I has begun a 14-day quarantine period for visitors

Effective reproductive number (R_e)

The effective reproductive number:

$$R_e = \text{# contacts per day} \times \text{Prob. infect. per contact} \times \text{Infectious period} \times \text{Population susceptibility}$$

Reduce pop. susceptibility: Vaccination (?)

Transmission ctrl: Contact tracing, case isolation, timely treatment

Transmission ctrl: Wear PPE, Personal hygiene, etc.

Social distancing/self-quarantine: Work from home, cancel social gatherings, etc.

Courtesy of Dr. Wan Yang, Columbia University

Effects of pandemic mitigation on health care needs
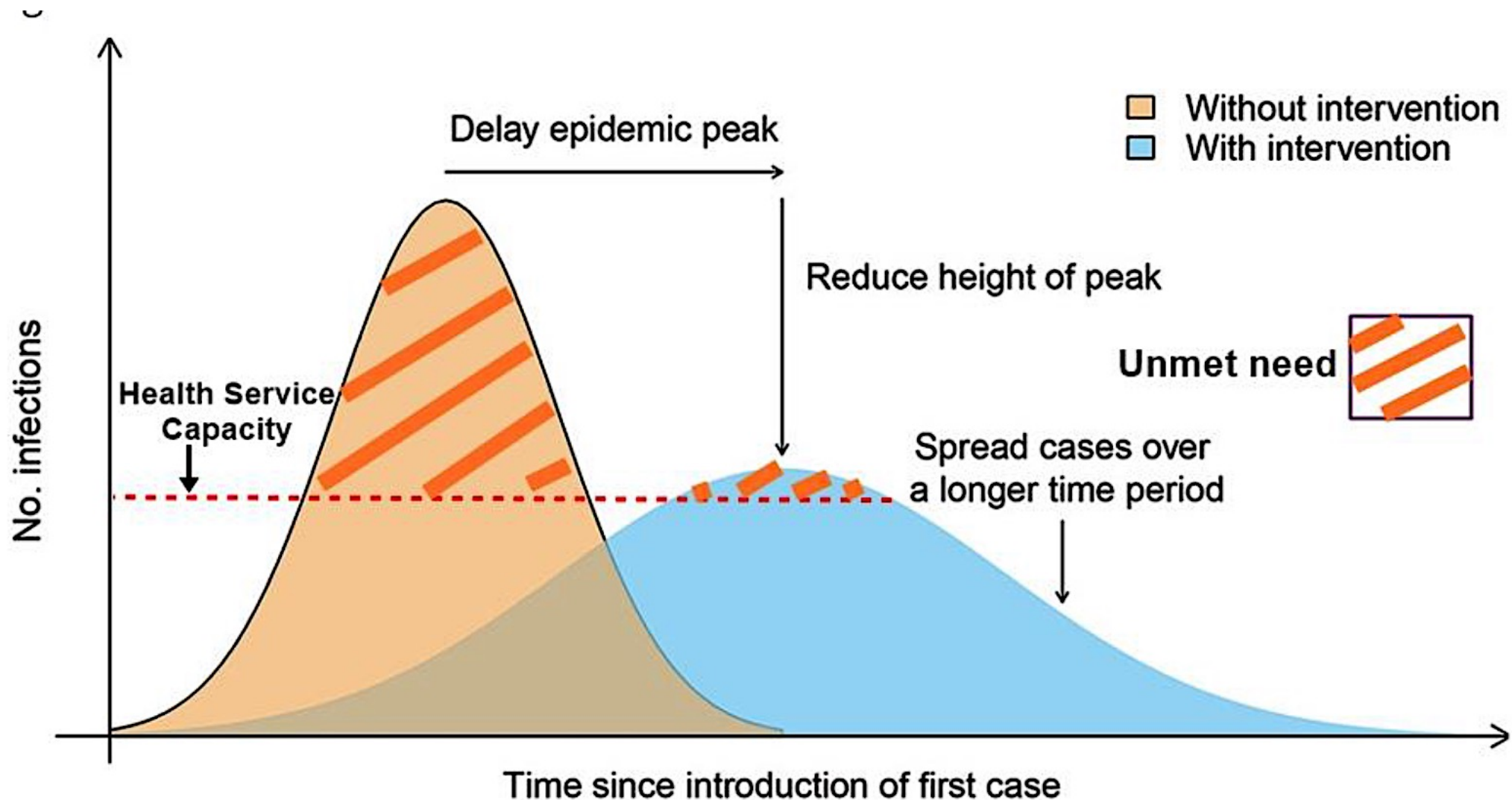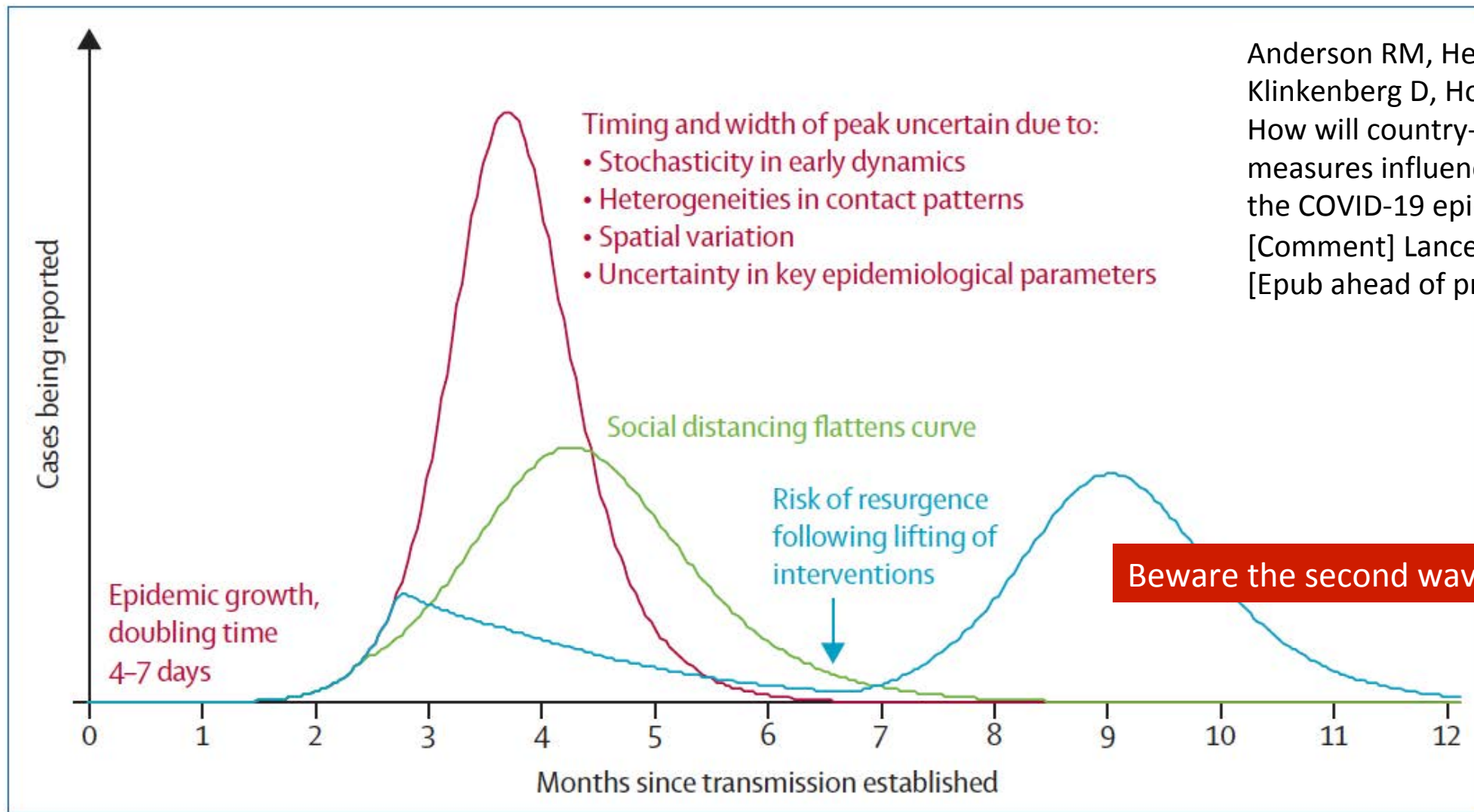
Figure: Illustrative simulations of a transmission model of COVID-19
A baseline simulation with case isolation only (red); a simulation with social distancing in place throughout the epidemic, flattening the curve (green), and a simulation with more effective social distancing in place for a limited period only, typically followed by a resurgent epidemic when social distancing is halted (blue). These are not quantitative predictions but robust qualitative illustrations for a range of model choices.

What are the lessons from the 1918-1919 influenza pandemic?
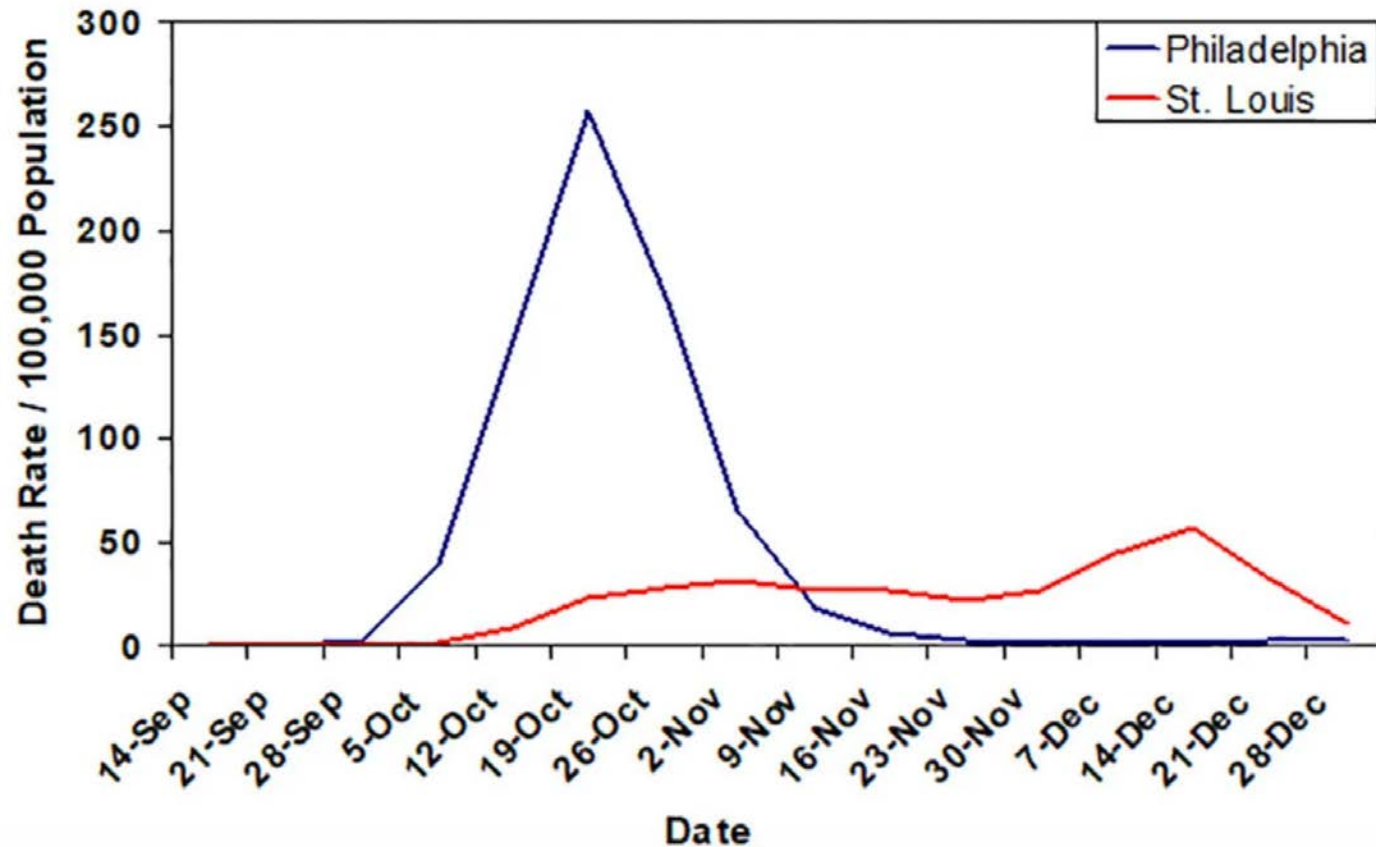
Closures included theaters, moving picture shows, schools, pool and billiard halls, Sunday schools, cabarets, lodges, societies, public funerals, open air meetings, dance halls and conventions until further notice.

1. Begin social distancing interventions early
2. Keep them going throughout outbreak period

Markel HD, Lipman HB, Navarro JA, et al. Nonpharmaceutical interventions implemented by U.S. cities during the 1918-1919 influenza pandemic. JAMA 2007; 298:644-54.

San Francisco and the 1918-19 influenza pandemic

- First case (imported from Chicago) on September 23, 1918
- Early attempt at isolation and quarantine of index case and contacts failed
- More than 2,000 cases by October 16
- On October 18, Board of Health closed schools and places of entertainment and banned lodge meetings, dances and other social gatherings

- October 21, wearing of masks in public was recommended
  - Mayor Rolph: "conscience, patriotism and self-protection demand immediate and rigid compliance [with mask order]."
  - Governor Stephens: "patriotic duty for every American citizen" to wear a mask
- October 25, became mandatory

San Francisco and the 1918-19 influenza pandemic

Armistice Day parade down Market Street in San Francisco on November 11, 1918. San Francisco History Center, San Francisco Public Library

An emergency flu hospital in Civic Center in San Francisco, California, 1918. Underwood Archives/Getty Images

San Francisco and the 1918-19 influenza epidemic

- Board of Health voted to lift various bans starting on Saturday, November 16
  - Continued requirement for masks in theatres and similar venues
  - Mayor and health officer each fined for not wearing mask at boxing match

- November 21, mask ordinance expired and citizens threw their masks into the streets
  - "…the sidewalks and runnels were strewn with the relics of a tortuous month"
- Celebrated with "throw away your masks" parties citywide
- Schools reopened November 25

- By December 7, cases had started to go up again, but no mask ordinance
- There were 600 cases reported on January 10, 1919
- Mask ordinance reinstated on January 17
- Rise of the "Anti-Mask League"; ordinance revoked on February 1
- By end of epidemic, 45,000 San Franciscans had been diagnosed with influenza and 3,000 (7%) had died
  - Mortality was was 30 deaths per 1,000 residents
  - Excess morality 673 per 100 000

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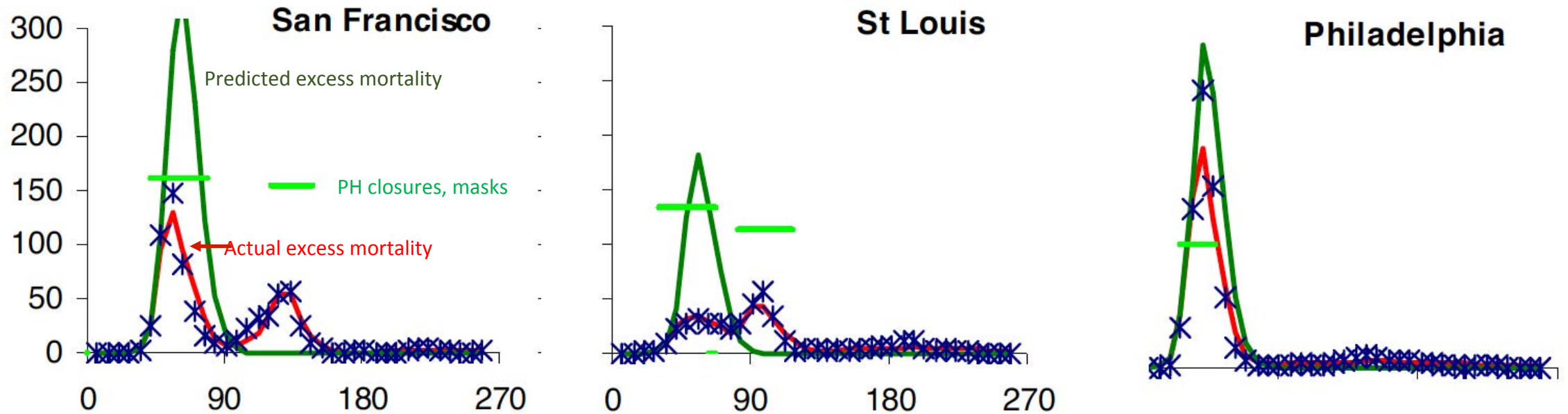
Bootsma MCJ, Ferguson MN. The effect of public health measures on the 1918 influenza pandemic in U.S. cities. Proc Natl Acad Sci 2007; 104:7488-93.

Has social distancing worked?

Does social distancing work? Modeling R_e and unreported cases, Wuhan

- Wang and colleagues modeled the epidemiology of 25,961 laboratory-confirmed cases in Wuhan through 18 February

- Examined four periods: before January, 11-22 January, 23 January-1 February and 2-18 February

- Used susceptible-exposed-infectious-recovered model

- Major findings: R_e decreased from 3.86 to 0.32 over the four periods
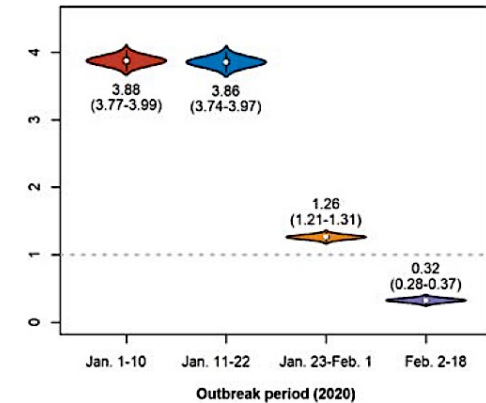
- 59% of cases were unreported

Wang C, Liu L, Hao X, et al. Evolving epidemiology and impact of non-pharmaceutical interventions on the outbreak of coronavirus disease 2019 in Wuhan, China. medRxiv 2020 Mar 3 [Epub ahead of print].
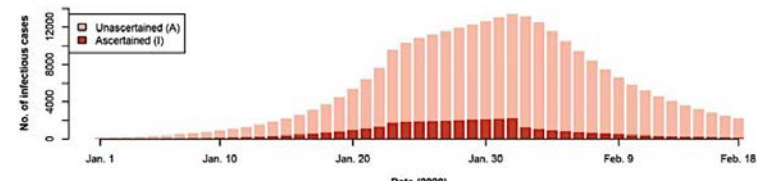
Estimating R_e from European experience

(G) Norway

(H) Spain
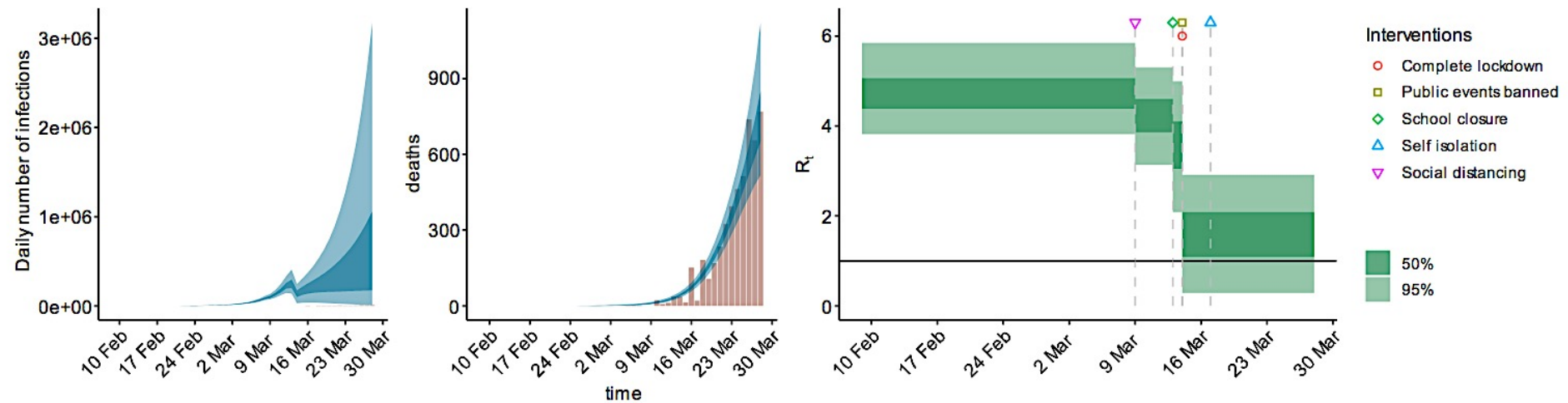
Empirical evidence that social distancing works

- Two adjacent Italian provinces in Lombardy region

- One (Lodi) began shelter-in-place on 26 February

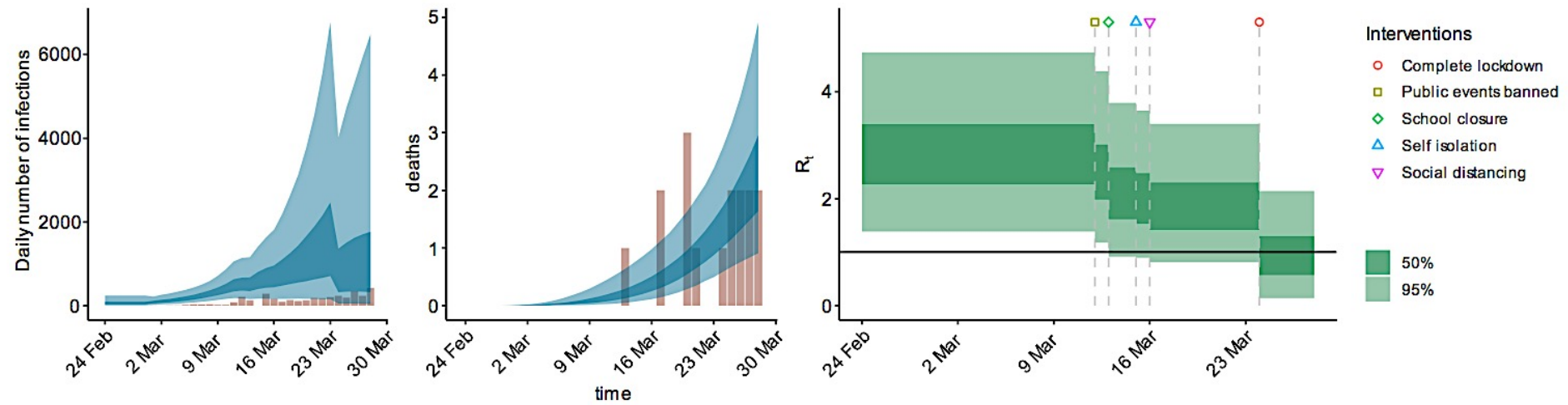- Other (Bergamo) began shelter-in-place on 9 March

- Empirical evidence that shelter in place orders can blunt transmission and new disease

STATISTICHE SUL CORONAVIRUS

Coronavirus, i dati di Lodi lo dimostrano: le misure di «lockdown» rallentano il contagio

Negli ultimi tre giorni, in particolare dal 6 al 9 marzo, in provincia di Lodi il tasso di diffusione del contagio ha rallentato la sua corsa rispetto alle settimane precedenti

COVID-19 cases by day, Lodi and Bergamo provinces, Italy, February-April, 2020

https://www.ilsole24ore.com/art/coronavirus-dati-lodi-dimostrano-misure-lockdown-rallentano-contagio-ADo675B
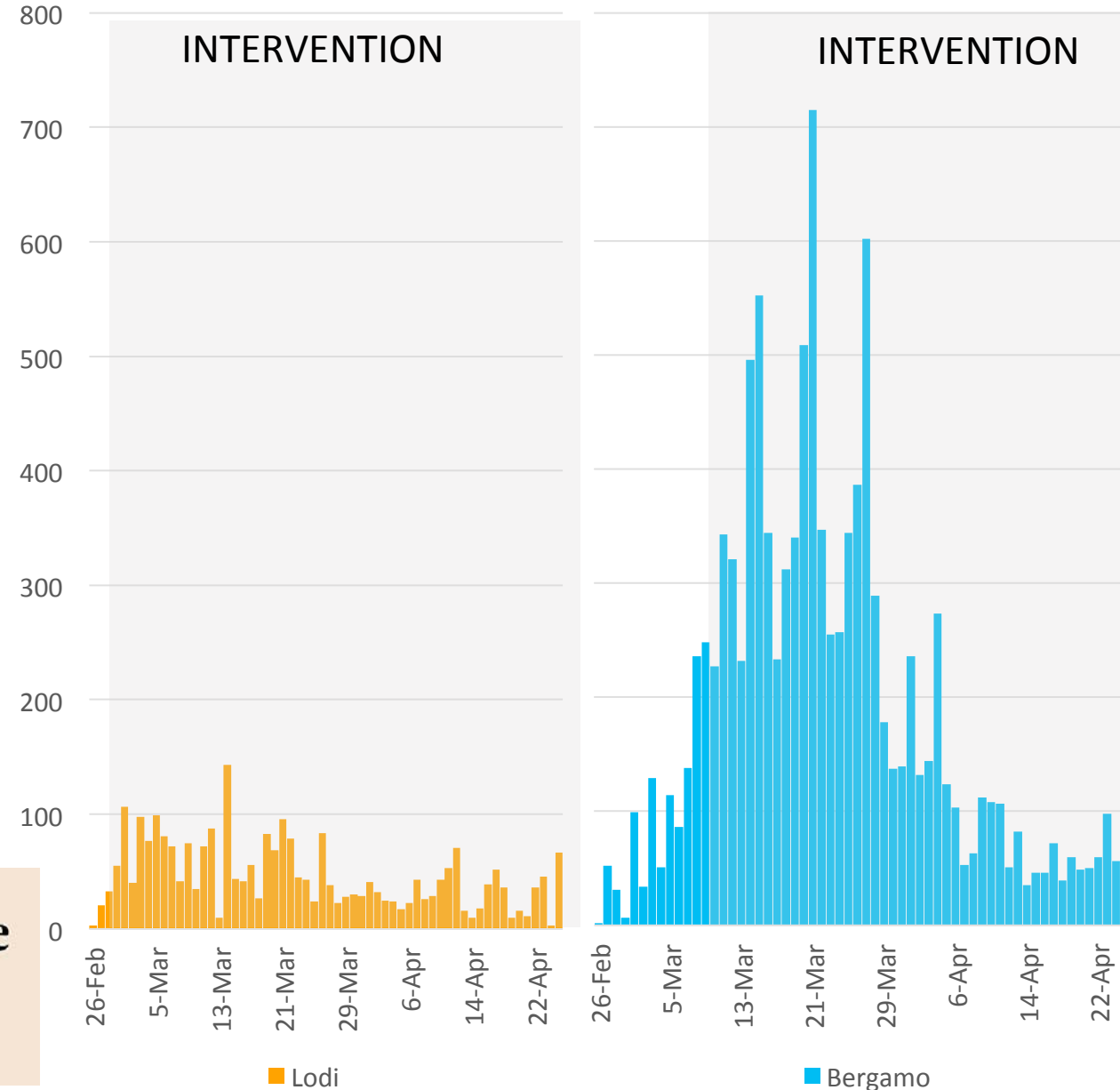
Preludes to shelter-in-place, San Francisco, 2020

OpenTable % year-over-year seated diners at restaurants
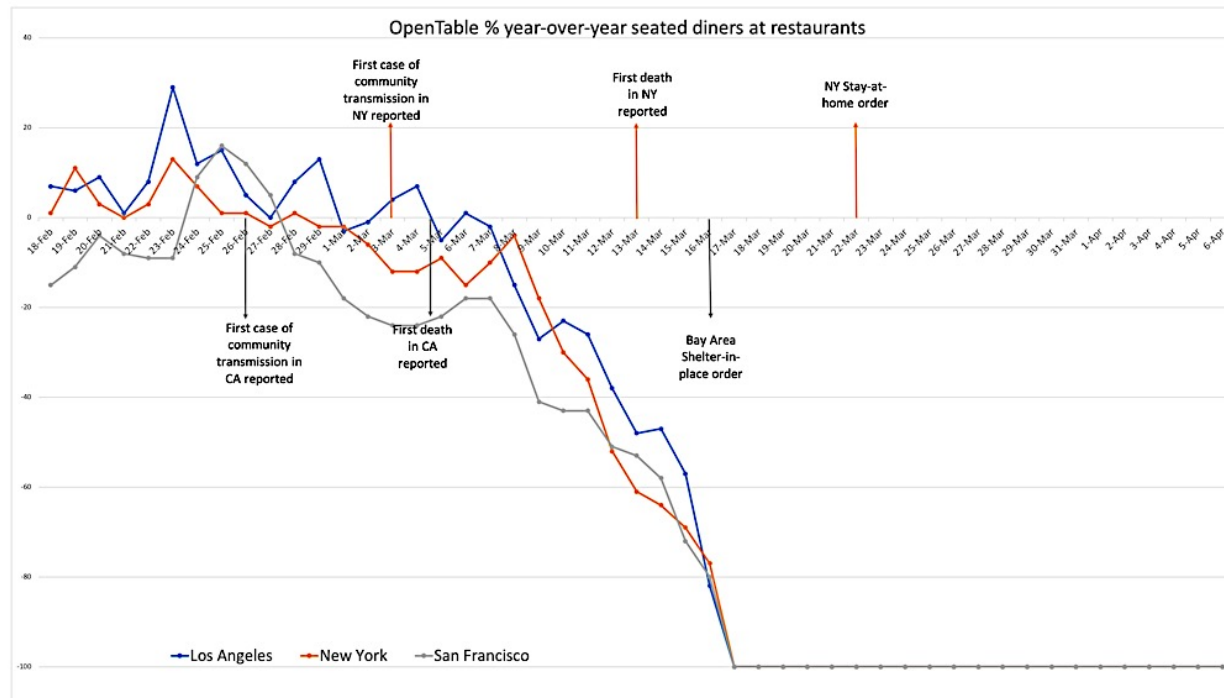
- Bay Area employers begin telecommuting earlier as well
  - Salesforce - March 4
  - Apple - March 6
  - Google - March 10
  - Twitter - March 11 (mandatory -- earlier in month was recommended)
  - Facebook – March 6
  - Lyft – March 6
  - UCSF – March 13

Data courtesy of Dr Janet Wojcicki, Pediatrics

FIGURE. (*Continued*) Selected community mitigation interventions,* cumulative COVID-19 case counts, average 3-day percentage change in case counts,† and percentage leaving home — four U.S. metropolitan areas,§,¶ February 26–April 1, 2020

San Francisco (five counties)
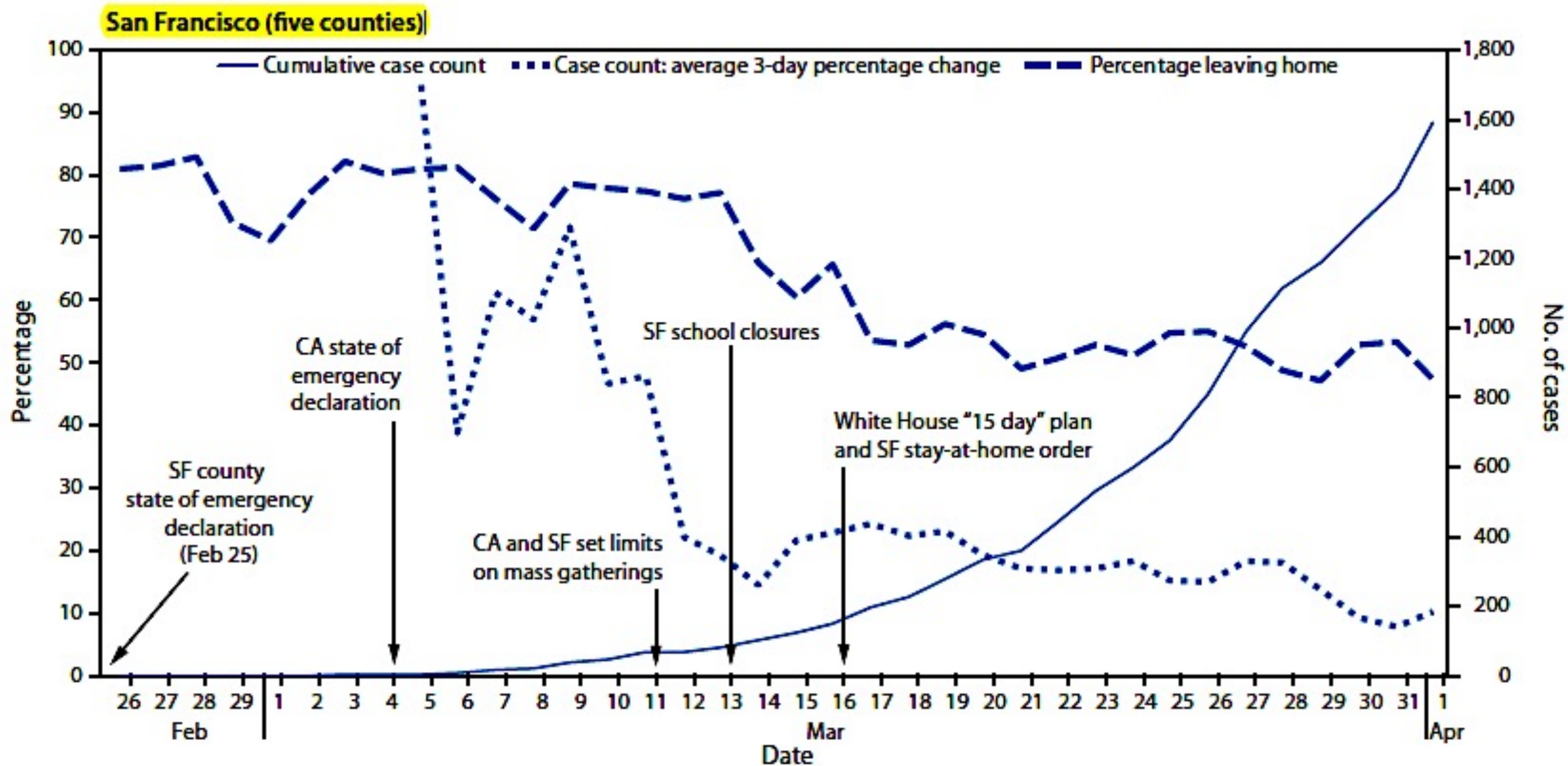
Is social distancing working in San Francisco?
COVID-19 cases by day, San Francisco and Los Angeles, March-April, 2020

San Francisco

Shelter in place

First COVID-19 death

Los Angeles

Shelter in place

First COVID-19 death

Is social distancing working in San Francisco?
COVID-19 cases by day, Bay Area and Southern California, March-April 2020
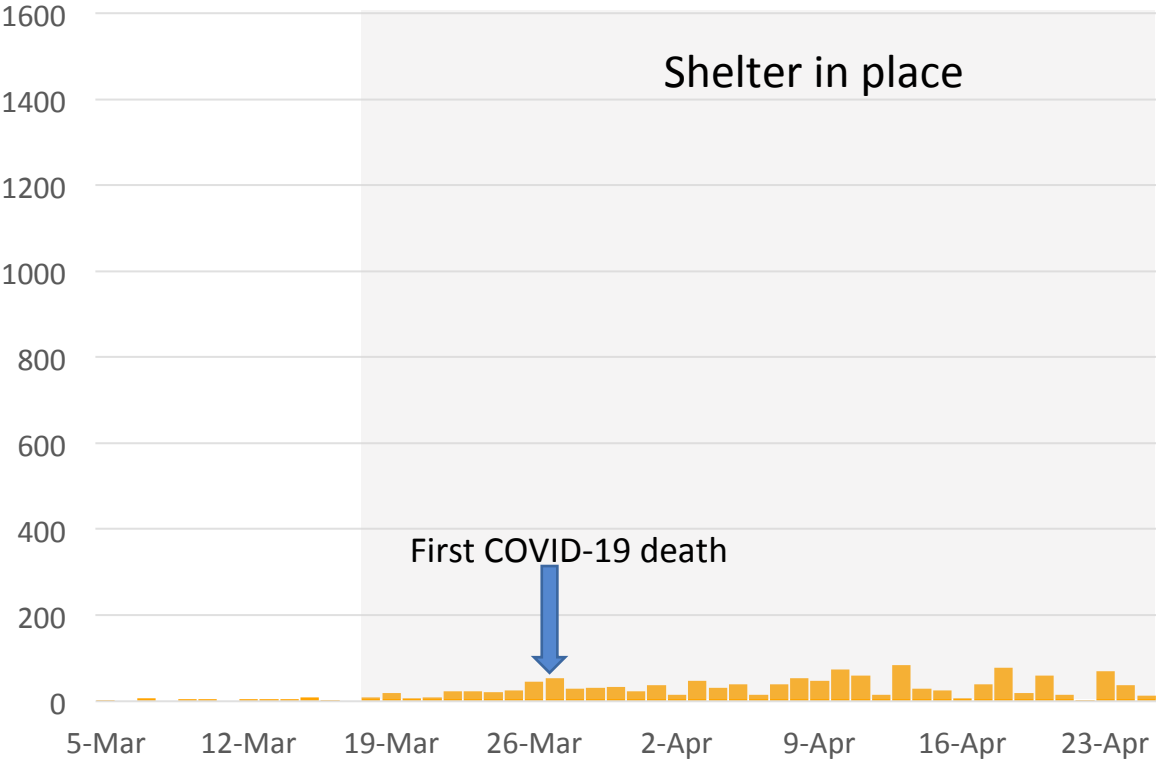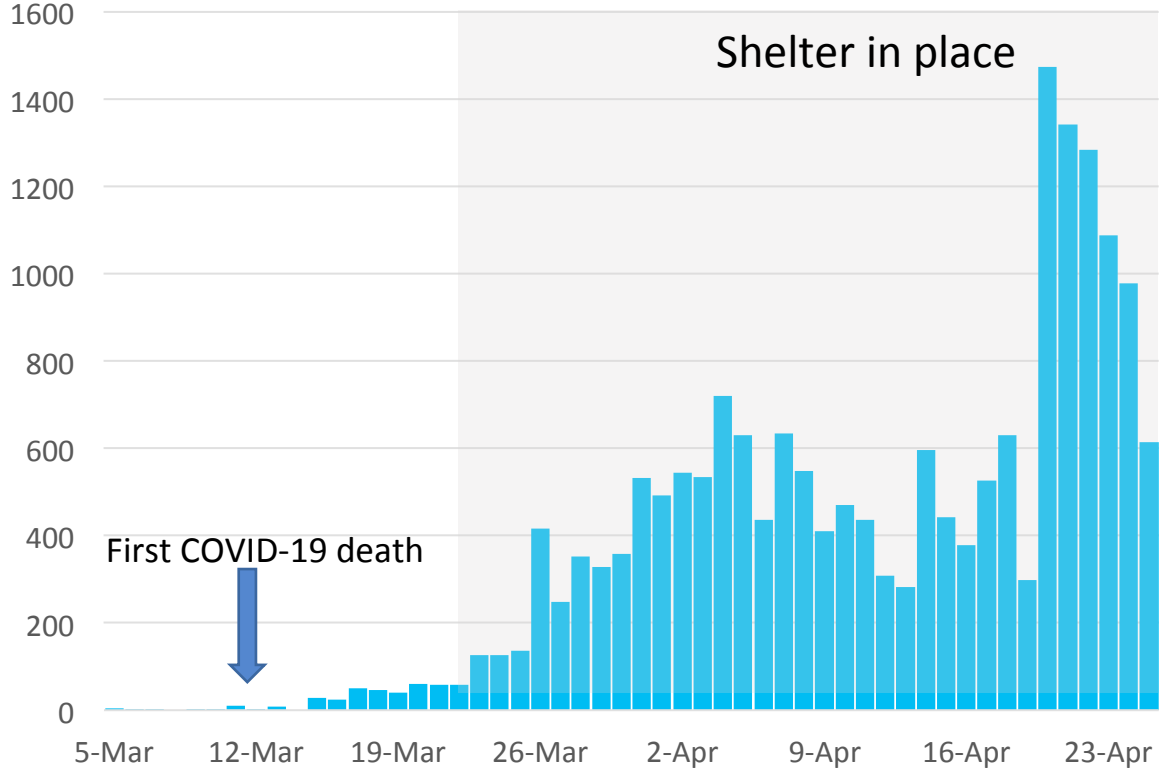
COVID-19 cases, Los Angeles and New York City, March-April 2020

COVID-19 cases by date of report, Los Angeles, 2020
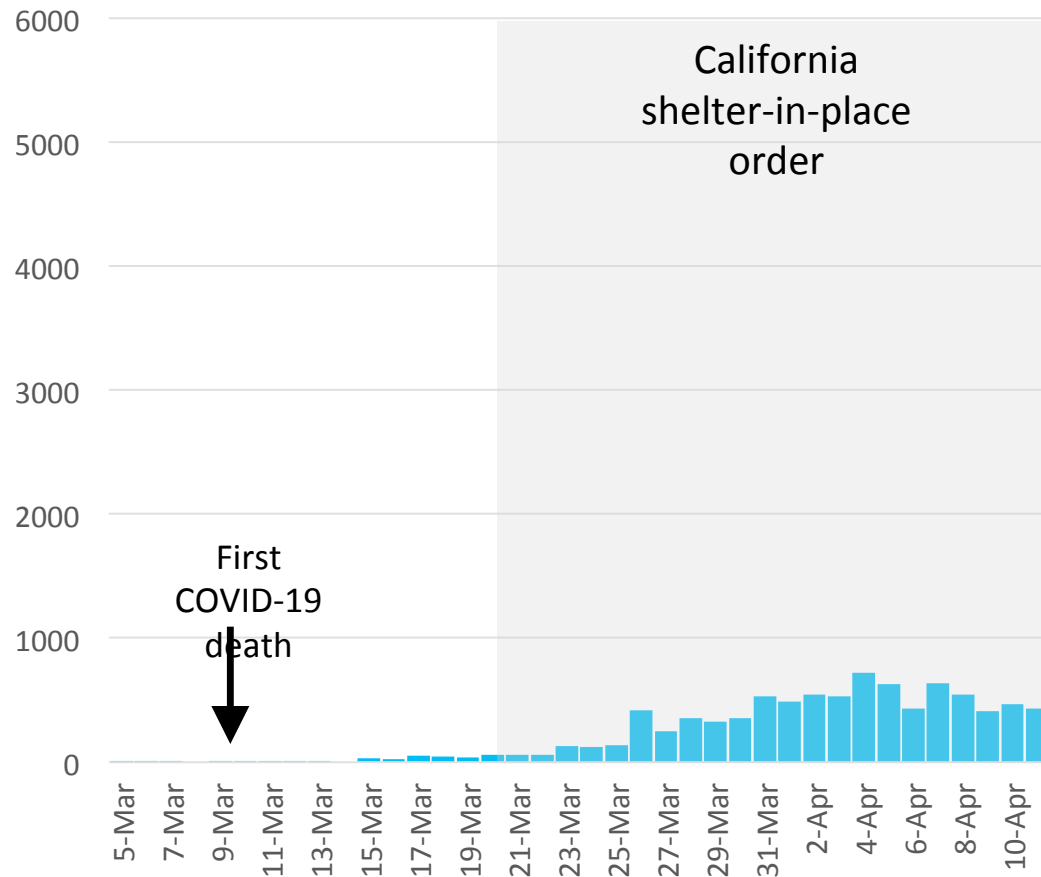
COVID-19 cases by date of report, New York City, 2020
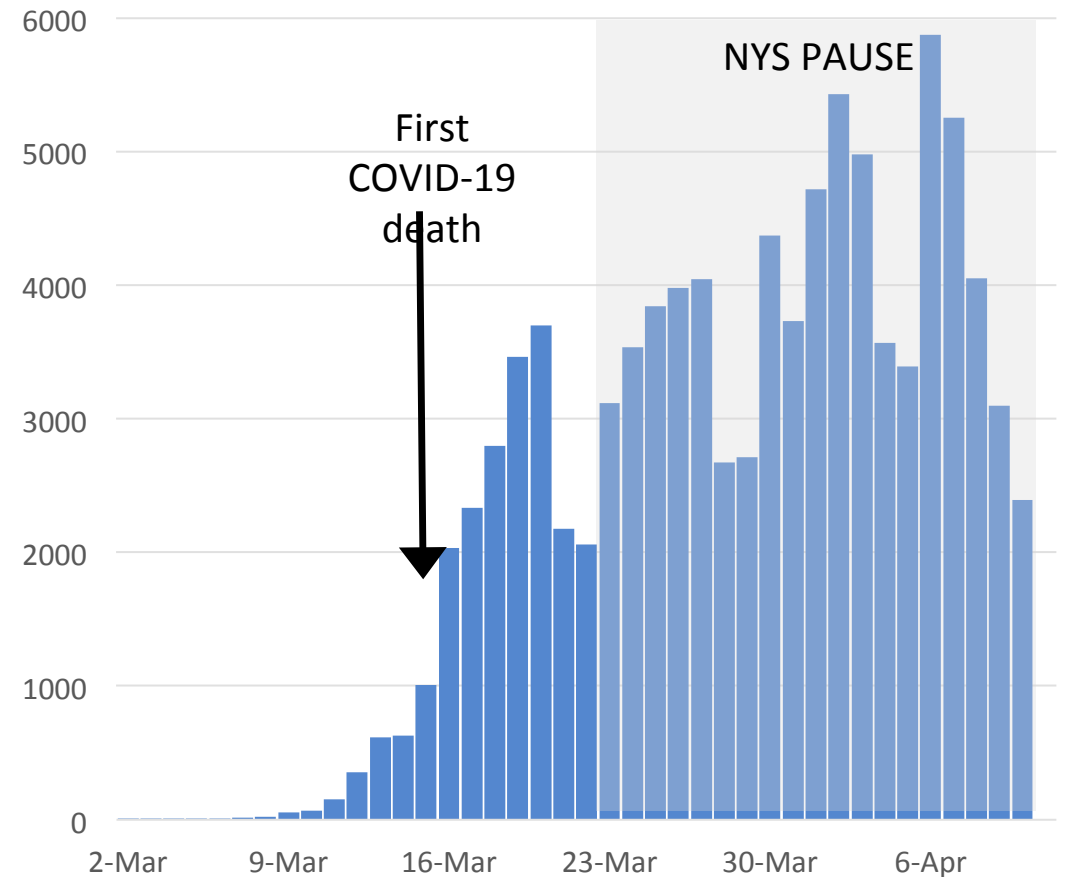
Change in distance traveled, compared with normal, on March 27 in U.S. counties

-60% or less ▇▇▇▇▇ +30% or more ☐ no data
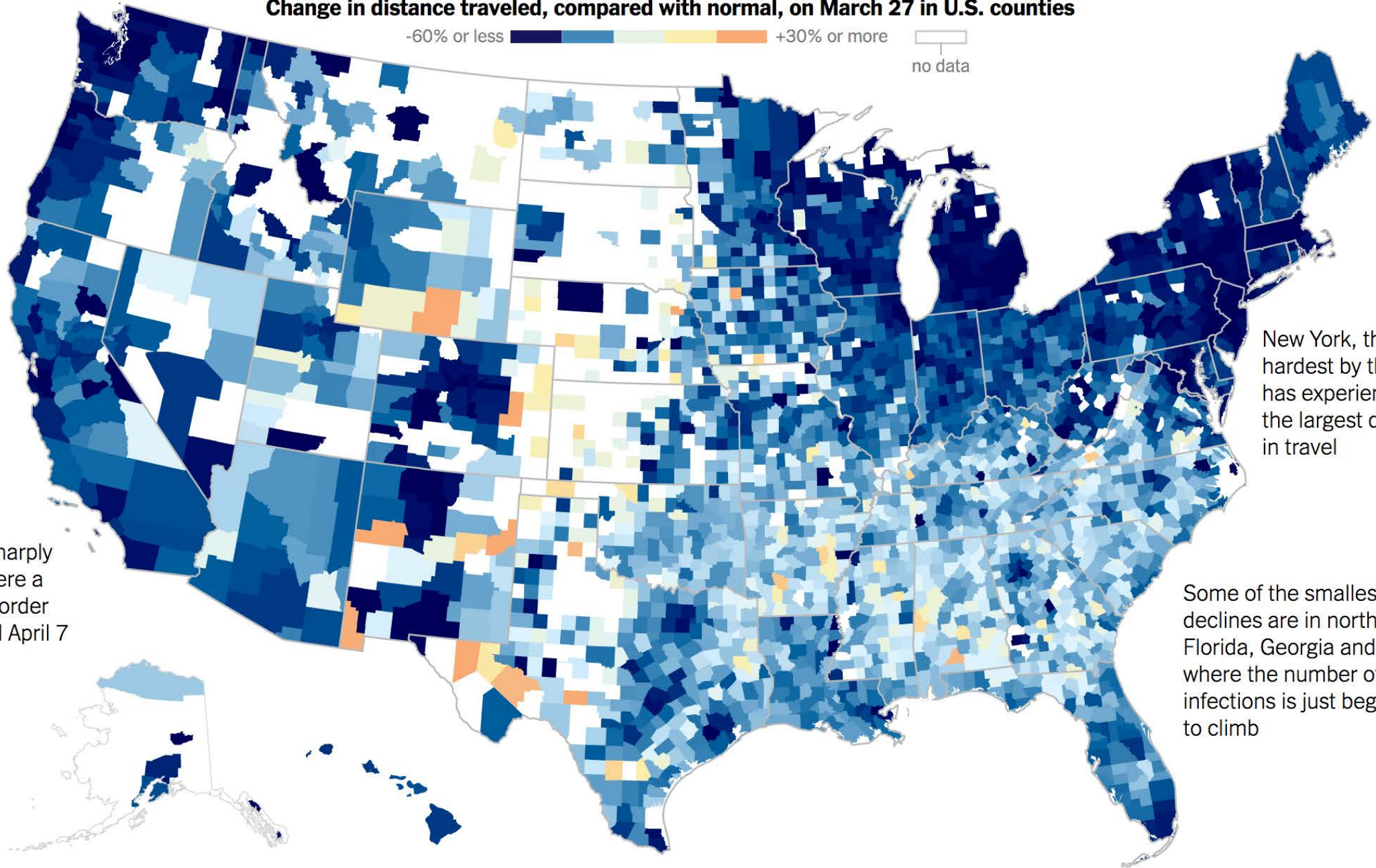
New York, the state hit hardest by the virus, has experienced some of the largest declines in travel

Movement fell sharply in California, where a shelter-in-place order is set to last until April 7

Some of the smallest declines are in northern Florida, Georgia and Alabama, where the number of infections is just beginning to climb

R$_e$ by state, United States, April 2020

Legend: 50% CI · 90% CI · 50% CI · 90% CI · Data Issue

California inset: 0.88 (3/15 – 4/26)
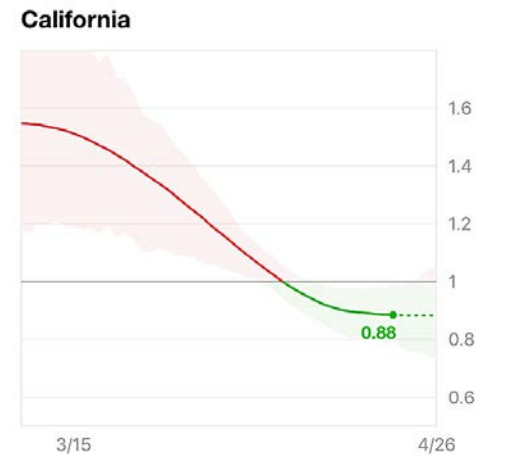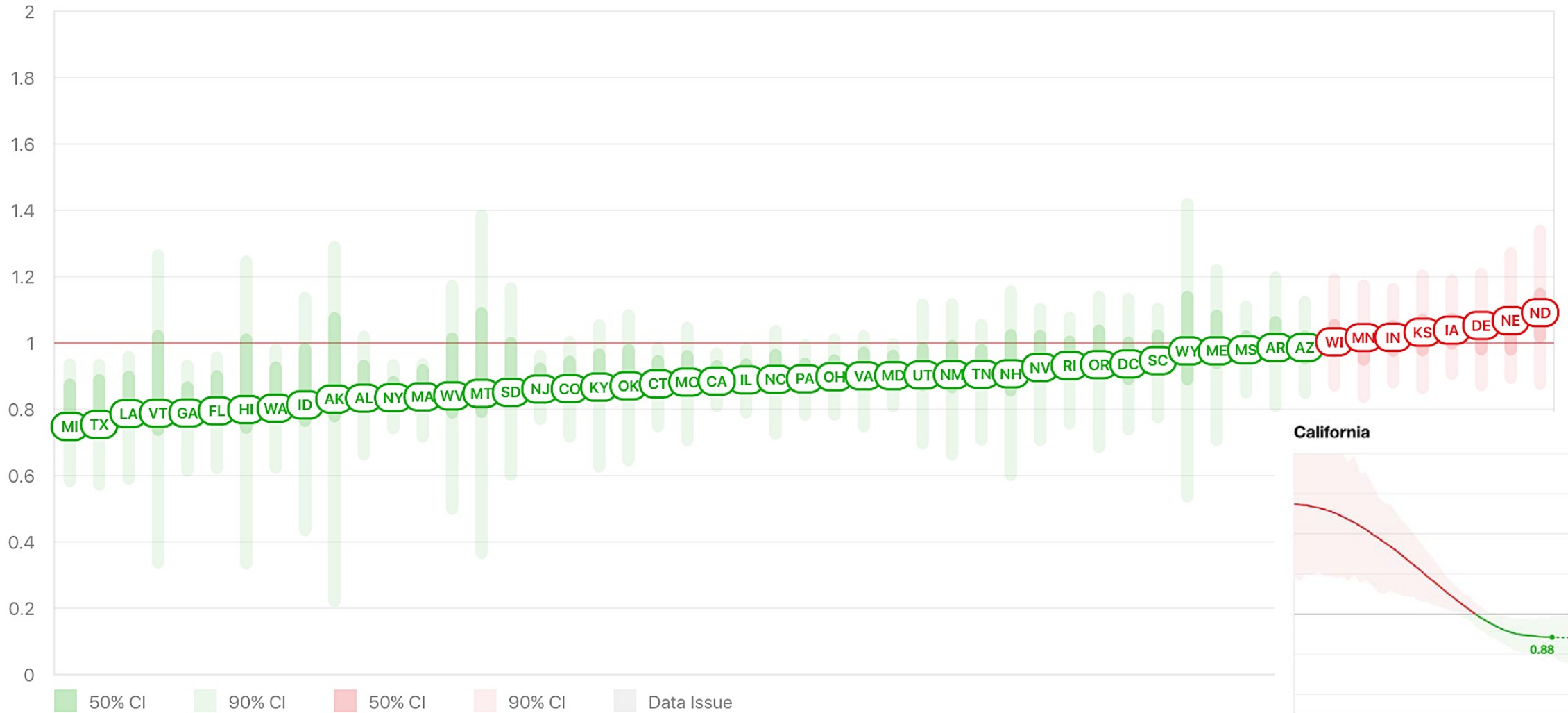
COVID-19 in homeless shelters

TABLE. SARS-CoV-2 testing among residents and staff members at 19 homeless shelters in four U.S. cities with community transmission of COVID-19, March 27–April 15, 2020

City	No. of shelters assessed	Date of testing	Residents		Staff members	
			No. tested	No. (%) positive	No. tested	No. (%) positive
Shelters reporting ≥2 cases in 2 weeks preceding testing						
Seattle	3	Mar 30–Apr 8	179	31 (17)	35	6 (17)
Boston	1	Apr 2–3	408	147 (36)	50	15 (30)
San Francisco	1	Apr 4–15	143	95 (66)	63	10 (16)
Subtotal	5	March 30–Apr 15	730	273 (37)	148	31 (21)
Shelters reporting 1 case in 2 weeks preceding testing						
Seattle	12	Mar 27–Apr 15	213	10 (5)	106	1 (1)
Shelters reporting no cases in 2 weeks preceding testing						
Atlanta	2	Apr 8–9	249	10 (4)	59	1 (2)
Total	**19**	**Mar 27–Apr 15**	**1,192**	**293 (25)**	**313**	**33 (11)**

Abbreviation: COVID-19 = coronavirus disease 2019.

"Given the high proportion of positive tests in the shelters with identified clusters and evidence for presymptomatic and asymptomatic transmission of SARS-CoV-2 (5), testing of all residents and staff members regardless of symptoms at shelters where clusters have been detected should be considered. If testing is easily accessible, regular testing in shelters before identifying clusters should also be considered. "

CDC. Assessment of SARS-CoV-1 infection prevalence In homeless shelters – four U.S. citieis, March 27-April 15, 2020. MMWR 2020 Apr 22; 69 [Early release].

How can individuals protect themselves

- Avoid epidemic areas (no trips to China, Iran, Italy or South Korea unless absolutely necessary (Japan – level 2)
- Avoid people who are sick (great advice for healthcare workers!)
- Washing hands frequently and correctly
- Avoid touching your face
- Stay home if you're sick
- Cover your cough or sneeze with Kleenex and throw it away!
- Disinfect frequently touched surfaces
- Seasonal influenza is a far greater risk to the public health right now – **get vaccinated**

- CDC does not recommend use of face masks for the general public; they should be reserved for people with symptoms, patients and caregivers
  - Don't hoard masks
  - Seriously people — STOP BUYING MASKS!
  - If you're going to use a mask, regular medical masks appear to be as effective as N95 respirators in a large trial in the U.S.

HAND HYGIENE

Front   Back

AREAS LESS LIKELY TO BE MISSED   AREAS MORE LIKELY TO BE MISSED

Radonovih LJ Jr, Simberkoff MS, Bessesen MT, et al. N95 respirators vs medical masks for preventing influenza among health personnel. A randomized clinical trial. JAMA 2019; 322:824-33.

https://www.cdc.gov/coronavirus/2019-ncov/about/prevention-treatment.html

Impact and the future

What have we gained by social distancing and what's next

- Initial estimates were that there would be 1.7 – 2.2 million deaths in the United States
  - Annual U.S. mortality 2.56 million

	U.S.	California	Bay Area*
Projected deaths (Imperial)	2.2 million	264,771 (12%)	44,211 (2%)
Projected deaths (CDC)	1.7 million	204,601 (12%)	34,163 (2%)
Deaths to date	54,887	1,723	252
Proportion of all U.S. deaths		3.1%	0.46%

- What's next?
  - Social distancing continues
  - Masks when outdoors or in public places
  - SIP continues for elderly and vulnerable
  - No mass gatherings
  - Staggered reopening of businesses
  - School reopenings?
- Contact tracing, isolation and quarantine first line of defense
- Short fuse for returning to SIP

Until we build immunity, our actions will be aligned to achieve the following…

- Ensure our ability to care for the sick within our hospitals
- Prevent infection in people who are at high risk for severe disease
- Build the capacity to protect the health and well-being of the public
- Reduce social, emotional and economic disruptions

Governor Gavin Newsom, 14 April 2020

Governor Newsom's six indicators for modifying stay-at-home orders

- Ability to monitor and protect our communities through testing, contact tracing, isolating, and supporting those who are positive (isolation) or exposed (quarantine)
- The ability to prevent infection in people who are at risk for more severe COVID-19
- The ability of the hospital and health systems to handle surges
- The ability to develop therapeutics to meet the demand

- The ability for businesses, schools, and child care facilities to support physical distancing
- The ability to determine when to reinstitute certain measures, such as stay-at-home orders if necessary

"… there is not a precise timeline for modifying the stay-at-home order, but … these six indicators will serve as the framework for making that decision."
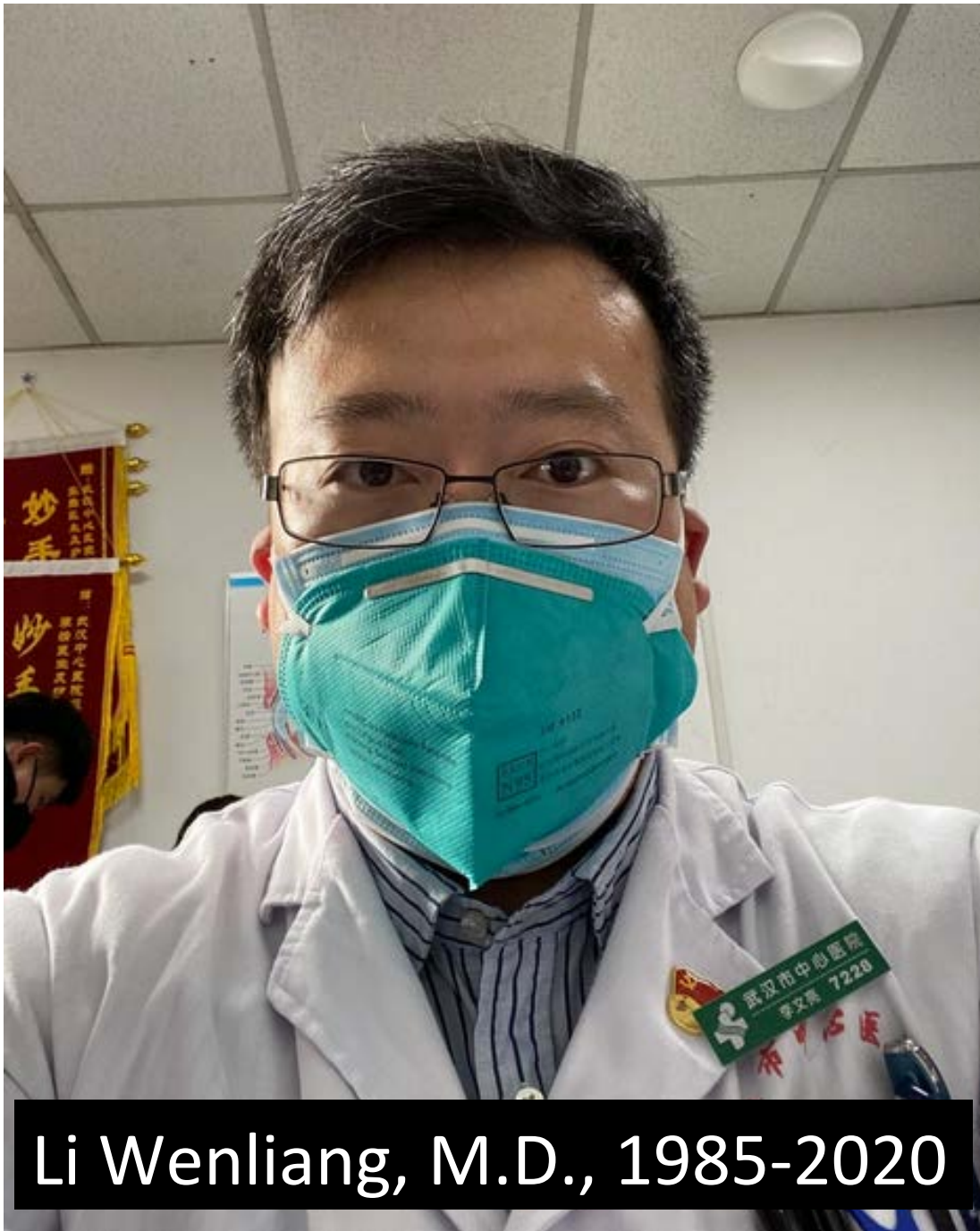
Li Wenliang, M.D., 1985-2020

CAPT Brett Crozier, USN