The recent epidemiology of COVID-19 in the United States and California: the role of micro-epidemics

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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)
  - Primarily nosocomially transmitted
  - Primarily cause pneumonia
  - High case-fatality rate (SARS 9.5%, MERS 34.4%)

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 live-animal market in Guangzhou

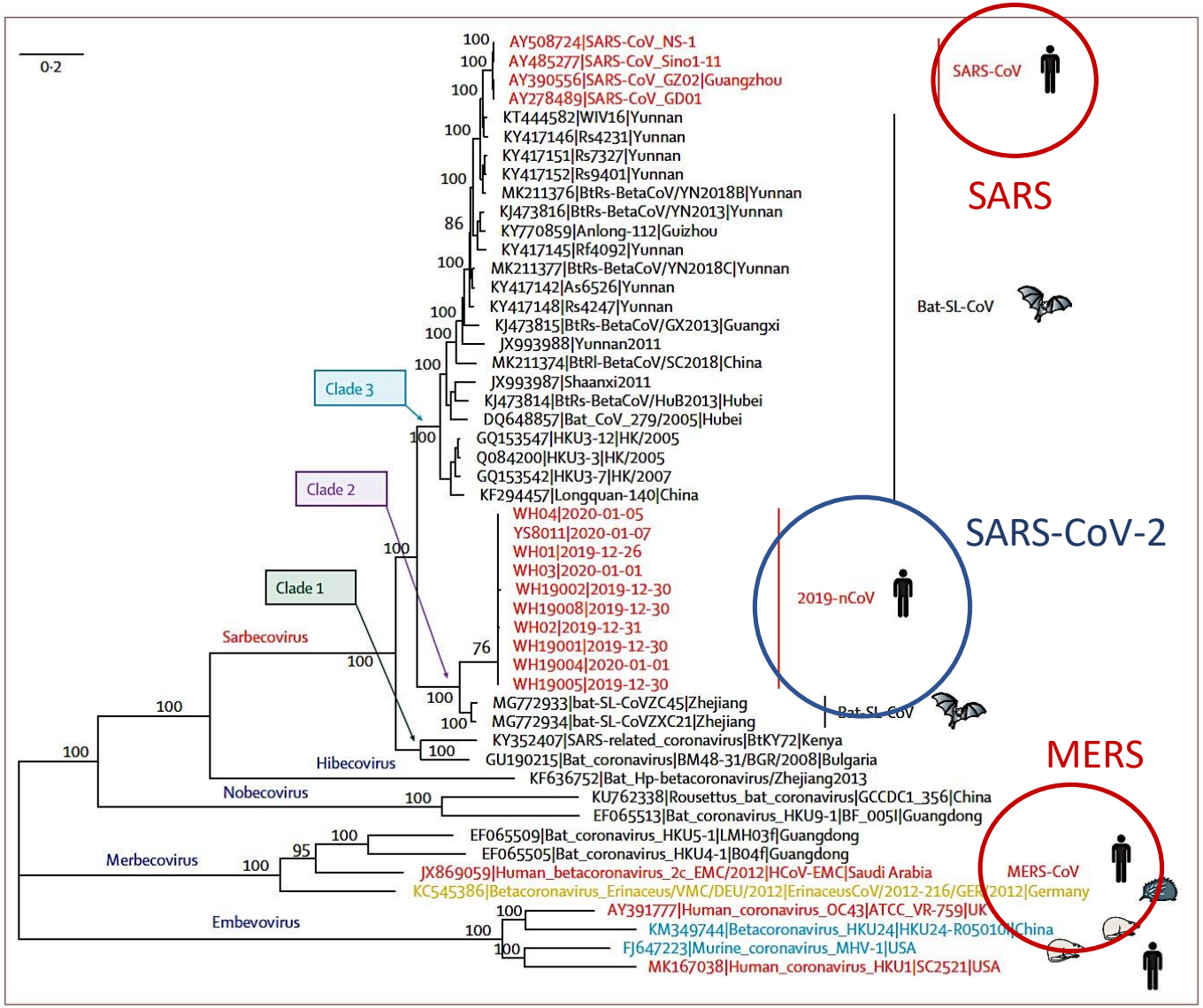
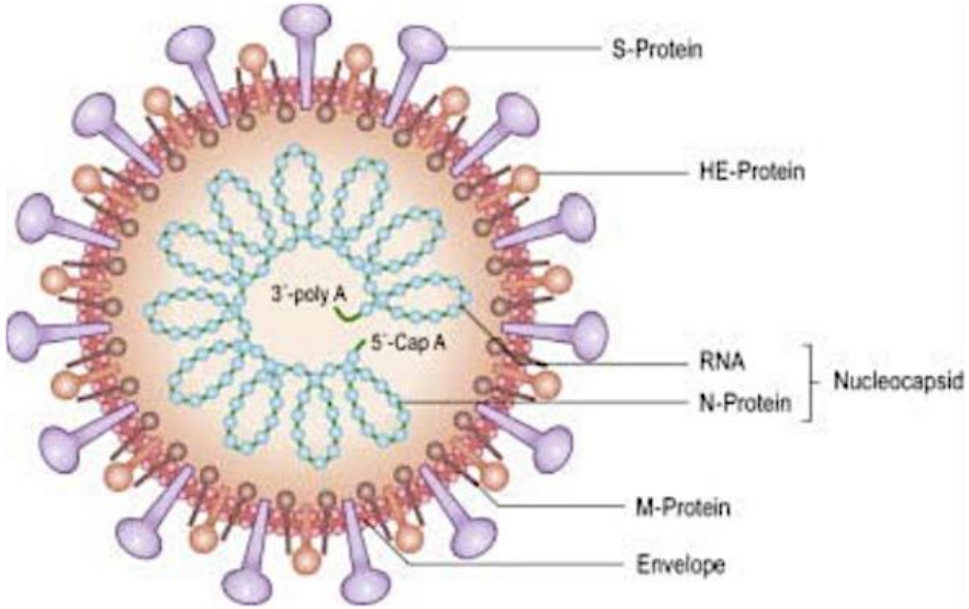


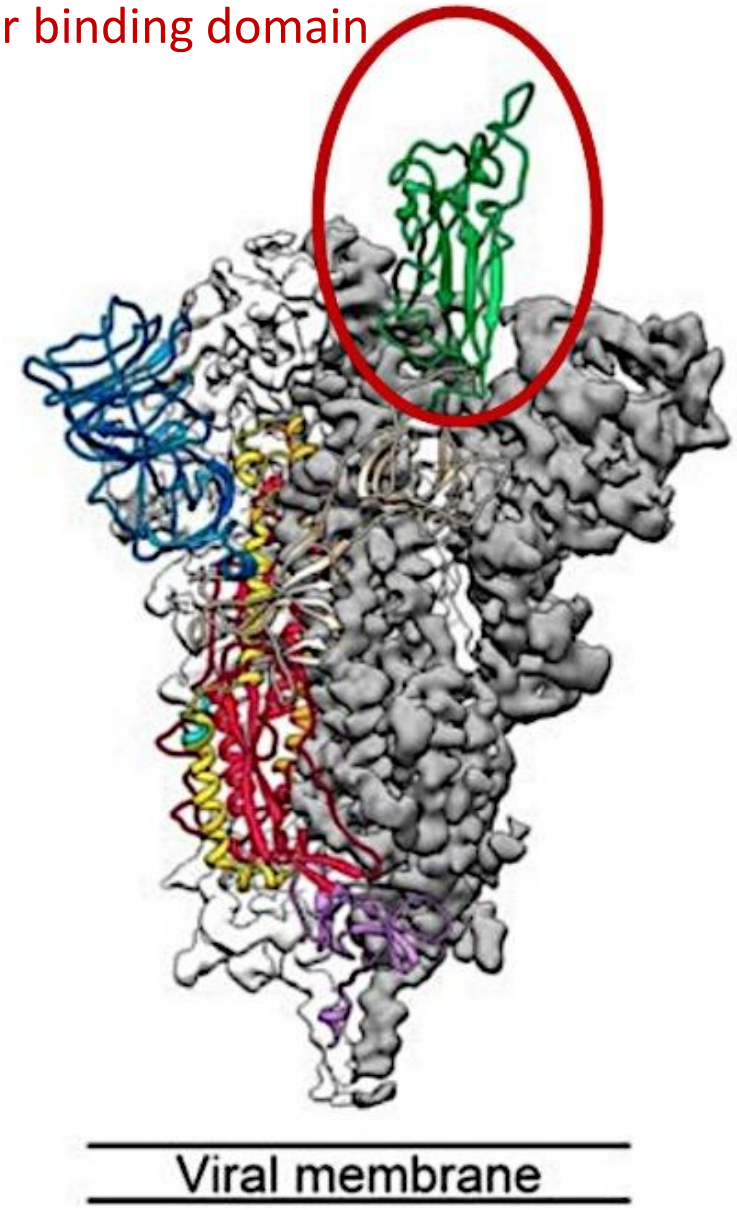
Figure 3: **Phylogenetic analysis of full-length genomes of 2019-nCoV and representative viruses of the genus Betacoronavirus**
2019-nCoV=2019 novel coronavirus. MERS-CoV=Middle East respiratory syndrome coronavirus. SARS-CoV=severe acute respiratory syndrome coronavirus.

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





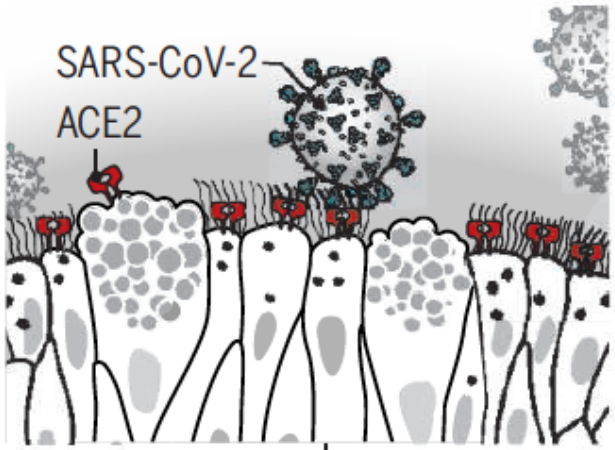
Key phases of disease progression

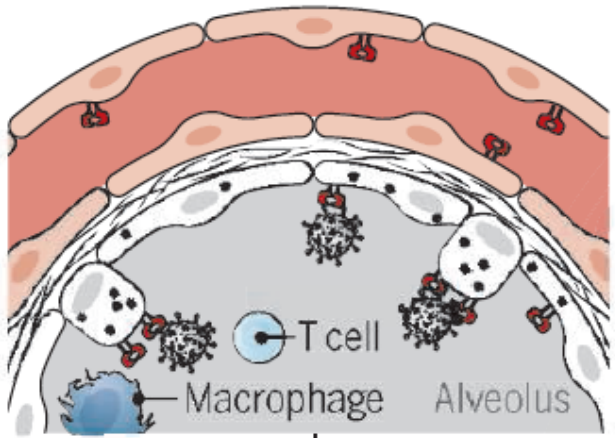
Severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) binds to angiotensin-converting enzyme 2 (ACE2). Initial infection of cells in the upper respiratory tract may be asymptomatic, but these patients can still transmit the virus. For those who develop symptoms, up to 90% will have pneumonitis, caused by infection of cells in the lower respiratory tract. Some of these patients will progress to severe disease, with disruption of the epithelial-endothelial barrier, and multi-organ involvement.

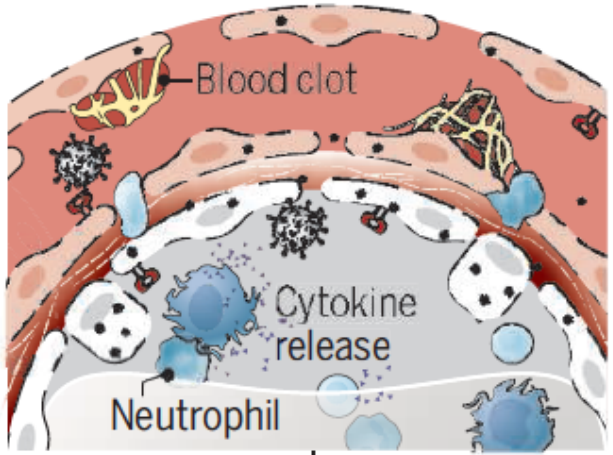
SARS-CoV-2 infects ACE2-expressing nasal epithelial cells in the **upper respiratory tract.**

Virus infects ACE2-expressing type II alveolar epithelial cells and patients exhibit **pneumonitis.**

Severe disease involves disruption of the epithelial-endothelial barrier, complement deposition, and hyperinflammation.







Day 1

Days 7 to 10

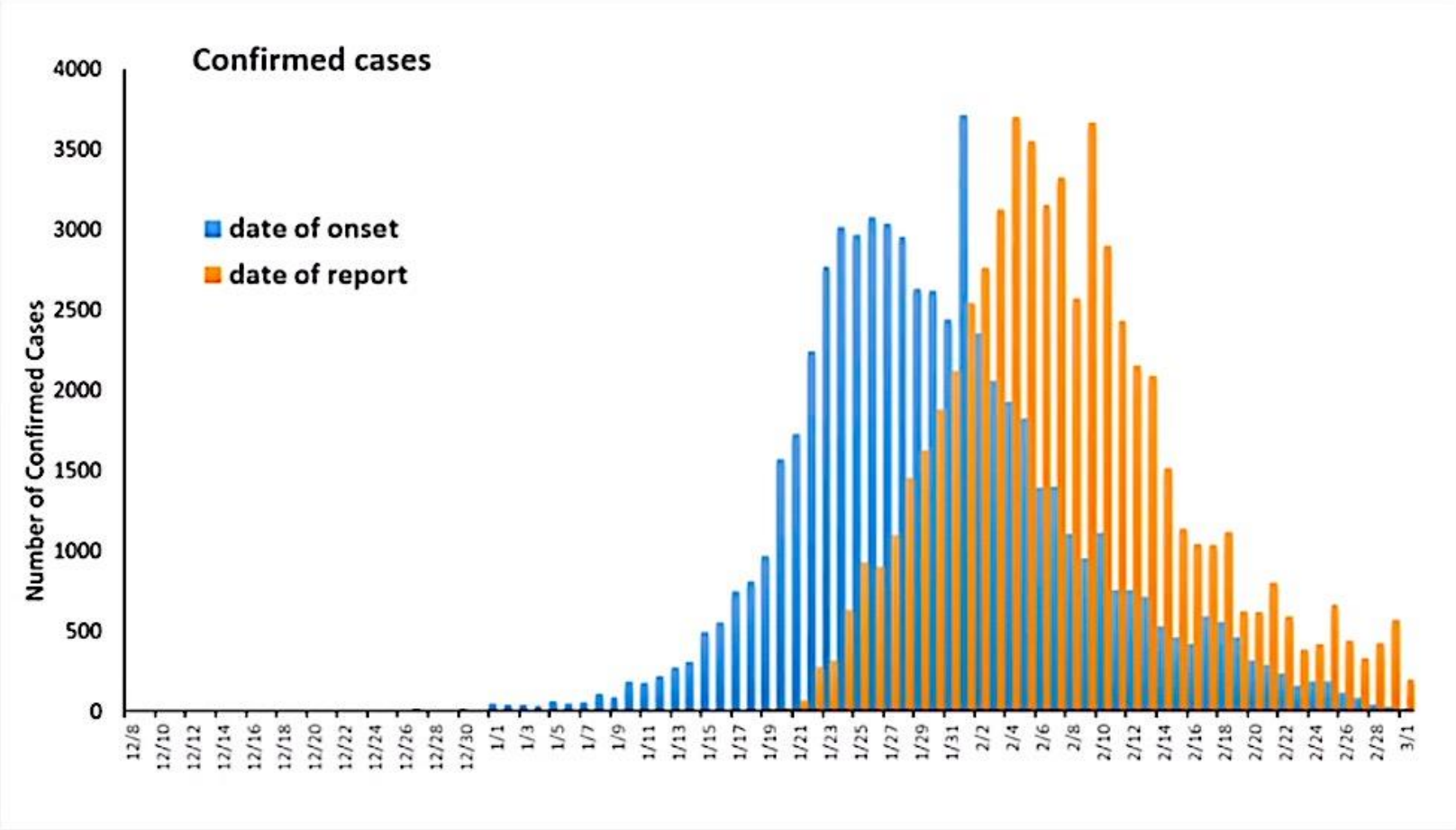
Presymptomatic/asymptomatic **Symptomatic** Early phase Late phase

Matheson NJ, Lehner PJ. How does SARS-CoV-2 cause CVOID-19? Science 2020; 369; 510-11.

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

- First case (COVID-19) apparent date of onset 1 December 2019, hospitalized 17 December
- 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

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



*Through 1 March 2020

China CDC/NHC 2020

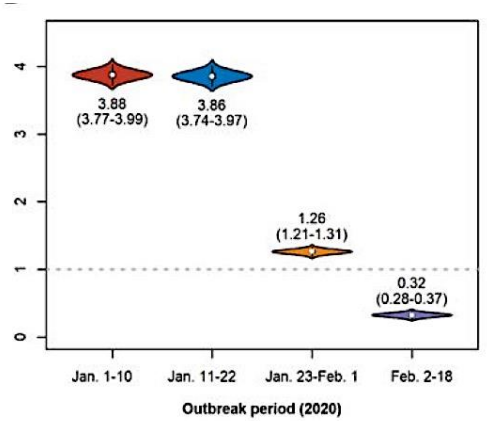
Transmission dynamics of COVID-19, China

- The majority of cases arose from close contacts of symptomatic cases
  - 1.5% of close contacts in China developed COVID-19
- Transmission was 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

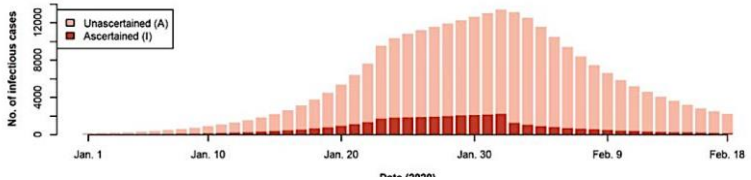
Modeling unreported cases, Wuhan

- Wang and colleagues modeled the epidemiology of 25,961 laboratory-confirmed cases in Wuhan through 18 February
- Examined four periods: 1-10 January, 11-22 January, 23 January-1 February (first week of lockdown) and 2-18 February
- "Unascertained" = undiagnosed because they were asymptomatic or mildly symptomatic

- Major findings: R_e decreased from 3.86 to 0.32 over the four periods



- 59% of cases were unascertained



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].

Prevalence of SARS-CoV-2 asymptomatic infection

Table. Summary of SARS-CoV-2 Testing Studies

Cohort	Tested, *n*	SARS-CoV-2 Positive, *n* (%)	Positive but Asymptomatic, *n* (%)	Notes*
Iceland residents (6)	13 080	100 (0.8)	43 (43.0)	R
Vo', Italy, residents (7)	5155	102 (2.0)	43 (42.2)	R, L
Diamond Princess cruise ship passengers and crew (8)	3711	712 (19.2)	331 (46.5)	–
Boston homeless shelter occupants (9)	408	147 (36.0)	129 (87.8)	–
New York City obstetric patients (11)	214	33 (15.4)	29 (87.9)	L
U.S.S. *Theodore Roosevelt* aircraft carrier crew (12)	4954	856 (17.3)	~500 (58.4)	E
Japanese citizens evacuated from Wuhan, China (2)	565	13 (2.3)	4 (30.8)	L
Greek citizens evacuated from the United Kingdom, Spain, and Turkey (14)†	783	40 (5.1)	35 (87.5)	L
Charles de Gaulle aircraft carrier crew (13)	1760	1046 (59.4)	~500 (47.8)	E
Los Angeles homeless shelter occupants (10)	178	43 (24.2)	27 (62.8)	–
King County, Washington, nursing facility residents (15)	76	48 (63.2)	3 (6.3)	L
Arkansas, North Carolina, Ohio, and Virginia inmates (16)	4693	3277 (69.8)	3146 (96.0)	–
New Jersey university and hospital employees (17)	829	41 (4.9)	27 (65.9)	–
Indiana residents (18)	4611	78 (1.7)	35 (44.8)	R
Argentine cruise ship passengers and crew (19)	217	128 (59.0)	104 (81.3)	–
San Francisco residents (29)	4160	74 (1.8)	39 (52.7)	–

E = estimated from incomplete source data; L = longitudinal data collected; R = representative sample.
* A dash indicates that the study did not have a representative sample, collected no longitudinal data, and did not require estimation of missing data.
† Clarified via e-mail communication with coauthor.

Oran DP, Topol EJ, Prevalence of asymptomatic SARS-CoV-2 infection. A narrative review. Ann Intern Med 2020 [Epub ahead of print].

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

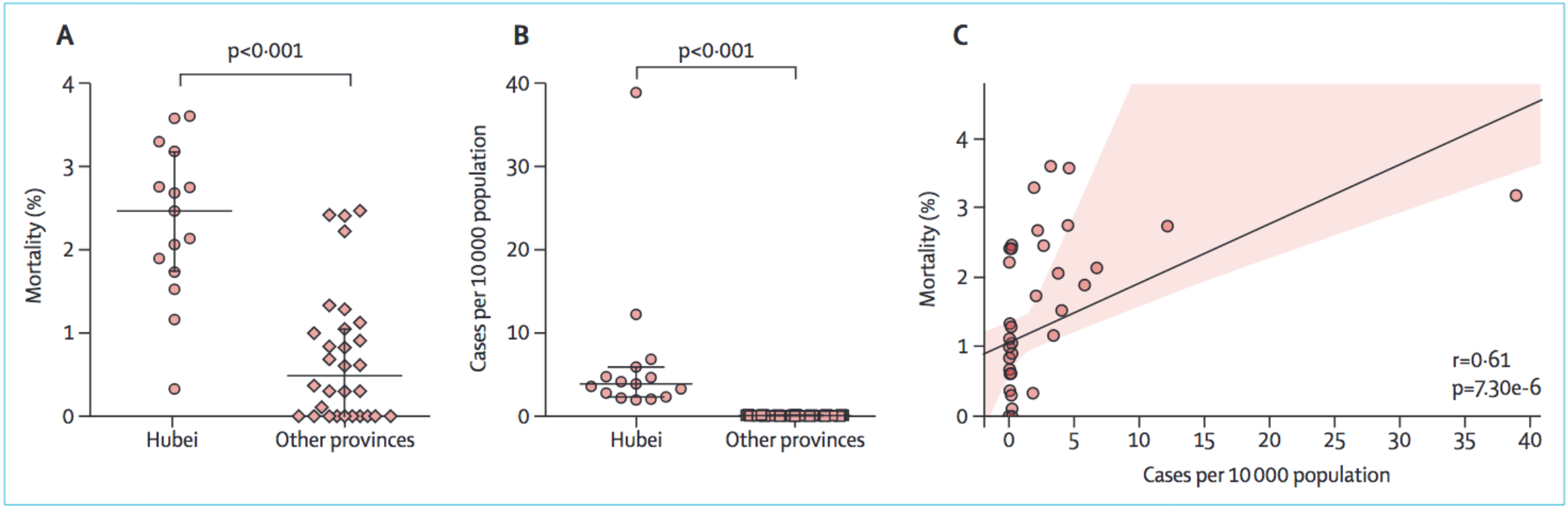


Figure: **Mortality and incidence of COVID-19 in Hubei and other provinces of China**
Mortality (A) and cumulative number of confirmed cases of COVID-19 since the start of the outbreak per 10 000 population (B) in Hubei and other provinces of China. Horizontal lines represent median and IQR. p values 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)

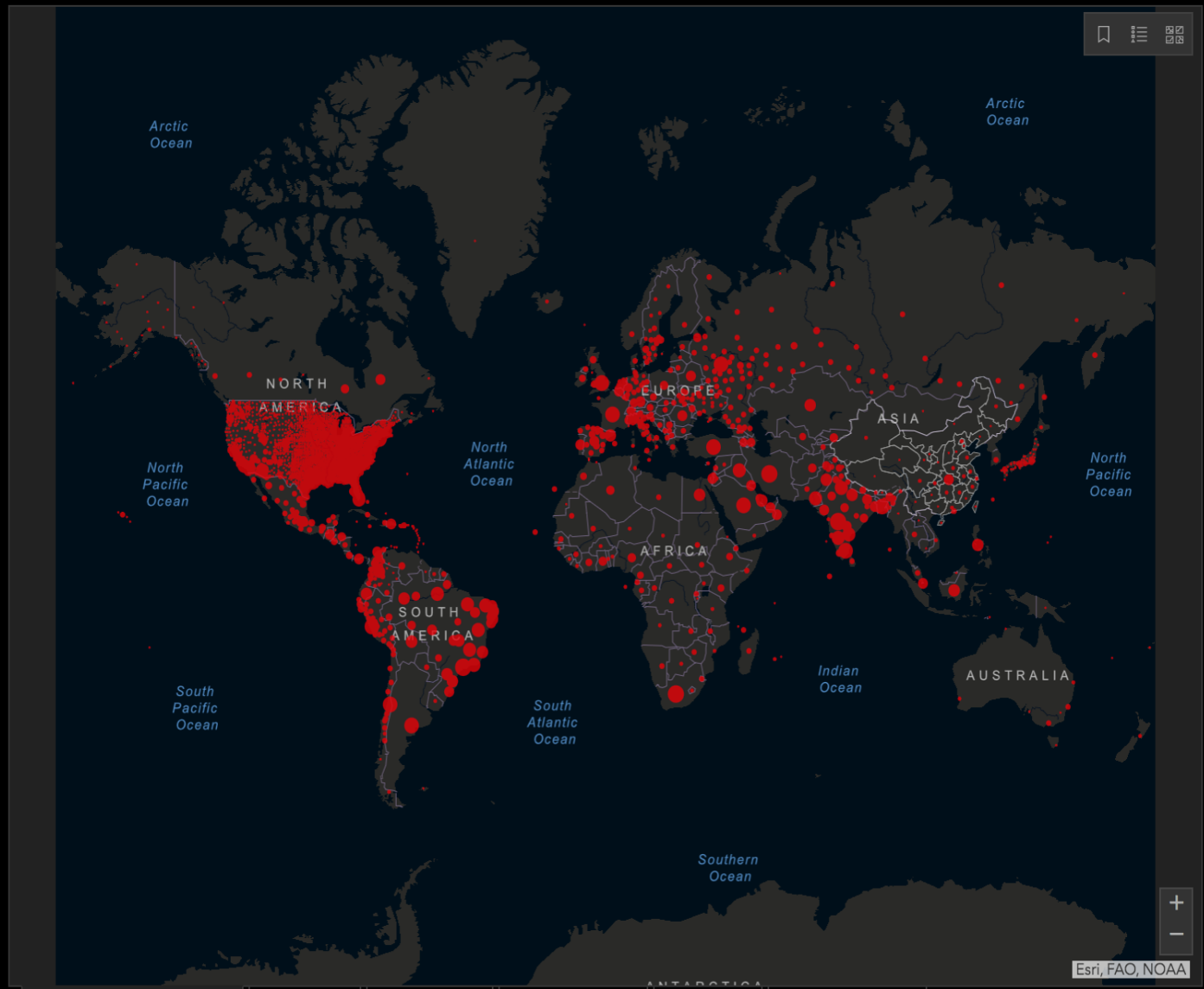
Total Confirmed
18,317,520

Confirmed Cases by Country/Region/Sovereignty

- 4,718,249 US
- 2,750,318 Brazil
- 1,855,745 India
- 859,762 Russia
- 516,862 South Africa
- 443,813 Mexico
- 433,100 Peru
- 361,493 Chile
- 327,352 Colombia
- 314,786 Iran
- 307,252 United Kingdom
- 297,054 Spain
- 280,461 Pakistan
- 280,093 Saudi Arabia
- 248,229 Italy
- 244,020 Bangladesh
- 233,851 Turkey
- 228,574 France
- 212,339 Germany
- 206,743 Argentina
- 131,886 Iraq

Admin0 | Admin1 | Admin2

Last Updated at (M/D/YYYY)
8/4/2020, 5:34:49 AM



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

188
countries/regions

Lancet Inf Dis Article: Here. Mobile Version: Here.
Lead by JHU CSSE. Technical Support: Esri Living Atlas team and JHU APL. Financial Support: JHU, NSF, Bloomberg Philanthropies and Stavros Niarchos Foundation. Resource support: Slack, Github and AWS. Click *here* to **donate** to the CSSE dashboard team, and other JHU COVID-19 Research Efforts. FAQ. Read more in this blog. Contact US.

Data sources: Full list available *here*.

Global Deaths
694,713

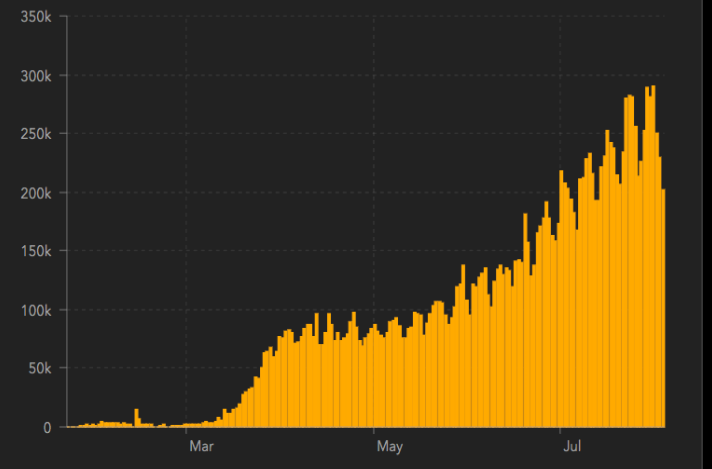
- 155,478 deaths US
- 94,665 deaths Brazil
- 48,012 deaths Mexico
- 46,295 deaths United Kingdom
- 38,938 deaths India
- 35,166 deaths Italy
- 30,297 deaths France
- 28,472 deaths Spain
- 19,811 deaths Peru
- 17,617 deaths

Global Deaths | Global Recovered

US State Level
Deaths, Recovered

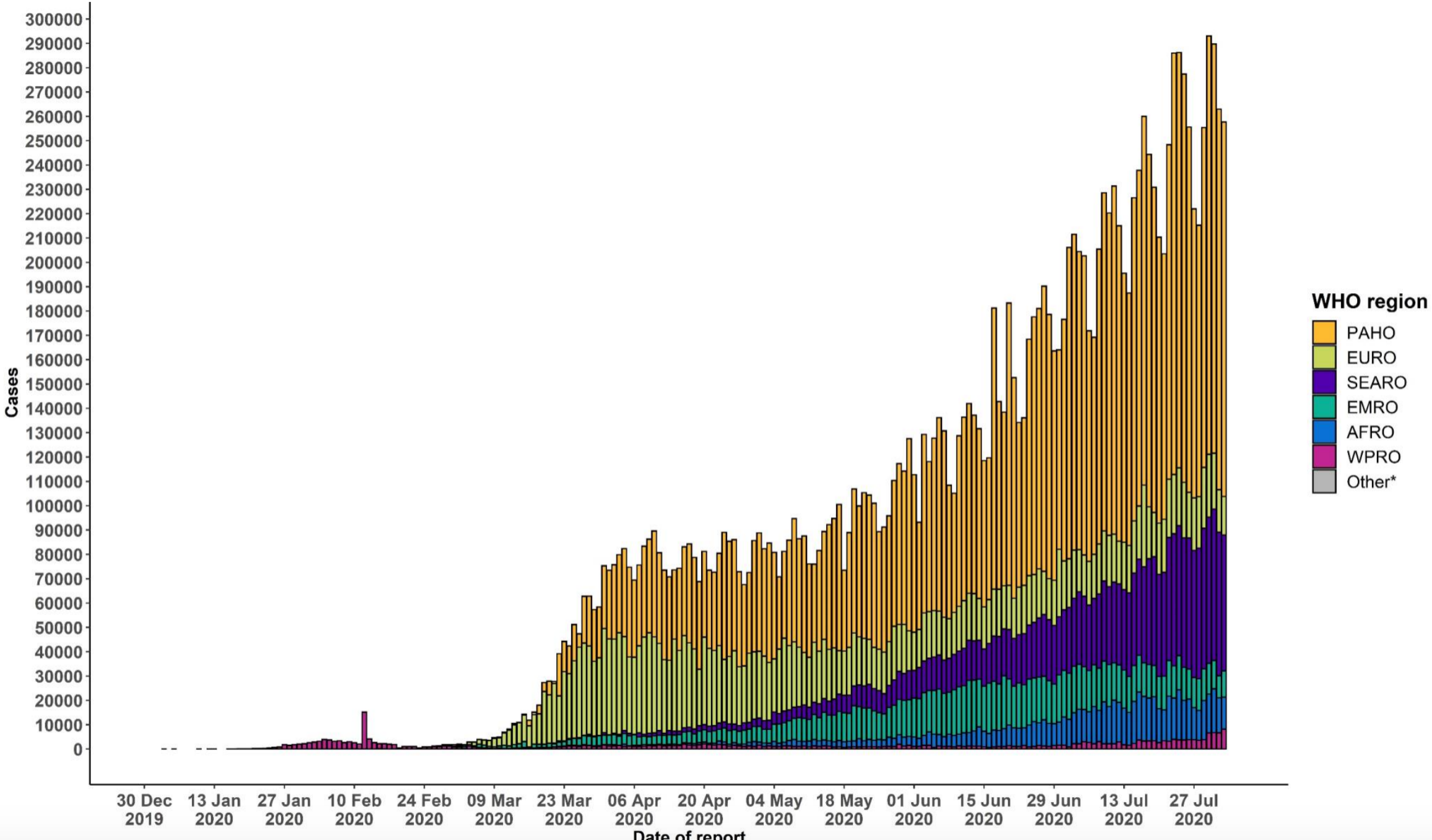
- 32,719 deaths, 73,279 recovered New York US
- 15,846 deaths, 32,660 recovered New Jersey US
- 9,507 deaths, recovered California US
- 8,648 deaths, 97,595 recovered Massachusetts US
- 7,723 deaths, recovered Illinois US
- 7,224 deaths, 86,757 recovered Pennsylvania US
- 7,157 deaths, recovered Florida US
- 7,016 deaths, 297,422 recovered Texas US
- 6,467 deaths, 60,022 recovered Michigan US
- 4,437 deaths, 8,613 recovered

US Deaths, Recovered



Confirmed | Logarithmic | Daily Cases

Figure 2. Number of confirmed COVID-19 cases, by date of report and WHO region, 30 December through 3 August**

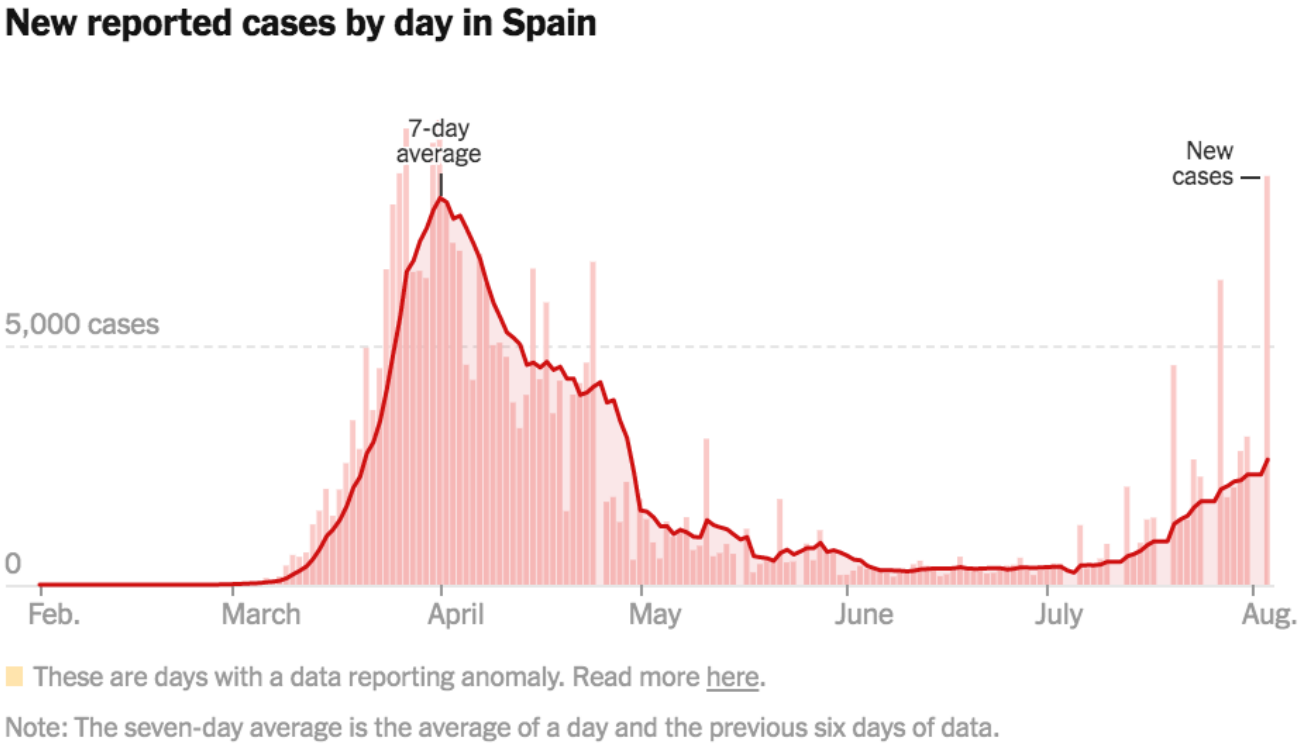


COVID-19 cases and deaths, Iran, United States and California, 2020

	Iran	United States*	California
Cases	314 786	4 197 364	520 885
Case per capita (per 10^5)	348.8	1 453.9	1 318.4
Deaths	17 617	146 008	9 507
Deaths per capita (per 10^5)	21.5	50.6	24.1
Cases last 7 days	18 265	365 186	56 132
Cases per capita last 7 days (per 10^5)	22.3	126.5	142.1

*United States without California.
US totals = 4 718 249 cases, 155 515 deaths and 421 358 cases in last 7 days

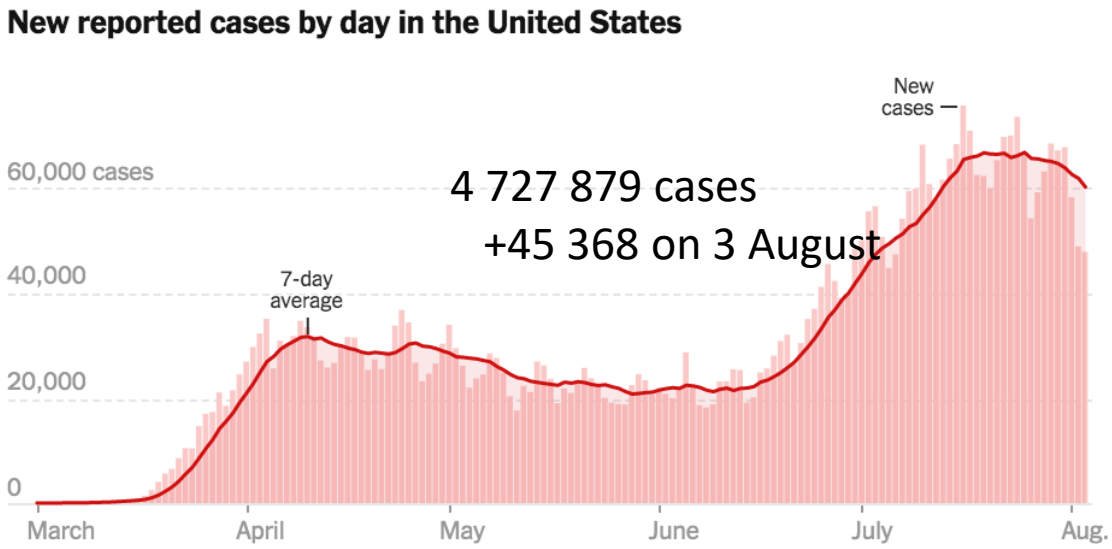
Is Spain a harbinger of a second wave of infection in Europe?

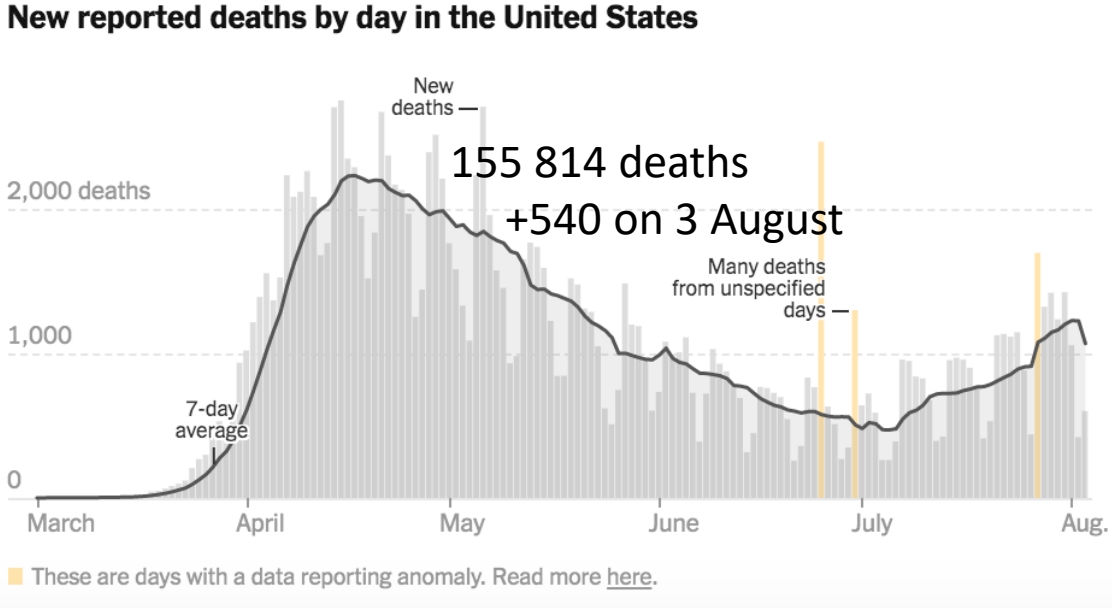


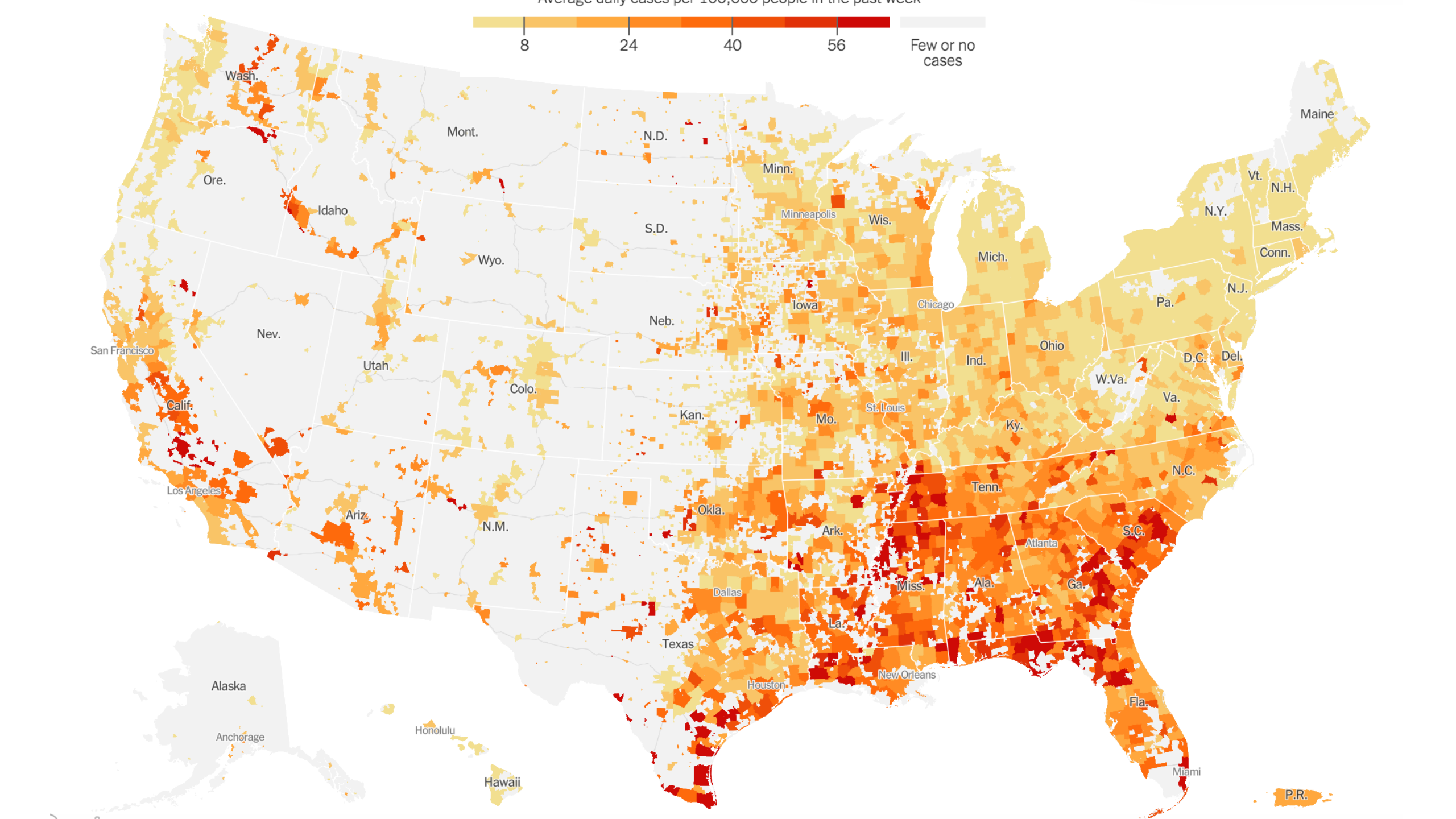
- UK announced that all travelers from continental Spain, including UK nationals, have to quarantine for 14 days

COIVD-19 cases and deaths, United States, 2020

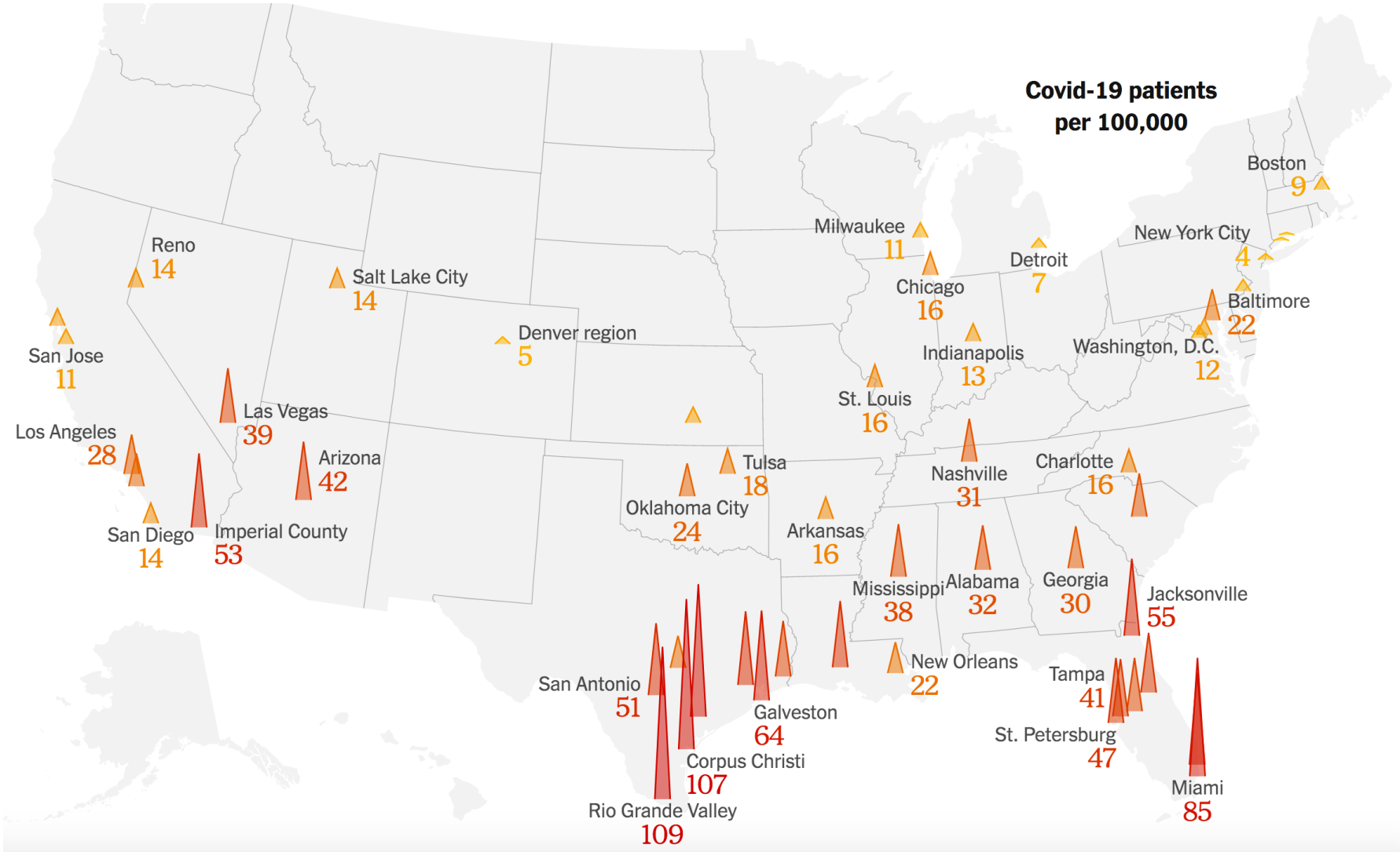
- Cases appear to be plateauing, recent surge greatest among states that were first to reopen
  - In 16 states, cases have increased in the last 14 days
  - Cases declining in 9 states and USVI
  - Surges have moved from the Southeast to the Upper Midwest
- U.S. is now averaging more than 60 000 cases and 1 000 deaths per day






Average daily cases per 100,000 people in the past week
8
24
40
56
Few or no cases
Wash.
Ore.
Idaho
Mont.
N.D.
Minn.
S.D.
Wyo.
Nev.
Utah
Colo.
Calif.
Ariz.
N.M.
Neb.
Kan.
Okla.
Texas
Iowa
Mo.
Ark.
La.
Wis.
Ill.
Mich.
Ind.
Ohio
Ky.
Tenn.
Miss.
Ala.
Ga.
S.C.
N.C.
Va.
W.Va.
Pa.
N.Y.
Vt.
N.H.
Maine
Mass.
Conn.
N.J.
D.C.
Del.
Fla.
San Francisco
Los Angeles
Minneapolis
Chicago
St. Louis
Dallas
Houston
New Orleans
Atlanta
Miami
Alaska
Anchorage
Honolulu
Hawaii
P.R.

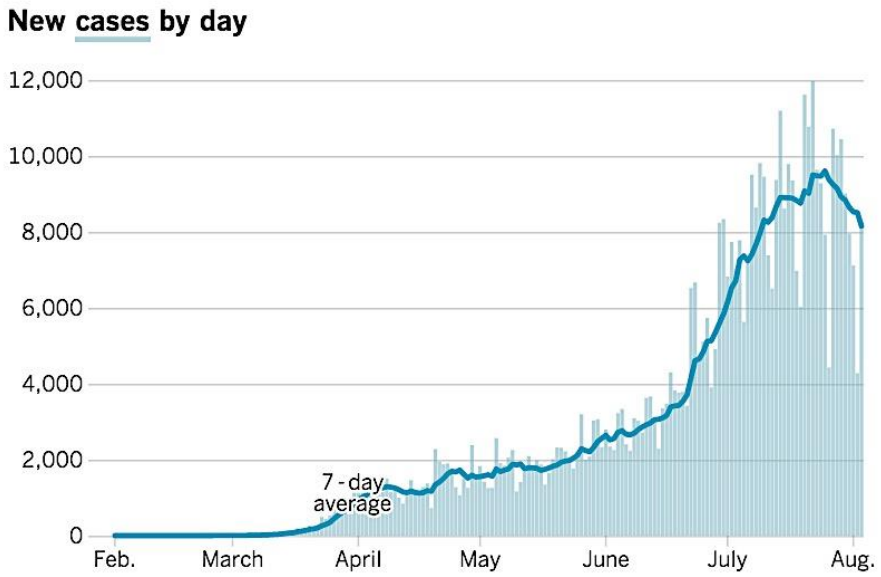
COVID-19 patients hospitalized per 100,000, United States, July 23, 2020

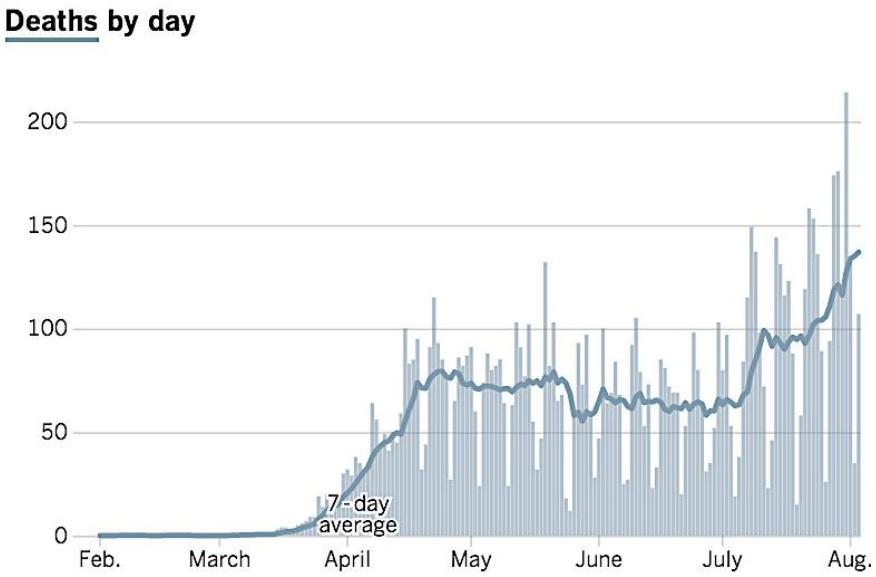


COVID-19 cases and deaths, California, 2020

STATE TOPS N.Y. IN TOTAL VIRUS CASES

California's rise is partly because of its population, but also because many reject masks and distancing.



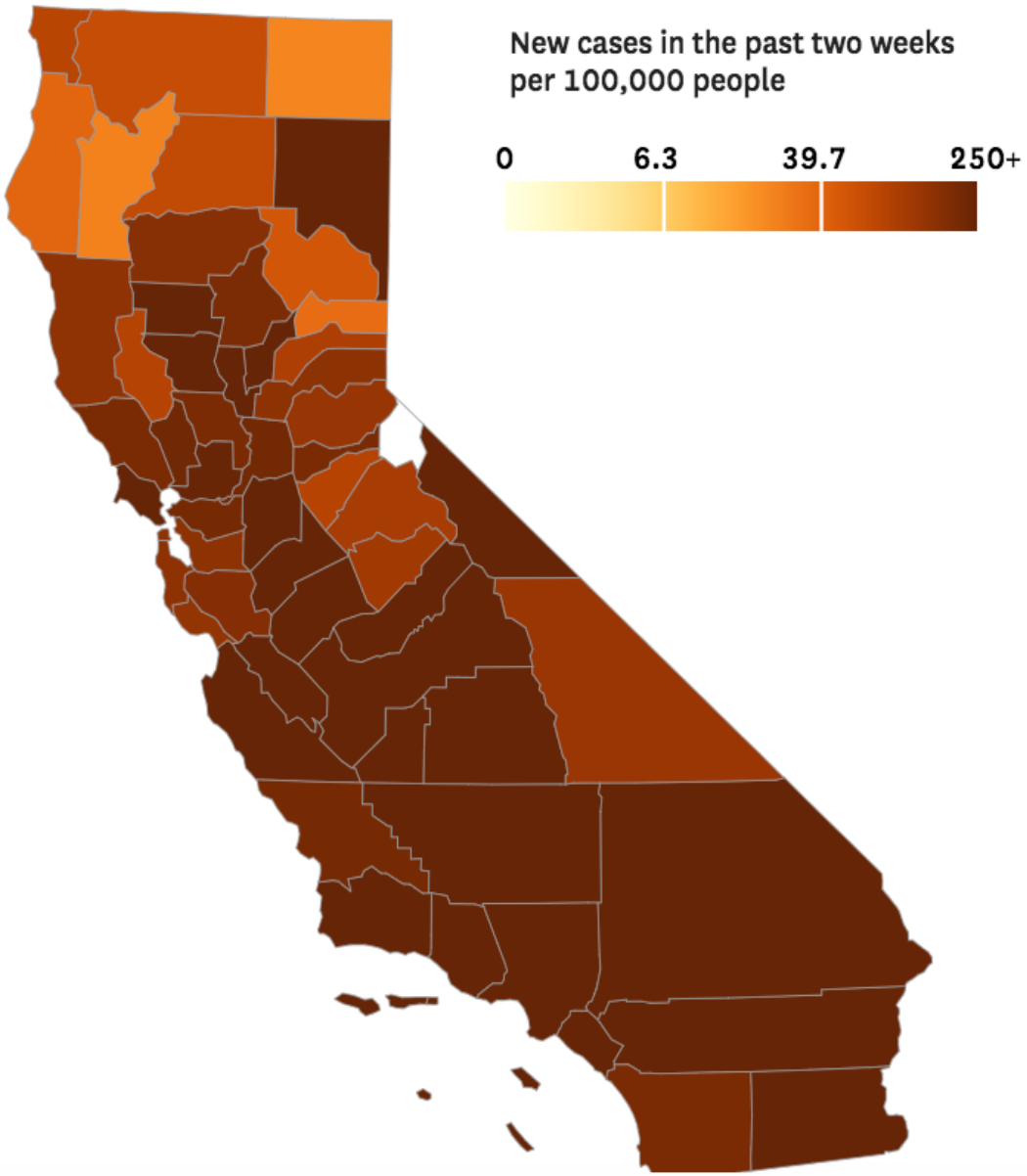


But California is:

- 3rd in total cases in last week (after Texas and Florida)
- 15th in cases per capita in the last week
- 22nd in total cases per capita
- 28th in total deaths per capita

Recent SARS-CoV-2 transmission in California

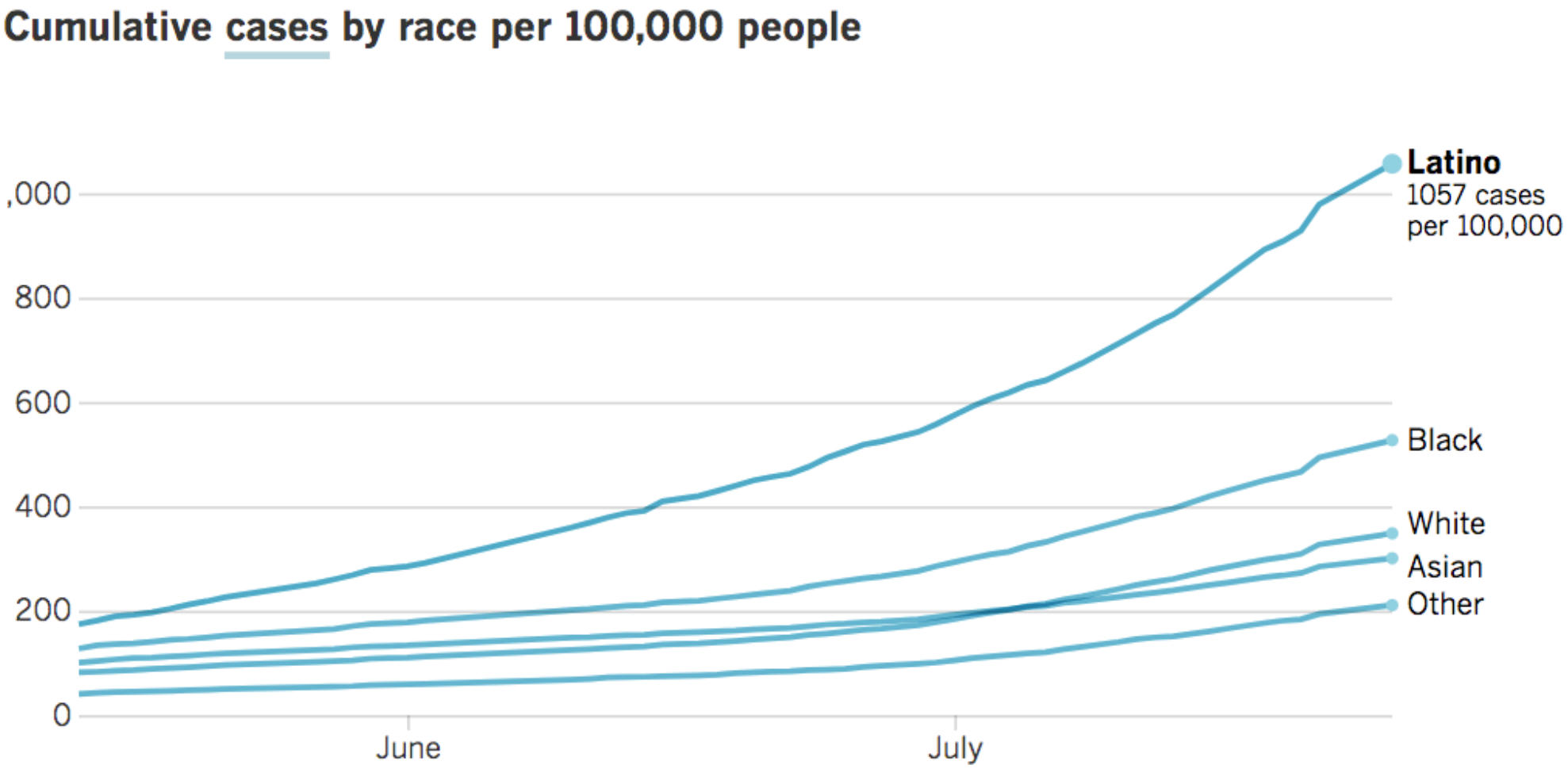
- Latino low-income, densely housed, essential workers and their families
  - Urban and rural
  - Primary Central American but also from Mexico
- Social gatherings, unwillingness to wear masks
- Institutional settings
  - Prisons, nursing homes, factories



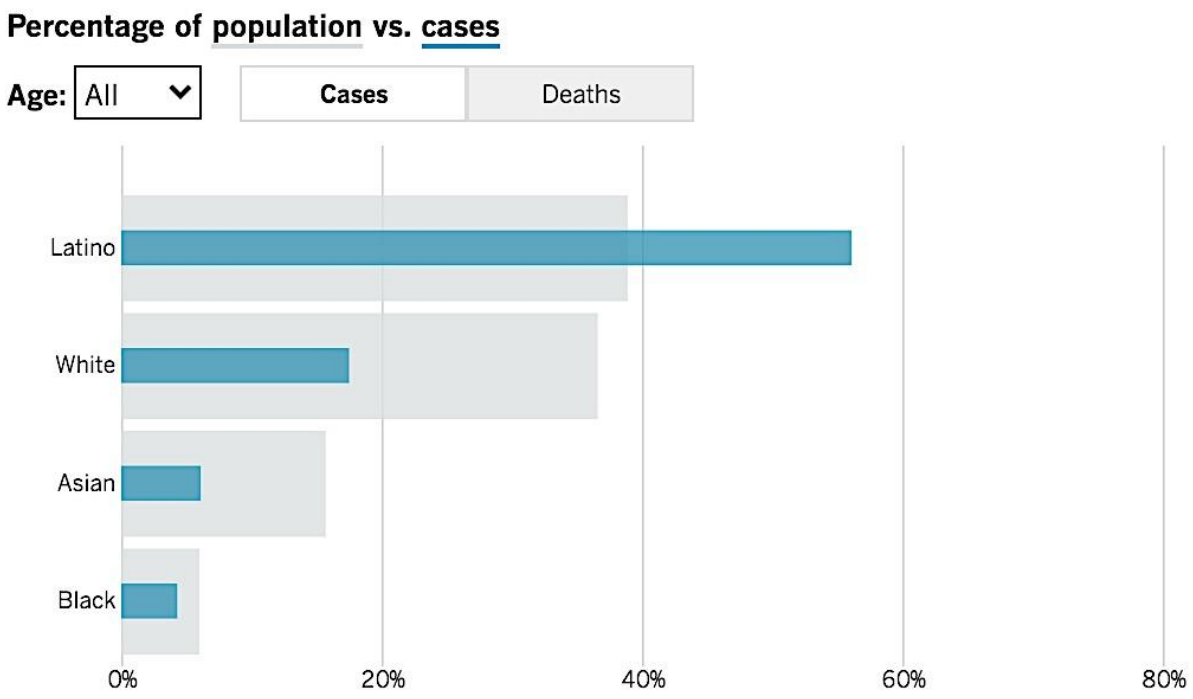
Huntington Beach, Calif.

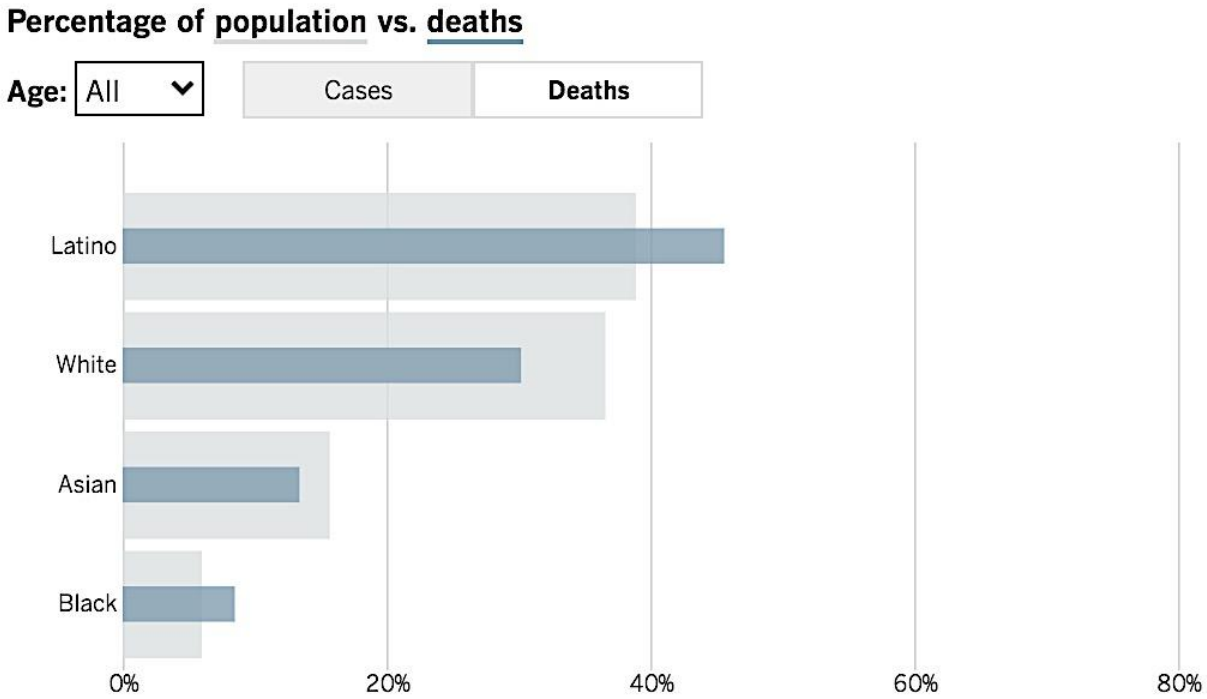
Source: New York Times, July 20, 2020

COVID-19 cases by race and date of onset, California, 2020



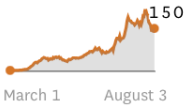
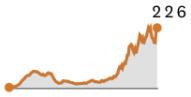
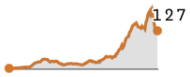
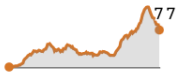
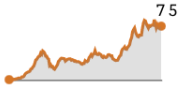
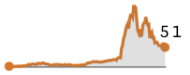
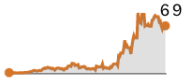
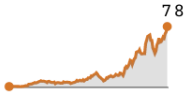
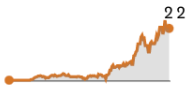
COVID-19 cases and deaths by race/ethnicity, California, 2020

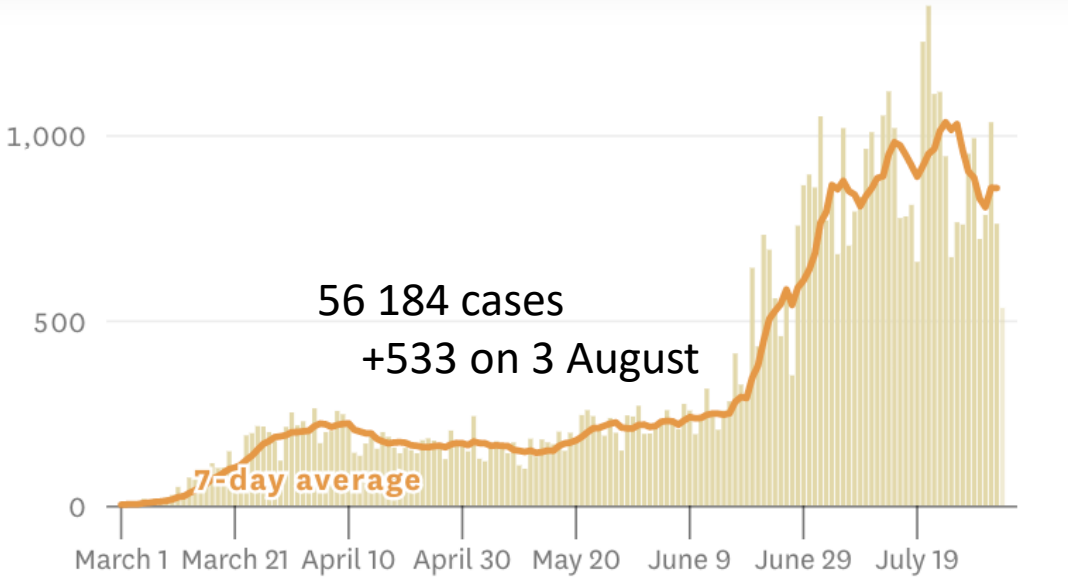


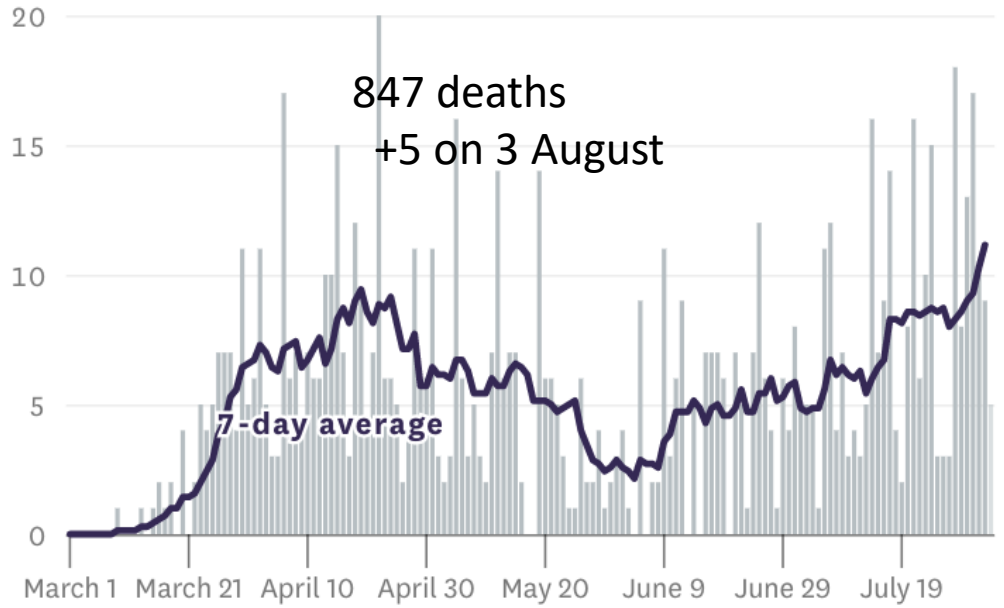



Sonoma
Napa
Solano
Marin
Contra
Costa
San Francisco
Alameda
San
Mateo
Santa
Clara

COVID-19 cases, Bay Area, 2020

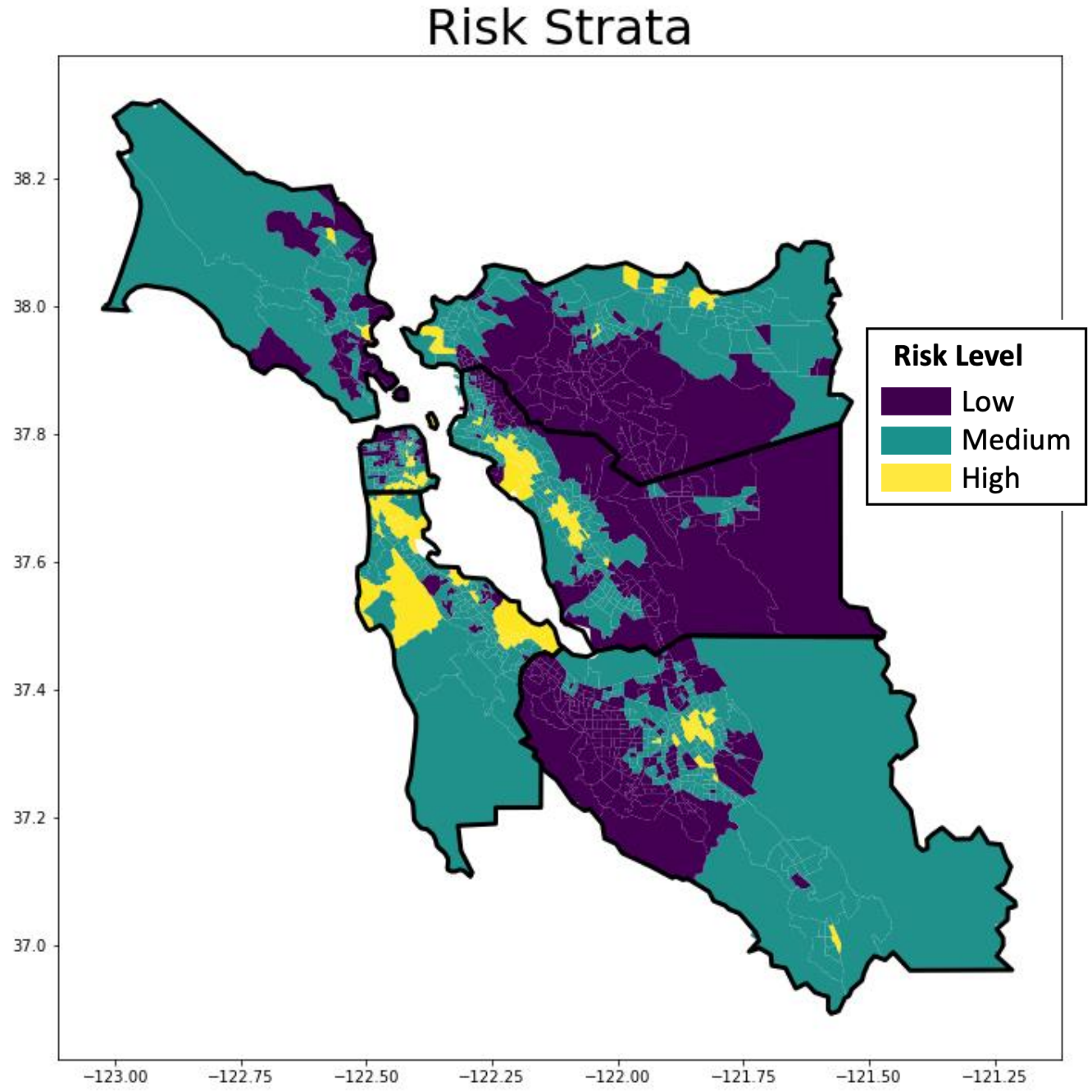
County	Total deaths	Total cases	New cases curve	Weekly change in new cases	R_e
Alameda	189	11,846		▼ 330 -24%	1.06
Santa Clara	191	10,794		▲ 0 +0%	1.08
Contra Costa	127	8,033		▼ 502 -36%	1.12
San Francisco*	61	6,916		▼ 182 -25%	1.11
San Mateo	119	5,683		▼ 64 -11%	1.03
Marin	75	5,115		▼ 60 -14%	0.77
Solano	37	3,721		▼ 93 -16%	1.03
Sonoma	39	3,113		▲ 142 +35%	1.22
Napa	9	963		▼ 3 -2%	1.12





Map of modeled risk strata for 6 Bay Area counties

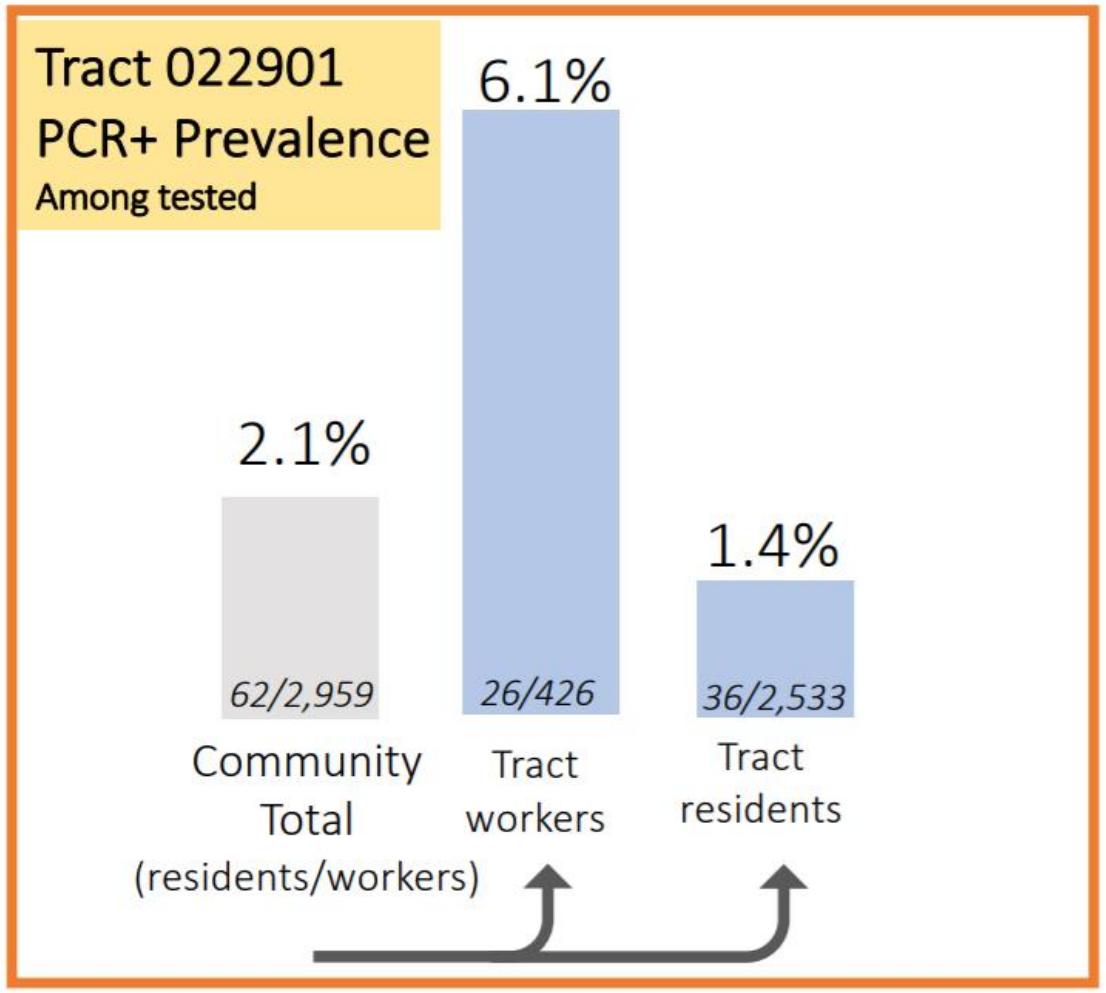
Stanford MEDICINE



Unidos en Salud, San Francisco, April 2020

- 3,113 residents of a single census tract in the Mission District, San Francisco
- 1.4% of residents infected
- 6.1% of workers who came to the census tract to work infected
- 53 percent asymptomatic
- 75% of infected participants were male
- 95% Latino
- Frontline service worker 6.56 times as likely to be infected
- 10.3 times less likely to be able to shelter in place and maintain income

Testing Results: PCR+ for COVID-19



>95% positive cases were Latino (only 44 % of sample)

>90% cannot work from home

>50% asymptomatic

CDCR PATIENTS: COVID-19 BY INSTITUTION

INSTITUTION:

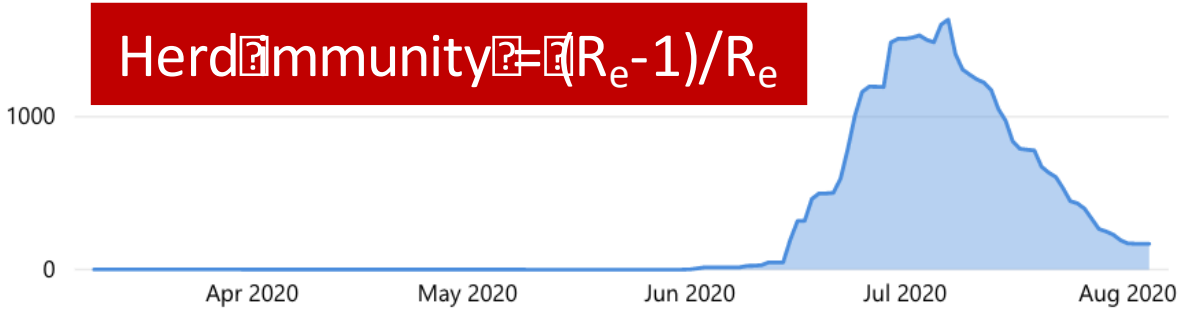
CA State Prison, San Quentin

CONFIRMED CASES: Cumulative Count

NEW IN LAST 14 DAYS	ACTIVE		RESOLVED	DEATHS
	CUSTODY	RELEASED		
93	168	55	1,965	21

ACTIVE CASES IN CUSTODY

Herd Immunity = $(R_e-1)/R_e$

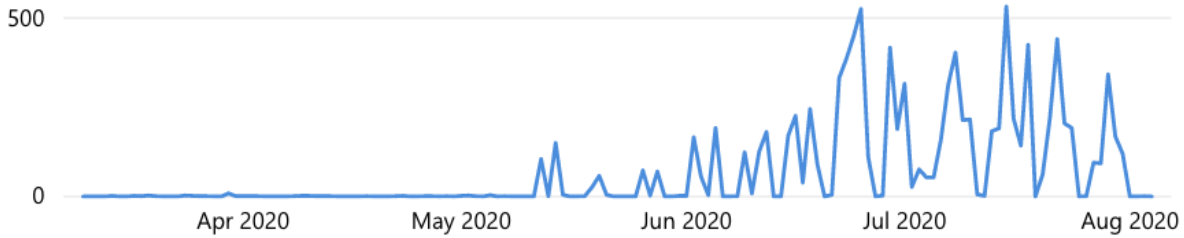


*Patients who resolved, died, or released before they resolved are not included in graph above. Active case count by date may be delayed 2-3 days while awaiting test results.

TESTING: Institution Count

CURRENT POPULATION	PATIENTS TESTED IN LAST 14 DAYS	% OF POPULATION TESTED IN LAST 14 DAYS
3,288	1,028	31%

PATIENTS TESTED BY DAY



*Released or transfered patients are in the 'Tested By Day' graph but not included in the 'Last 14 Days' count if no longer at the selected institution. Counts may be delayed 2-3 days while awaiting results.

CONFIRMED CASES : Rate Comparison

Cumulative Per 1,000 People

Institution: SQ	CDCR	California	United States
671.8	79.9	13.0	14.2

TESTING: Rate Comparison

Cumulative Per 1,000 People

Institution: SQ	CDCR	California	United States
919.7	582.4	203.4	172.0

Data Last Updated: Aug 4 2020 9:46AM

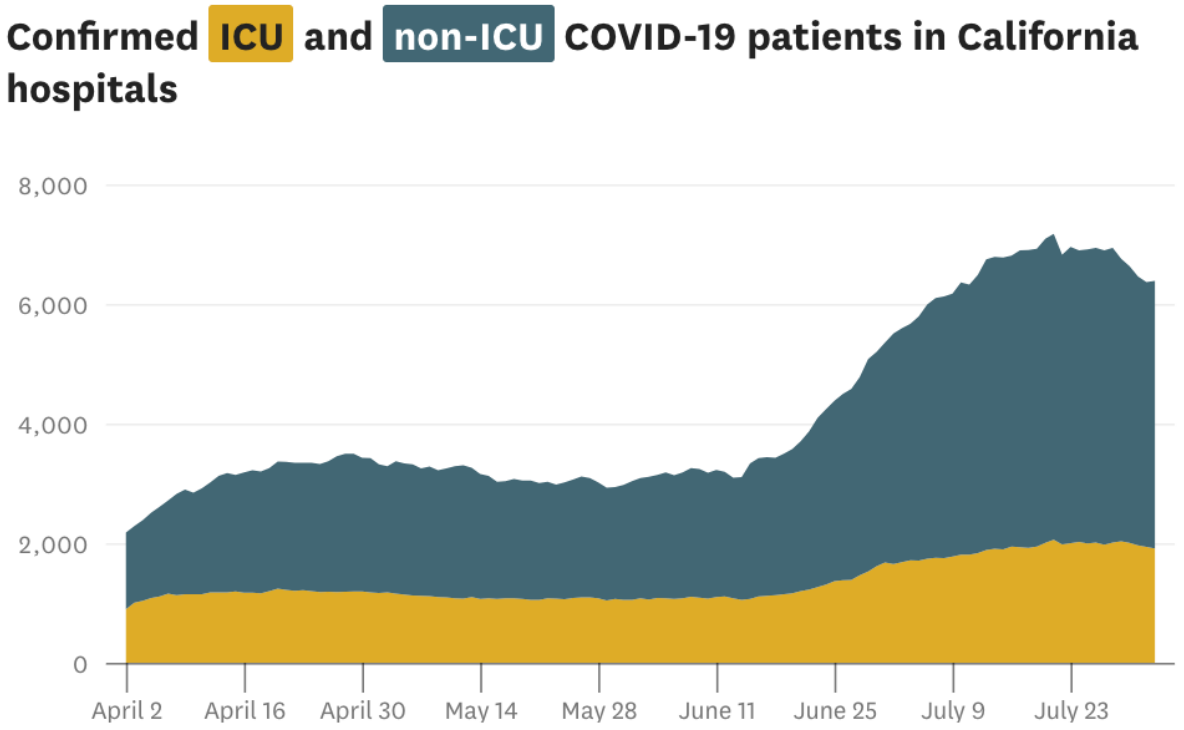
Two strategic goals

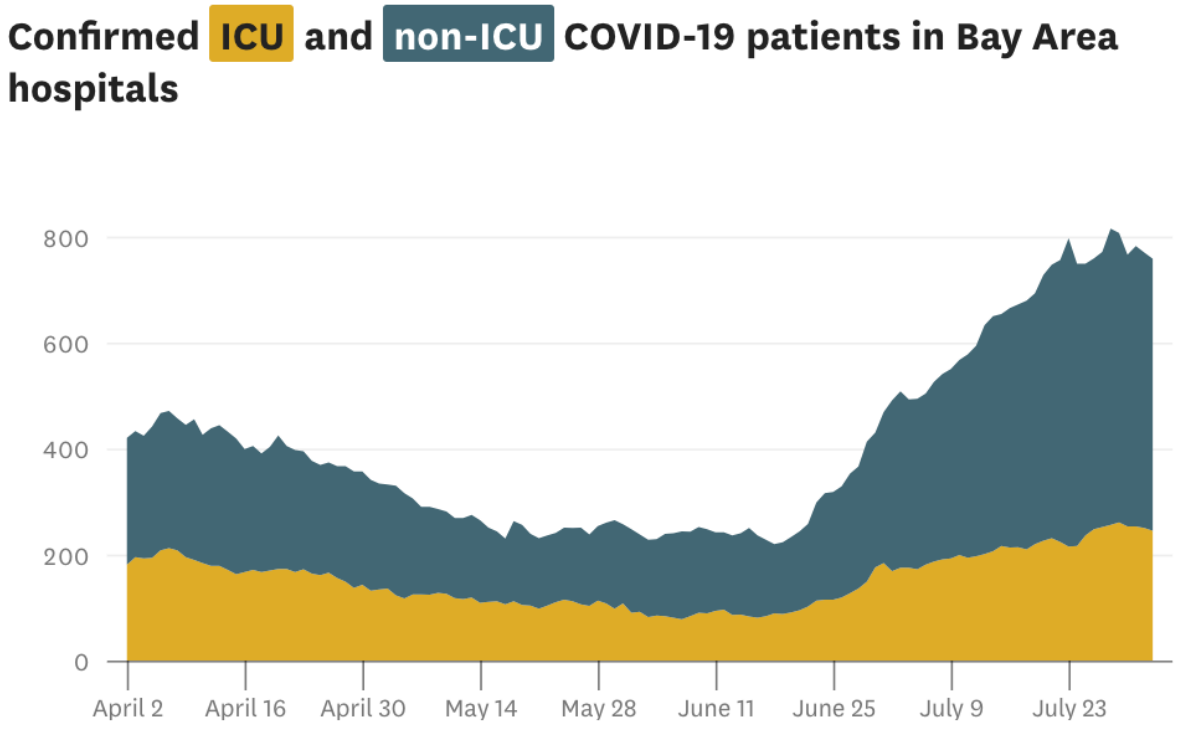
- Limit new cases by decreasing R_e, the effective reproductive number
- Flatten and prolong the outbreak to (1) assure adequacy of health care resources and (2) buy time for antivirals and eventually vaccine

What interventions do we have available?

- Individual-level interventions
  - Wearing masks
  - Social distancing
  - Staying home if ill
  - Hand hygiene
- Public health interventions
  - *Cordon sanitaire* and shelter-in-place
  - Case investigation and contact tracing, isolation and quarantine
  - Case finding (focused testing)
  - Increased ventilations (indoor spaces)

COVID-19 hospital inpatient days by date, California and San Francisco Bay Area, 2020





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


https://public.flourish.studio/visualisation/2562261/