

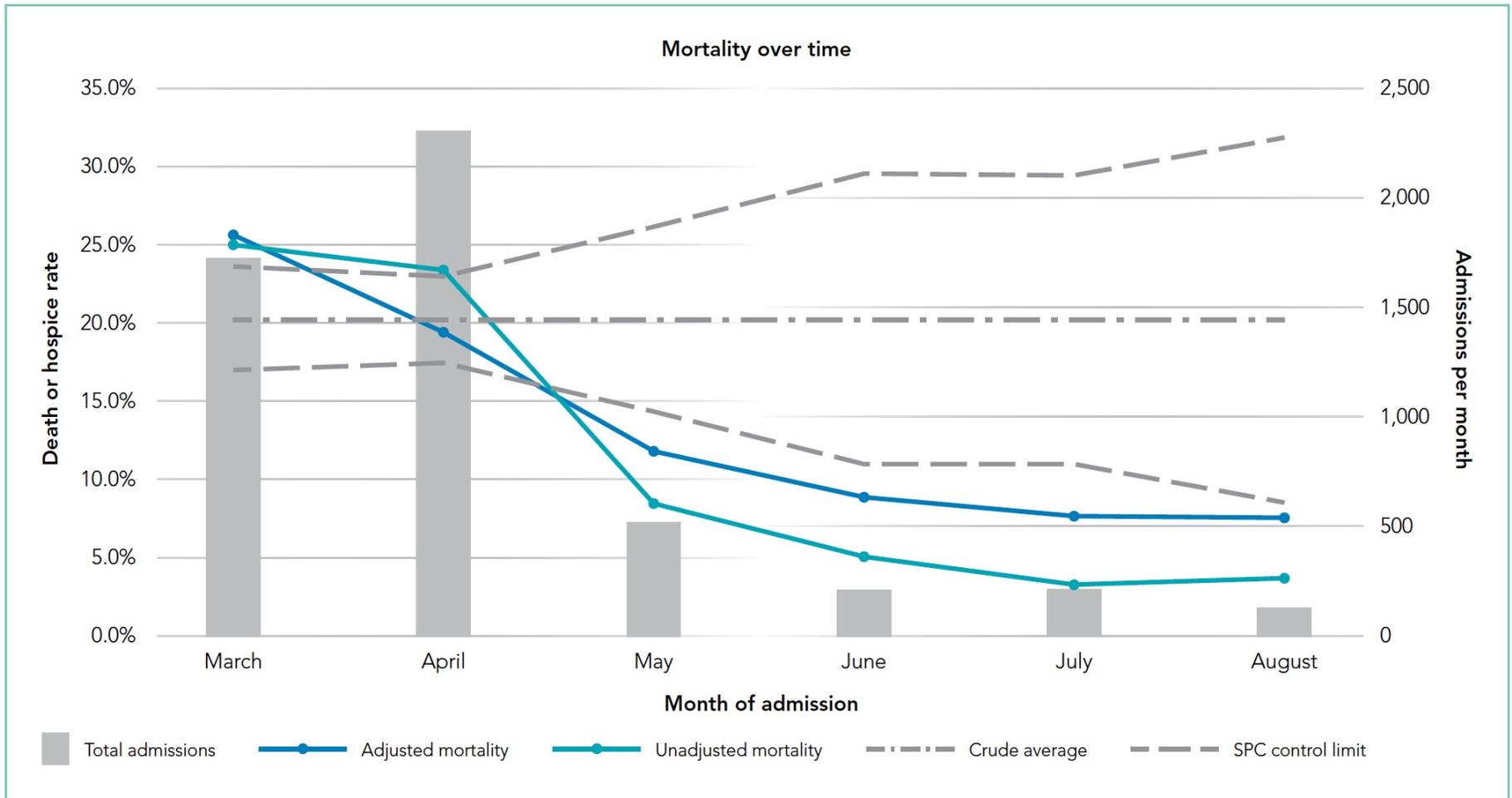
# Priorities for post-COVID-19 public health

Sandro Galea

Boston University School of Public Health

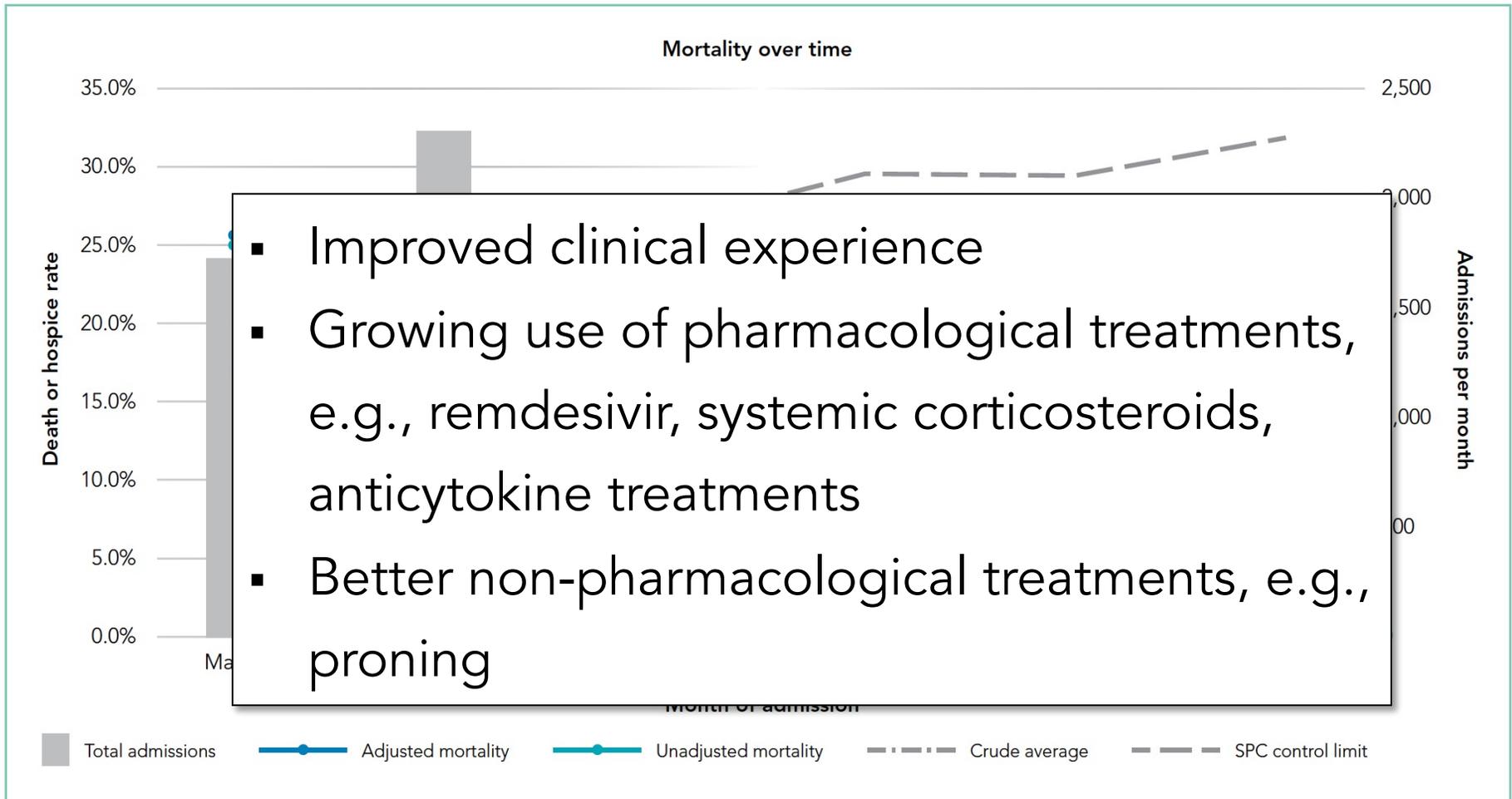


1. A lot went right during COVID-19



**FIG.** Adjusted and Unadjusted Mortality or Hospice Rate, by Month of Admission.





**FIG.** Adjusted and Unadjusted Mortality or Hospice Rate, by Month of Admission.

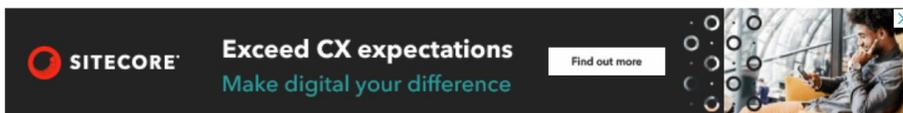
COVID-19 VIRUS

• **LATEST UPDATES**

THE VACCINE RACE

CASE COUNT

THE COVID STORM SERIES



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## Pfizer's Covid-19 Vaccine Proves 90% Effective in Latest Trials

Drugmaker and partner BioNTech could seek FDA authorization by end of November



### The New York Times

**The Road to a Coronavirus Vaccine**

Vaccine Tracker

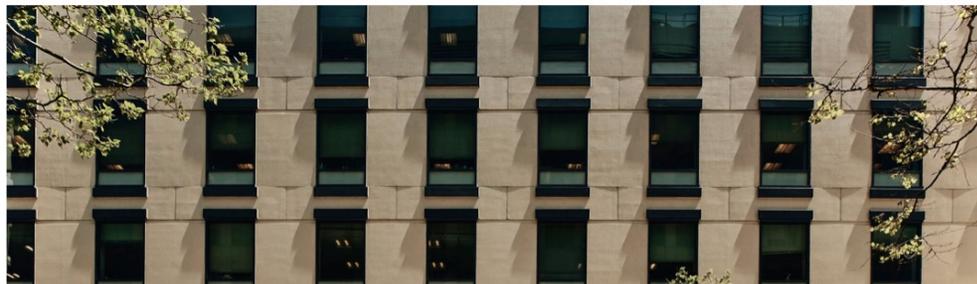
FAQ: Pfizer's Vaccine

After the First Vaccine

Understanding Long-Term Safety

## *Early Data Show Moderna's Coronavirus Vaccine Is 94.5% Effective*

Moderna is the second company to report preliminary results from a large trial testing a vaccine. But there are still months to go before it will be widely available to the public.



## The 5 stages of vaccine development

A vaccine usually takes more than 10 years to develop and costs up to \$500 million

### 1. Discovery research

2-5 years



### 2. Pre-clinical

2 years



### 3. Clinical development

Phase I Is it safe?

1-2 years



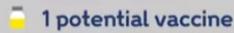
Phase II Does it activate an immune response?

2-3 years



Phase III Does it protect against the disease?

2-4 years



Manufacturing starts

### 4. Regulatory review and approval

1-2 years



### 5. Manufacturing and delivery



Manufacturing vaccines requires specialist facilities that are highly regulated and expensive to develop. It usually starts following Phase II clinical trials to develop the thousands of doses needed for Phase III trials.

**= 10 years and costs \$500 million**

Sources: <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5518734/>  
<https://www.weforum.org/agenda/2020/04/why-a-coronavirus-vaccine-takes-over-a-year-to-produce-and-why-that-is-incredibly-fast/>  
<https://www.nejm.org/doi/full/10.1056/NEJMp2005630>



# Developing mRNA-vaccine technologies

Thomas Schlake,\* Andreas Thess, Mariola Fotin-Mleczek and Karl-Josef Kallen

CureVac GmbH; Tübingen, Germany

**Keywords:** mRNA, adjuvant, vaccine, mRNA production, mRNA design, mRNA uptake, formulation, protein expression

**Abbreviations:** ARCA, anti-reverse cap analog; cDNA, complementary DNA; CTL, cytotoxic T cell; dsRNA, double-stranded RNA; EMCV, encephalomyocarditis virus; GMP, good manufacturing practice; HPLC, high performance liquid chromatography; IRES, internal ribosome entry site; mRNA, messenger RNA; MHC, major histocompatibility complex; miRNA, microRNA; ORF, open reading frame; pAPC, professional antigen presenting cell; pDNA, plasmid DNA; PEG, polyethylenglycol; siRNA, small interfering RNA; tRNA, transfer RNA; TLR, toll-like receptor; UTR, untranslated region

mRNA vaccines combine desirable immunological properties with an outstanding safety profile and the unmet flexibility of genetic vaccines. Based on in situ protein expression, mRNA vaccines are capable of inducing a balanced immune response comprising both cellular and humoral immunity while not subject to MHC haplotype restriction. In addition, mRNA is an intrinsically safe vector as it is a minimal and only transient carrier of information that does not interact with the genome. Because any protein can be expressed from mRNA without the need to adjust the production process, mRNA vaccines also offer maximum flexibility with respect to development. Taken together, mRNA presents a promising vector that may well become the basis of a game-changing vaccine technology platform. Here, we outline the current knowledge regarding different aspects that should be considered when developing an mRNA-based vaccine technology.

excluded. Finally, this lack of genomic integration in combination with mRNA being non-replicative as well as metabolically decaying within a few days<sup>8</sup> makes mRNA a merely transient carrier of information.

mRNA as the technological basis of therapeutics and vaccines is characterized by a great flexibility with respect to production and application. Any protein can be encoded and expressed by mRNA, in principle enabling the development of prophylactic and therapeutic vaccines fighting diseases as diverse as infections and cancer as well as protein replacement therapies. Since changes of the encoded protein just alter the sequence of the RNA molecule, leaving its physico-chemical characteristics largely unaffected, diverse products can be manufactured using the same established production process without any adjustment, saving time and reducing cost compared with other vaccine platforms. In terms of efficacy, mRNA-based therapeutics profit from the fact that they do not need to cross the nuclear envelope as

# Developing mRNA-vaccine technologies

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mRNA presents a promising vector that may well become the basis of a game-changing vaccine technology platform...

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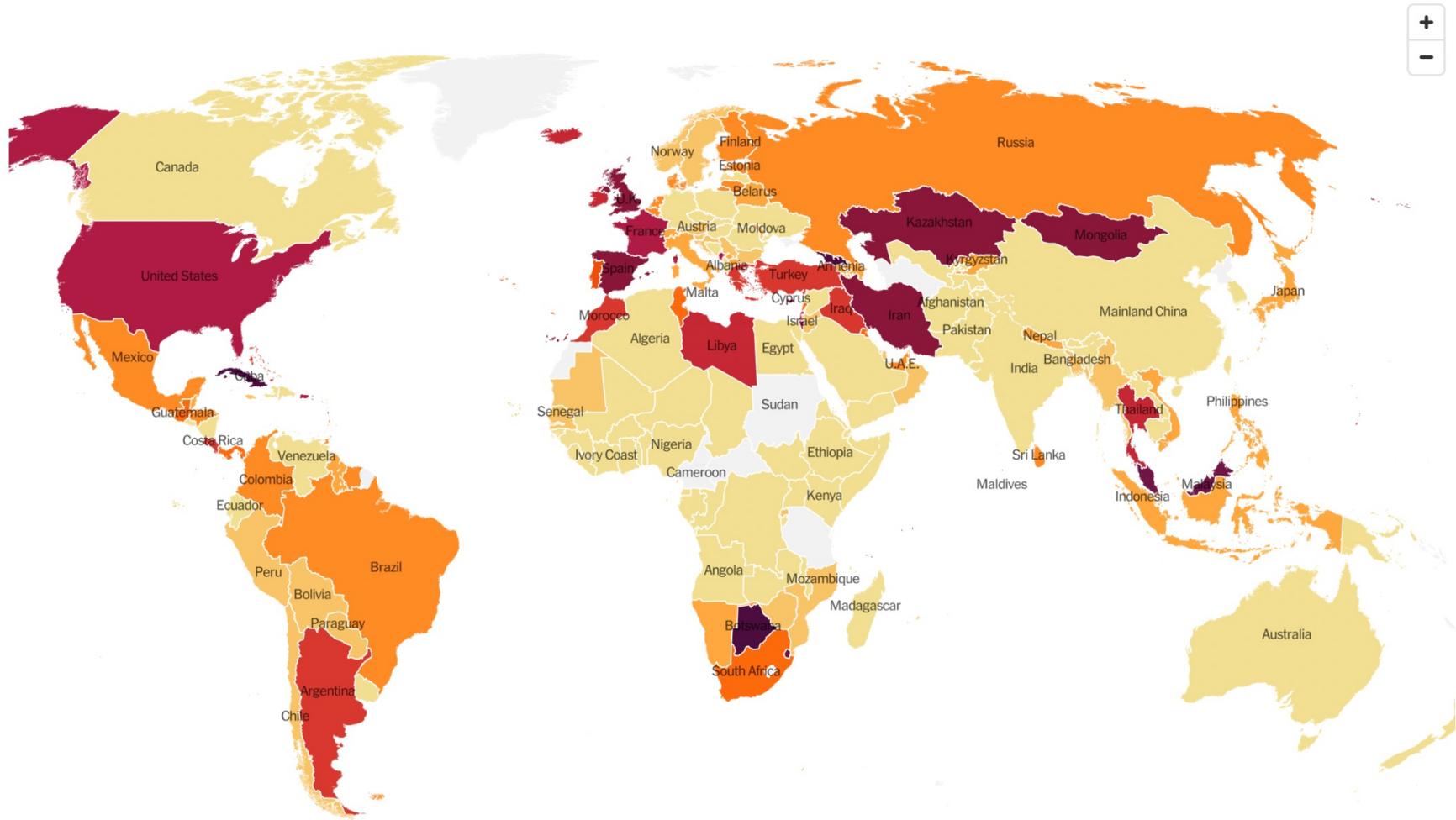
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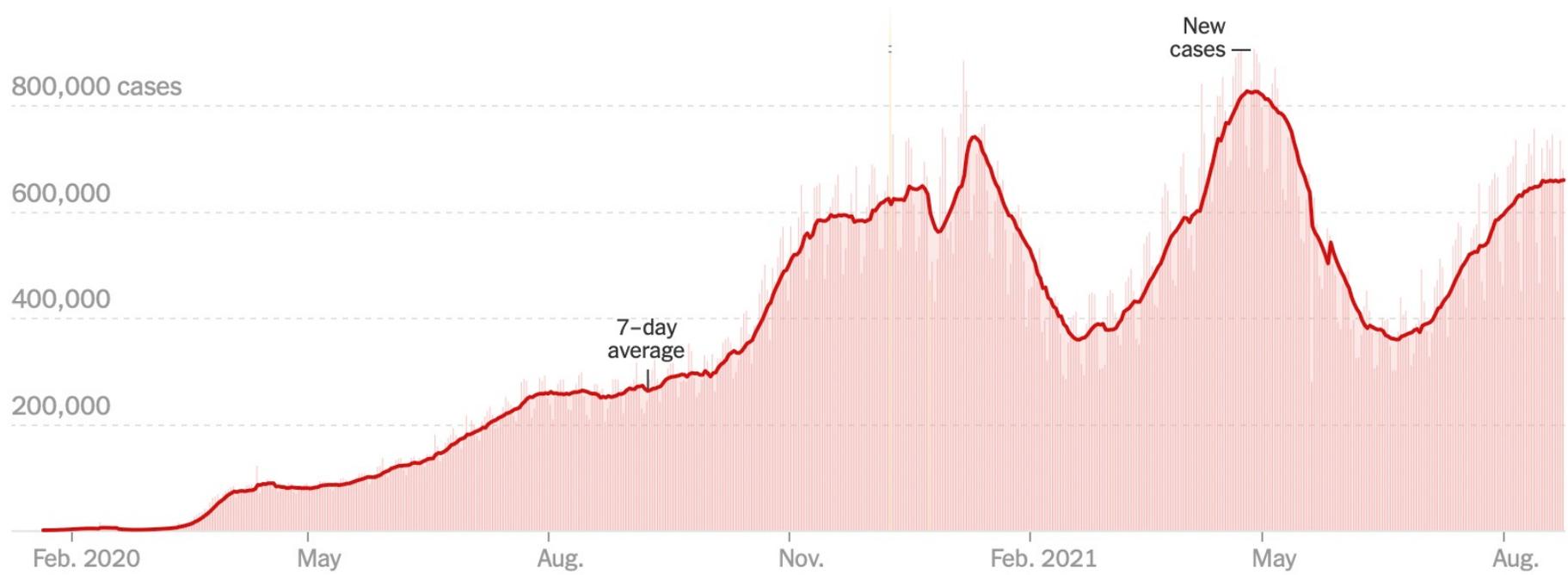
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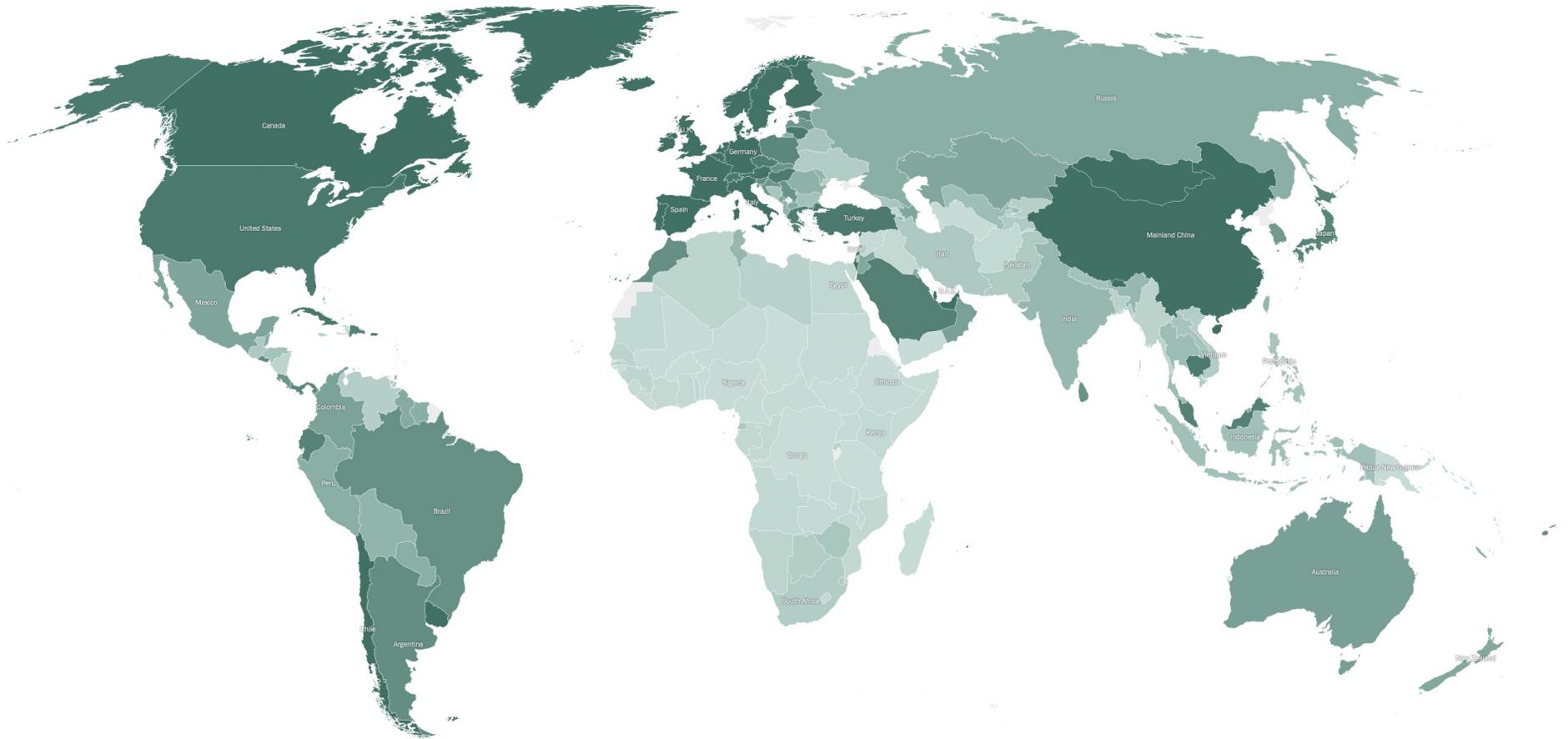
and therapeutic vaccines fighting diseases as diverse as infections and cancer as well as protein replacement therapies. Since changes of the encoded protein just alter the sequence of the RNA molecule, leaving its physico-chemical characteristics largely unaffected, diverse products can be manufactured using the same established production process without any adjustment, saving time and reducing cost compared with other vaccine platforms. In terms of efficacy, mRNA-based therapeutics profit from the fact that they do not need to cross the nuclear envelope as

2. So much went wrong



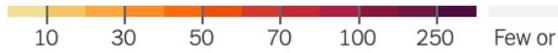


Doses administered per 100 people  
20 40 60 80 100 120 No data  
Double-click to zoom into the map.



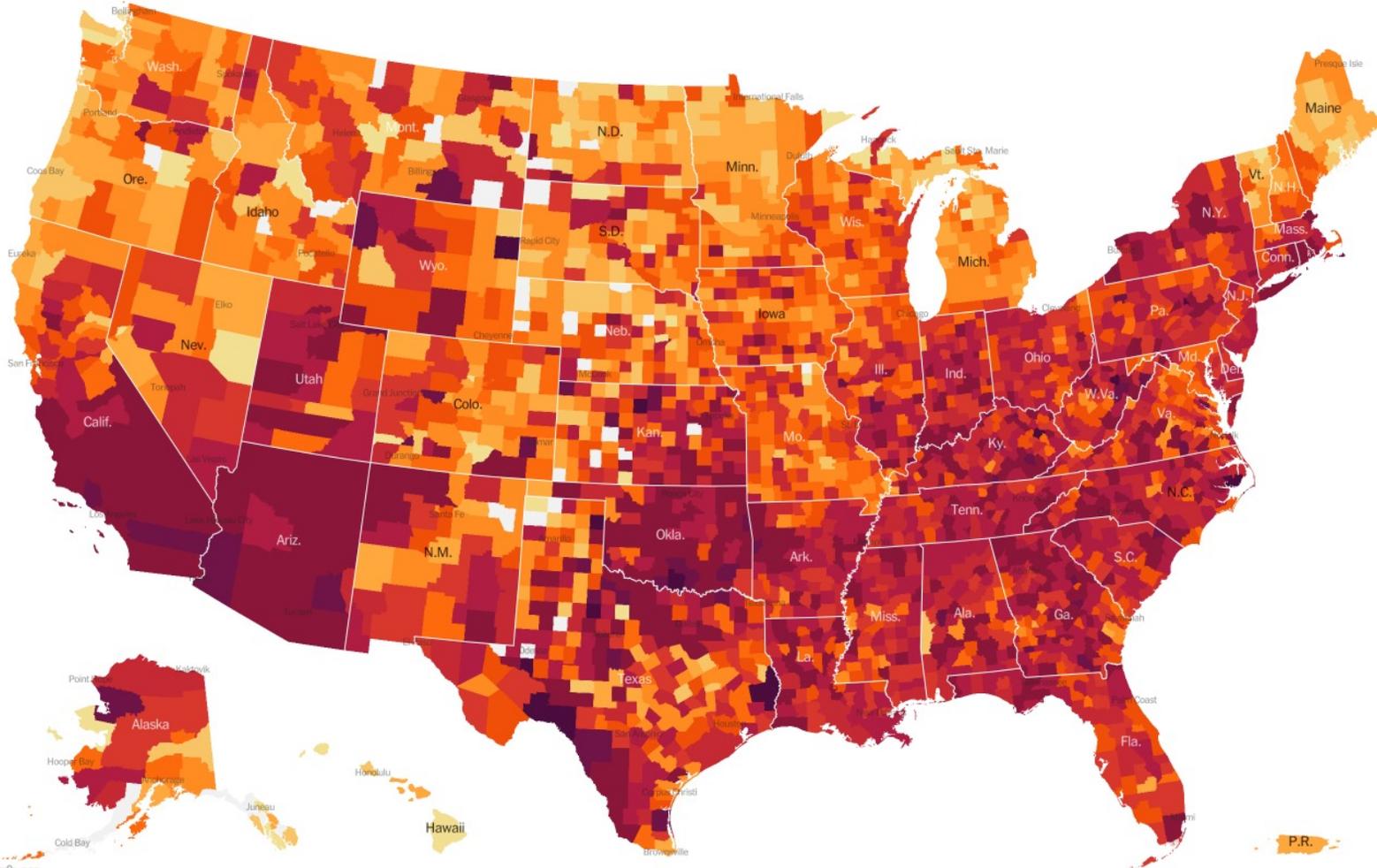
Hot spots	Total cases	Deaths	Per capita
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Average daily cases per 100,000 people in past week



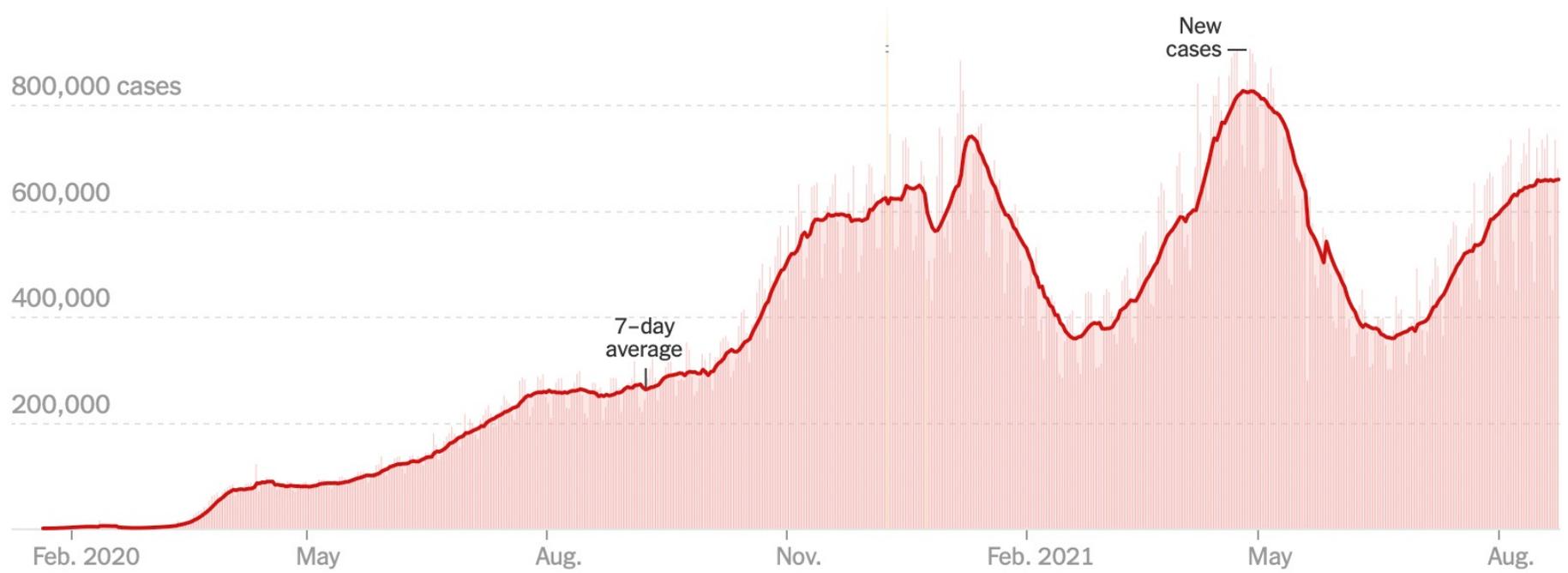
Double-click to zoom into the map.

Few or no cases



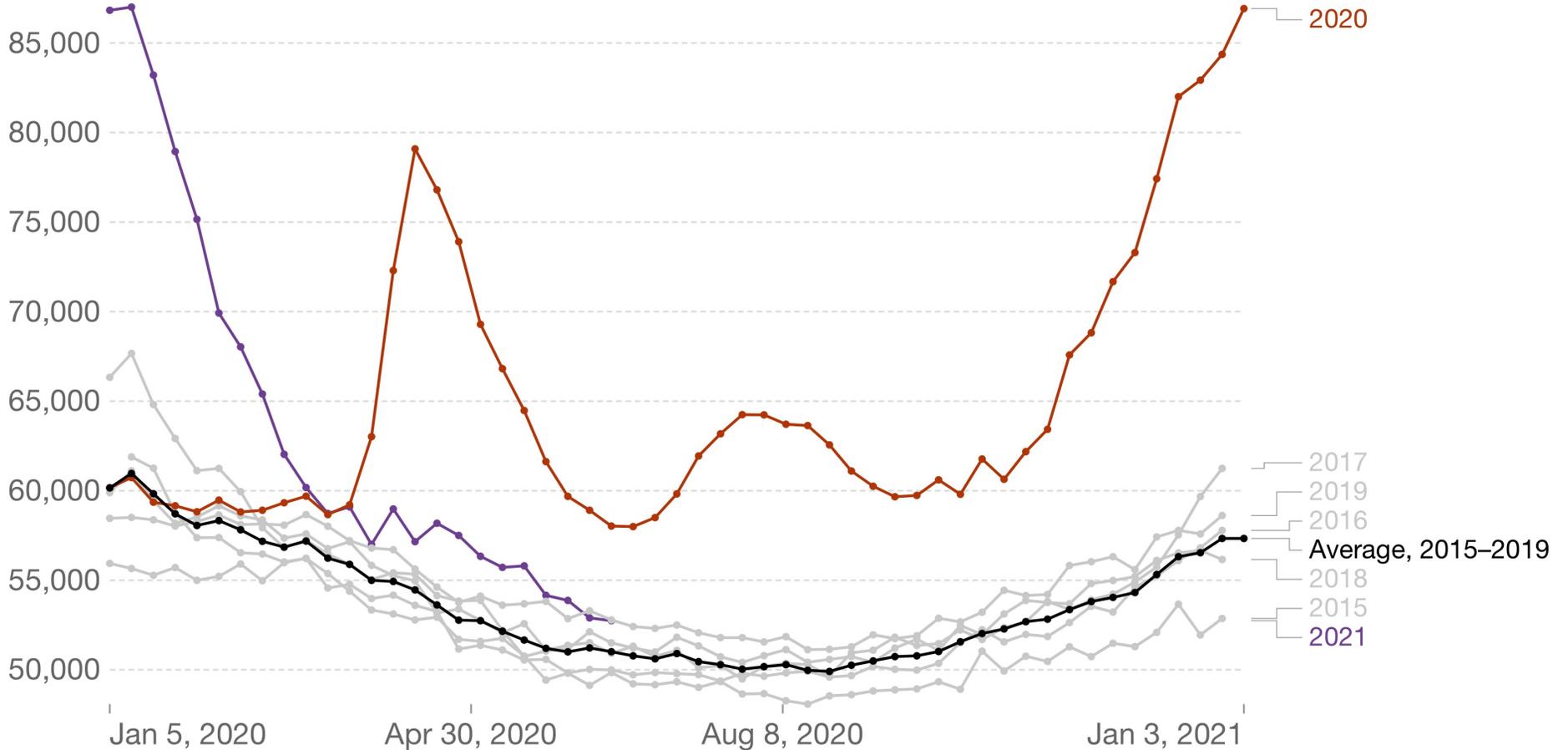
Sources: State and local health agencies. Population and demographic data from Census Bureau.

► About this data



# Excess mortality during COVID-19: Number of deaths from all causes compared to previous years, United States

Shown is how the number of weekly or monthly deaths in 2020–2021 differs from the number of deaths in the same period over the years 2015–2019. The reported number of deaths might not count all deaths that occurred due to incomplete coverage and delays in death reporting.

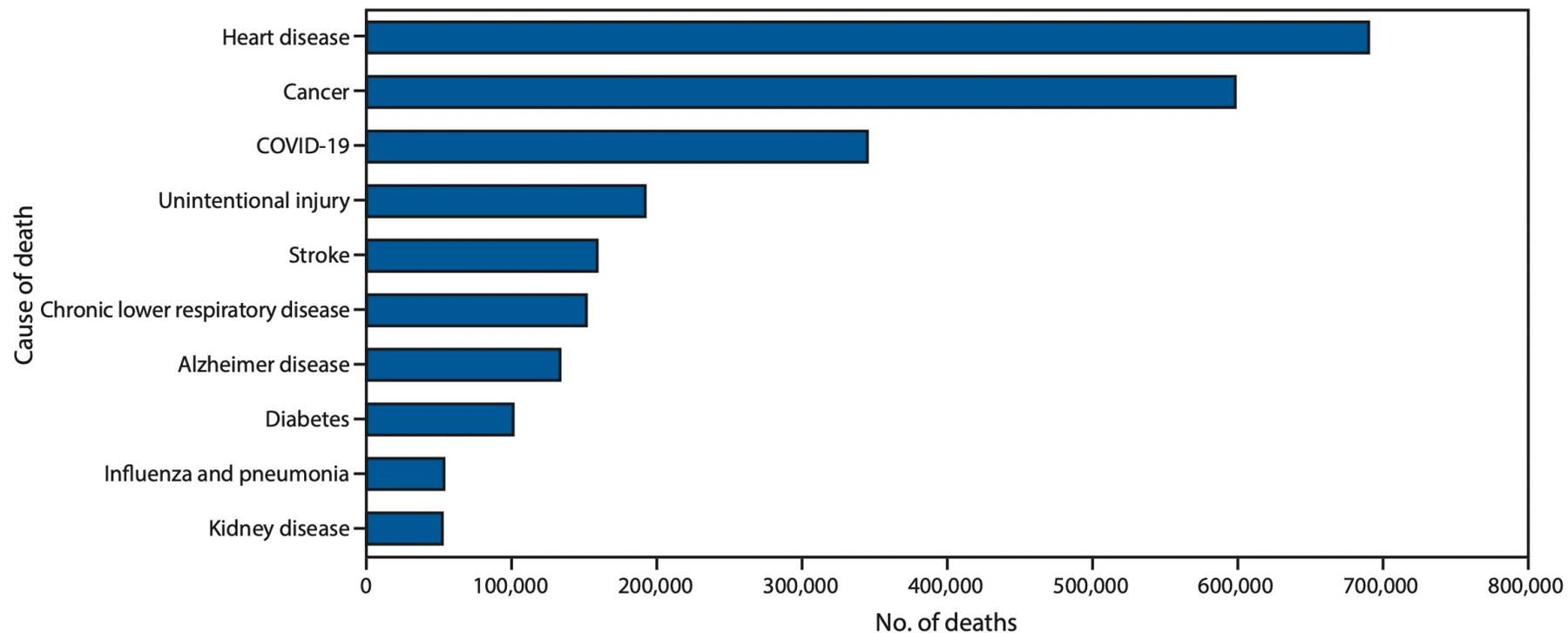


Source: Human Mortality Database (2021), World Mortality Dataset (2021)

OurWorldInData.org/coronavirus • CC BY

Note: Comparisons across countries are affected by differences in the completeness of death reporting. Details can be found at our Excess Mortality page.

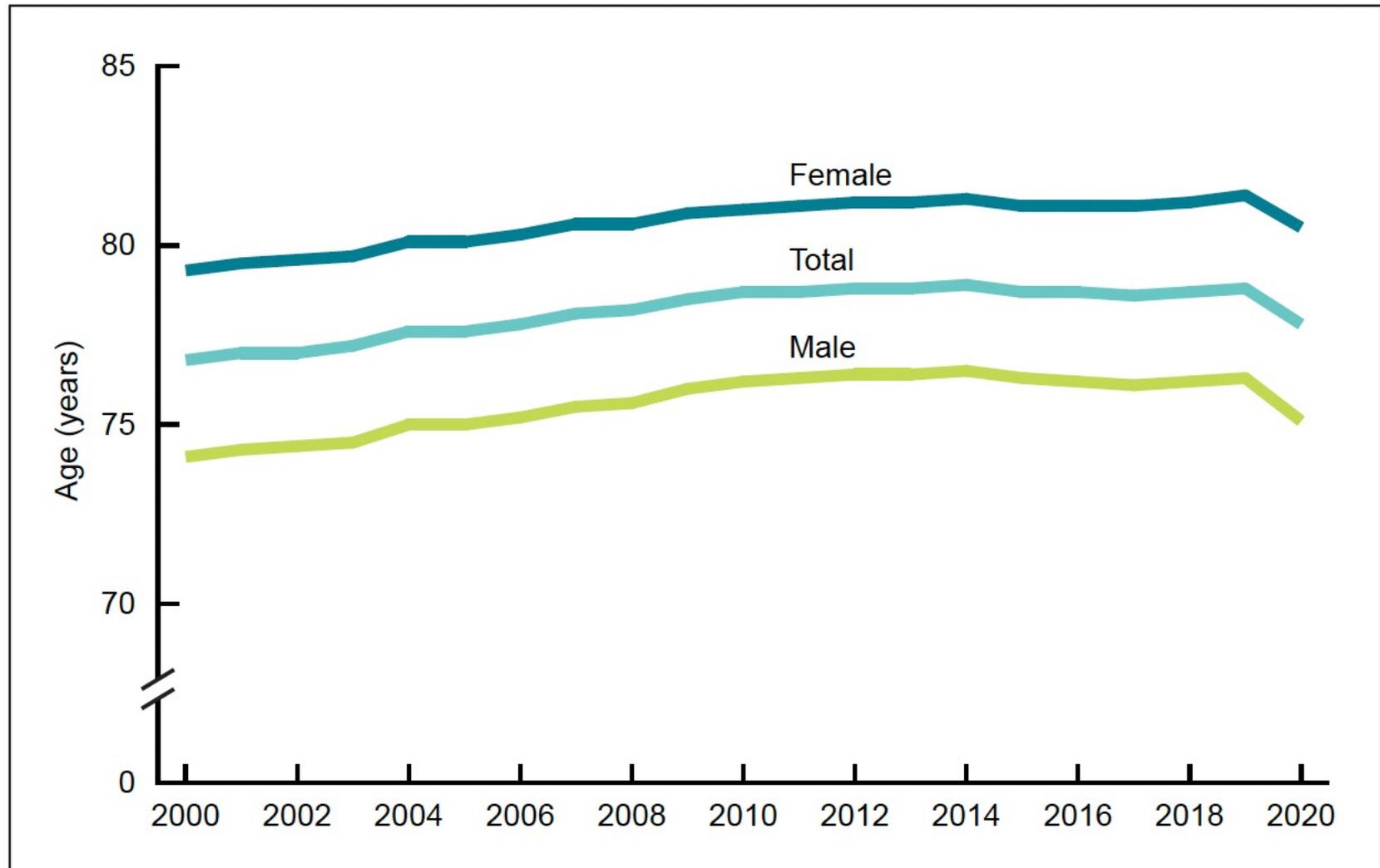
**FIGURE 2. Provisional\* number of leading underlying causes of death<sup>†</sup> — National Vital Statistics System, United States, 2020**



\* National Vital Statistics System provisional data are incomplete. Data from December are less complete due to reporting lags. Deaths that occurred in the United States among residents of U.S. territories and foreign countries were excluded.

<sup>†</sup> Deaths for which COVID-19 was a contributing, but not the underlying, cause of death are not included in this figure.

Figure 1. Life expectancy at birth, by sex: United States, 2000–2020



NOTES: Life expectancies for 2019 by Hispanic origin and race are not final estimates; see Technical Notes. Estimates are based on provisional data from January 2020 through June 2020.

SOURCE: National Center for Health Statistics, National Vital Statistics System, Mortality data.



<https://www.businessinsider.com/chart-us-weekly-coronavirus-deaths-compared-heart-disease-cancer-flu-2020-4>

# Overall rates of COVID-19 mortality for Black and white Americans

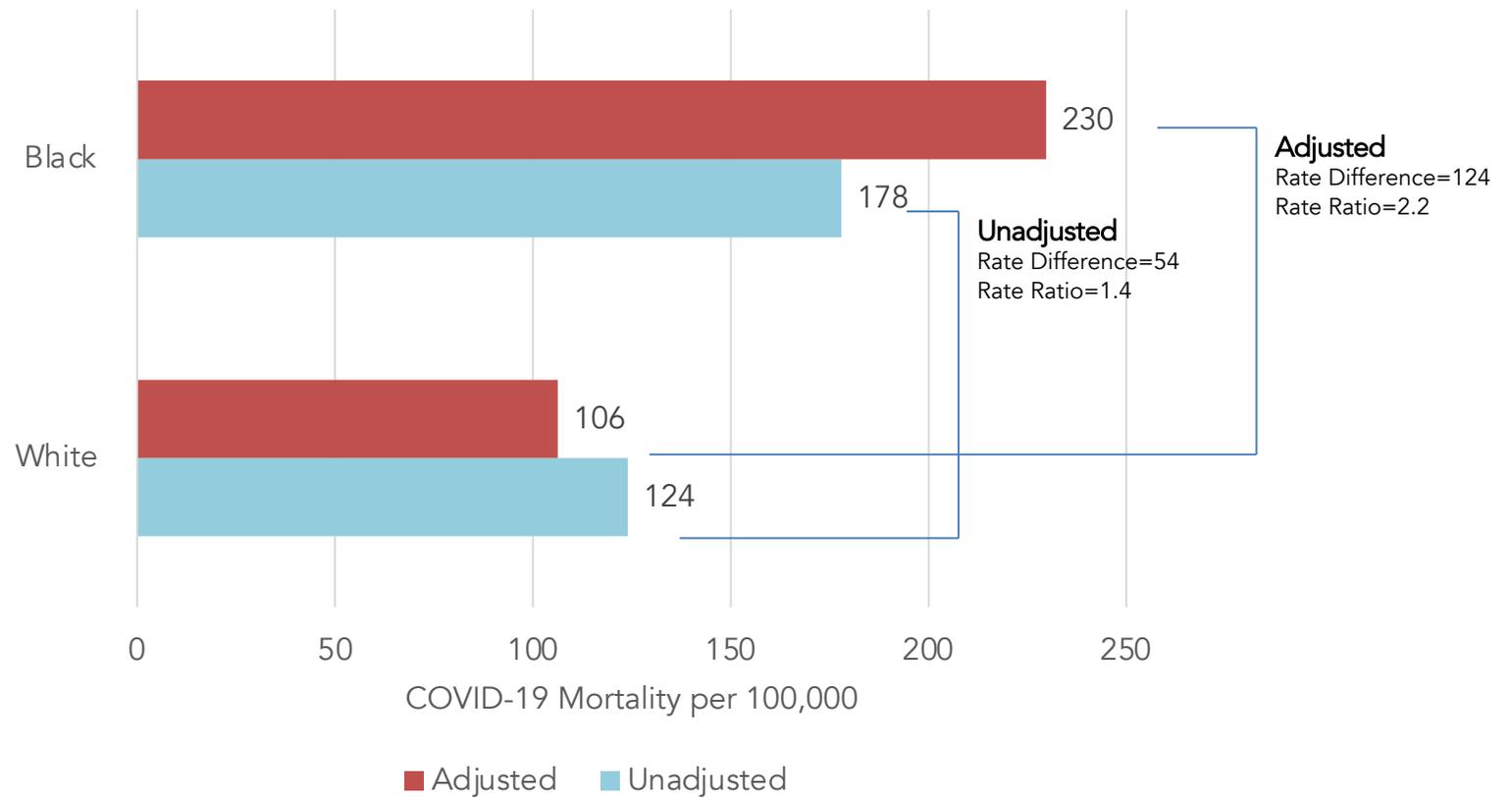
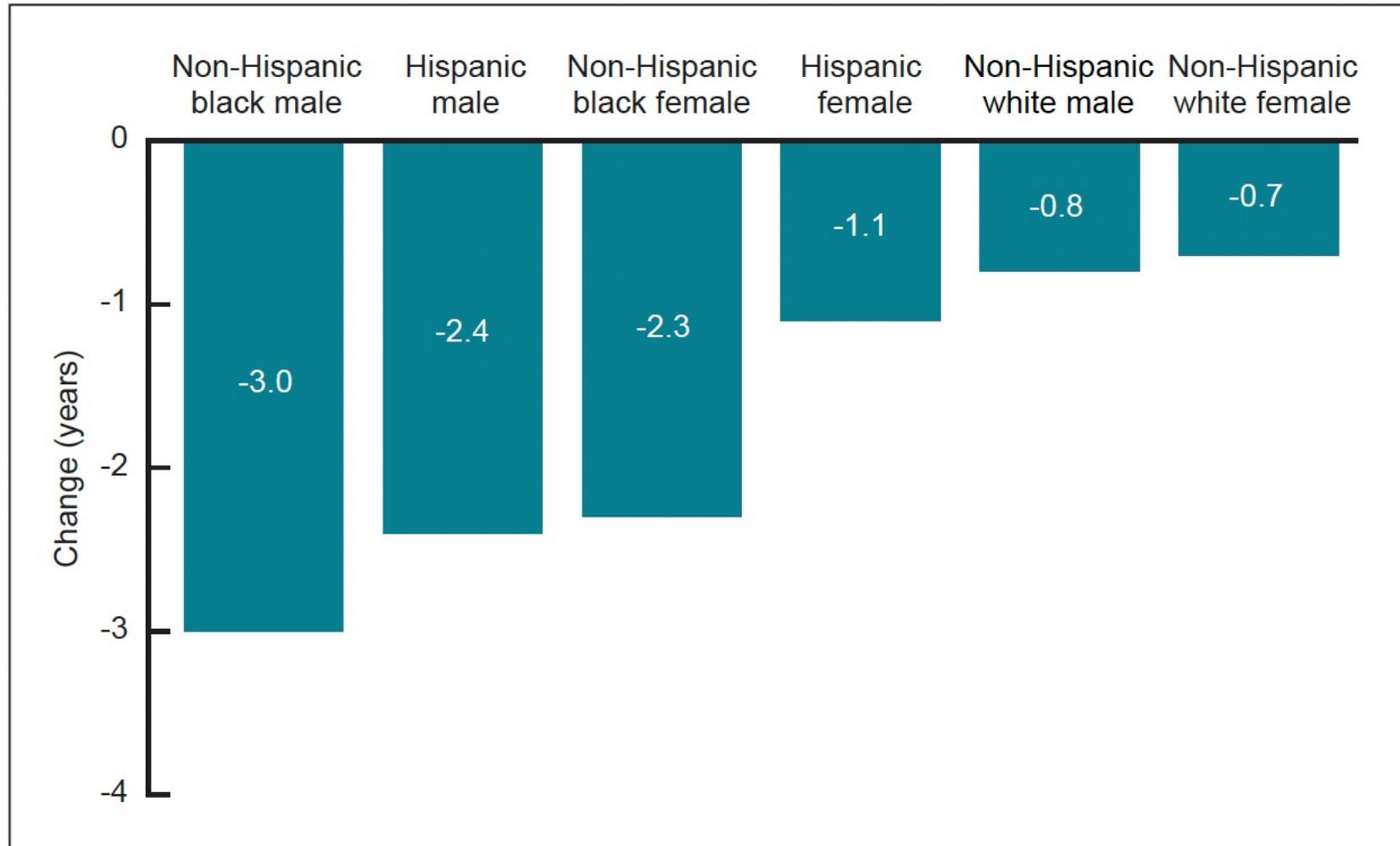


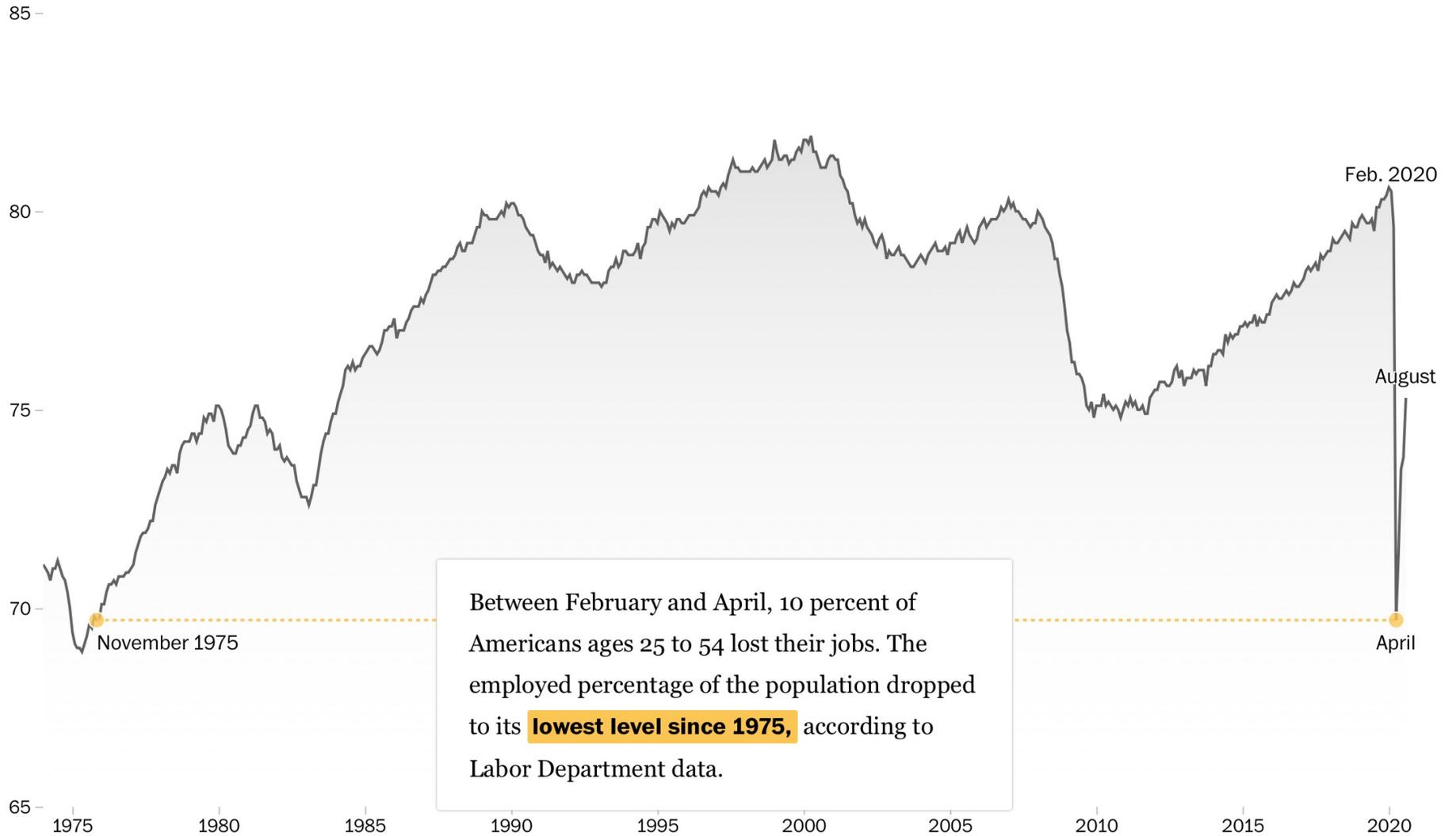
Figure 4. Change in life expectancy at birth, by Hispanic origin and race and sex: United States, 2019 and 2020



NOTES: Life expectancies for 2019 by Hispanic origin and race are not final estimates; see Technical Notes. Estimates are based on provisional data from January 2020 through June 2020.

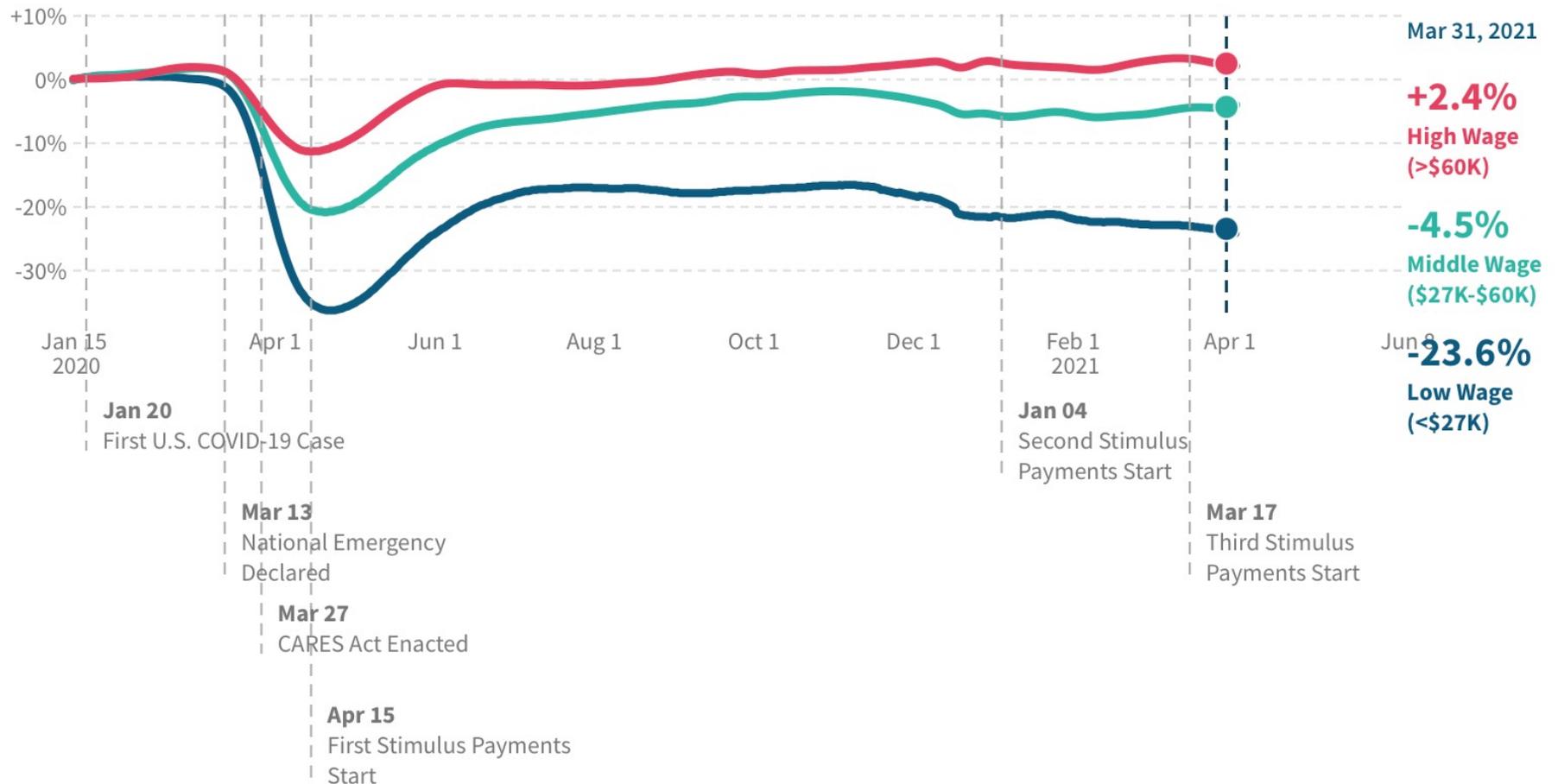
SOURCE: National Center for Health Statistics, National Vital Statistics System, Mortality data.

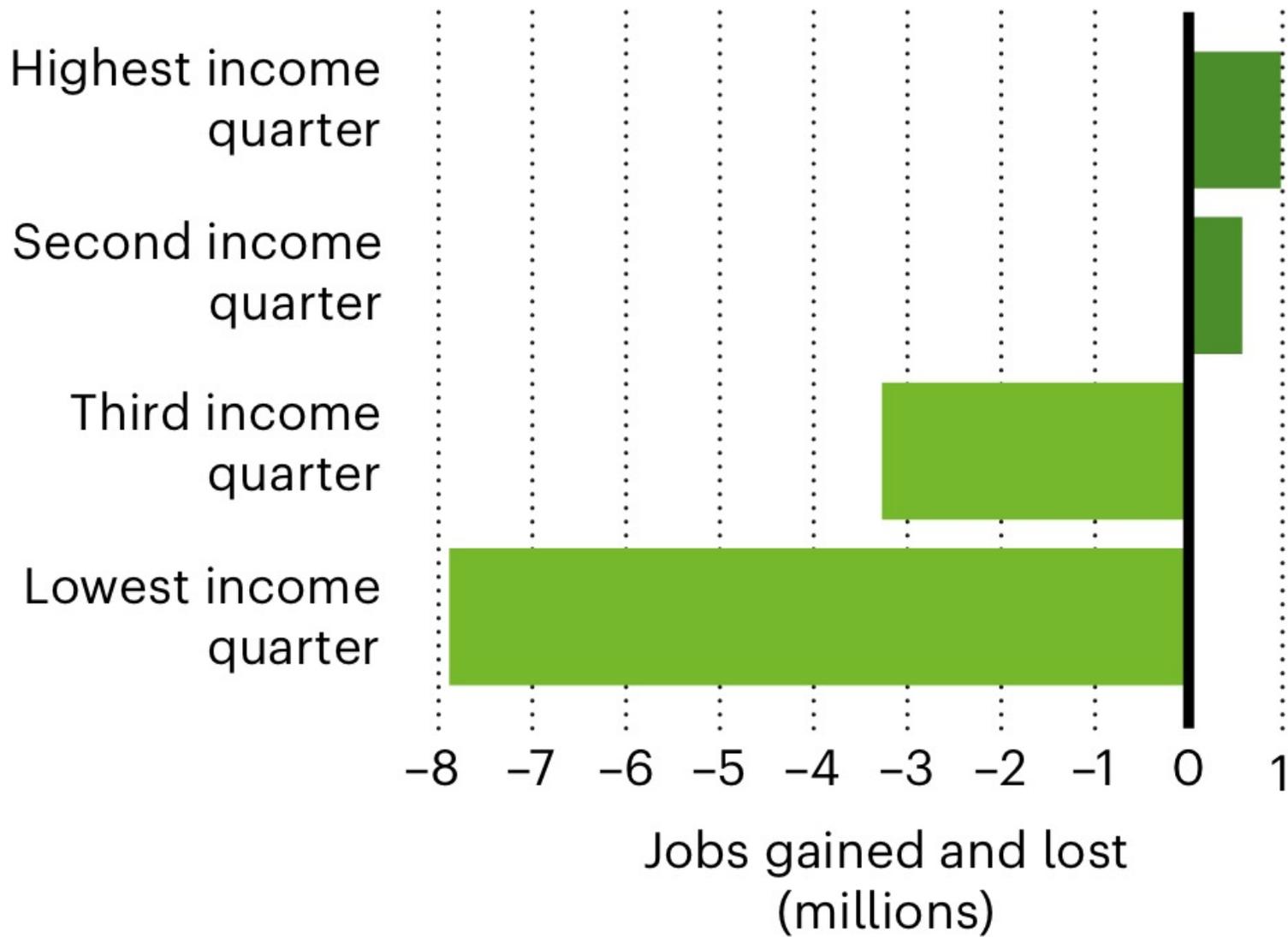
PERCENT OF PEOPLE 25-54 WHO ARE EMPLOYED



In **the United States**, as of March 31 2021, employment rates among workers in the bottom wage quartile decreased by **23.6%** compared to January 2020 (not seasonally adjusted).

DOWNLOAD CHART 

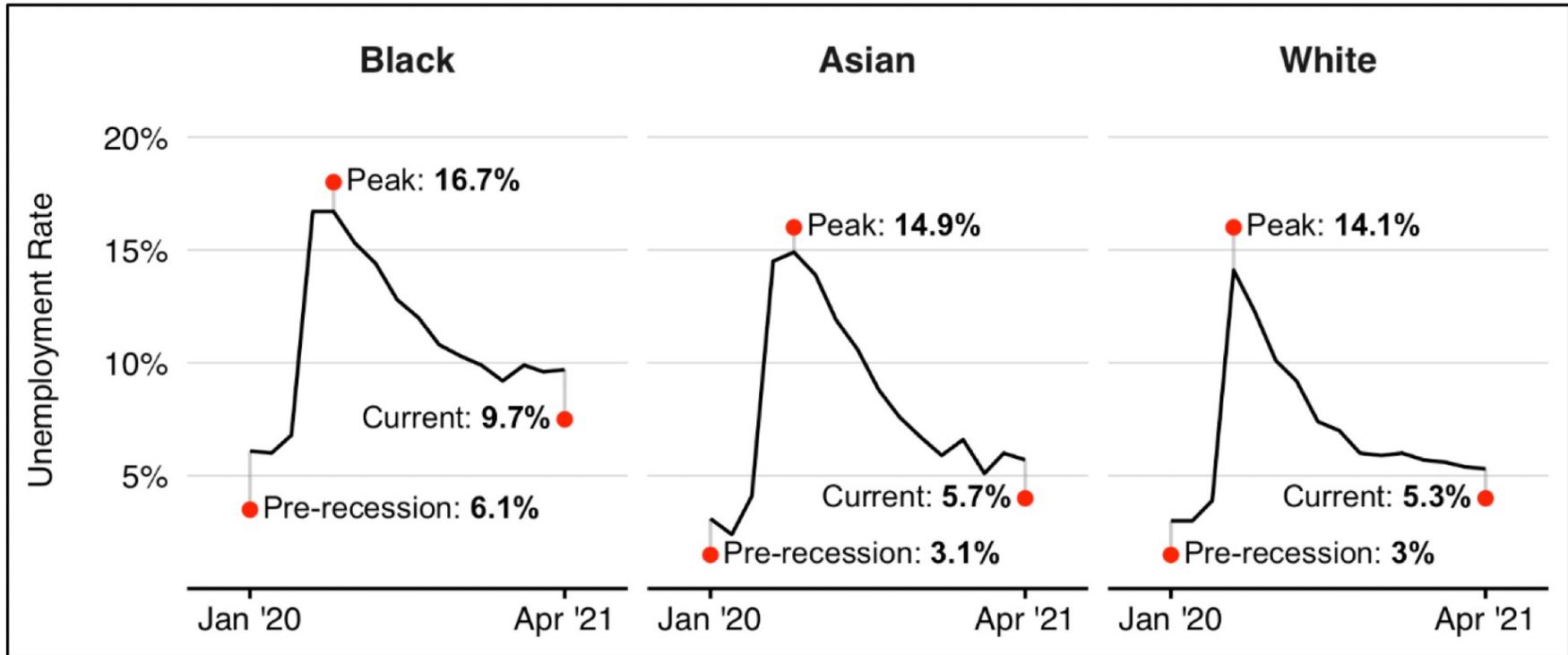






<https://www.washingtonpost.com/graphics/2020/business/coronavirus-recession-equality/>

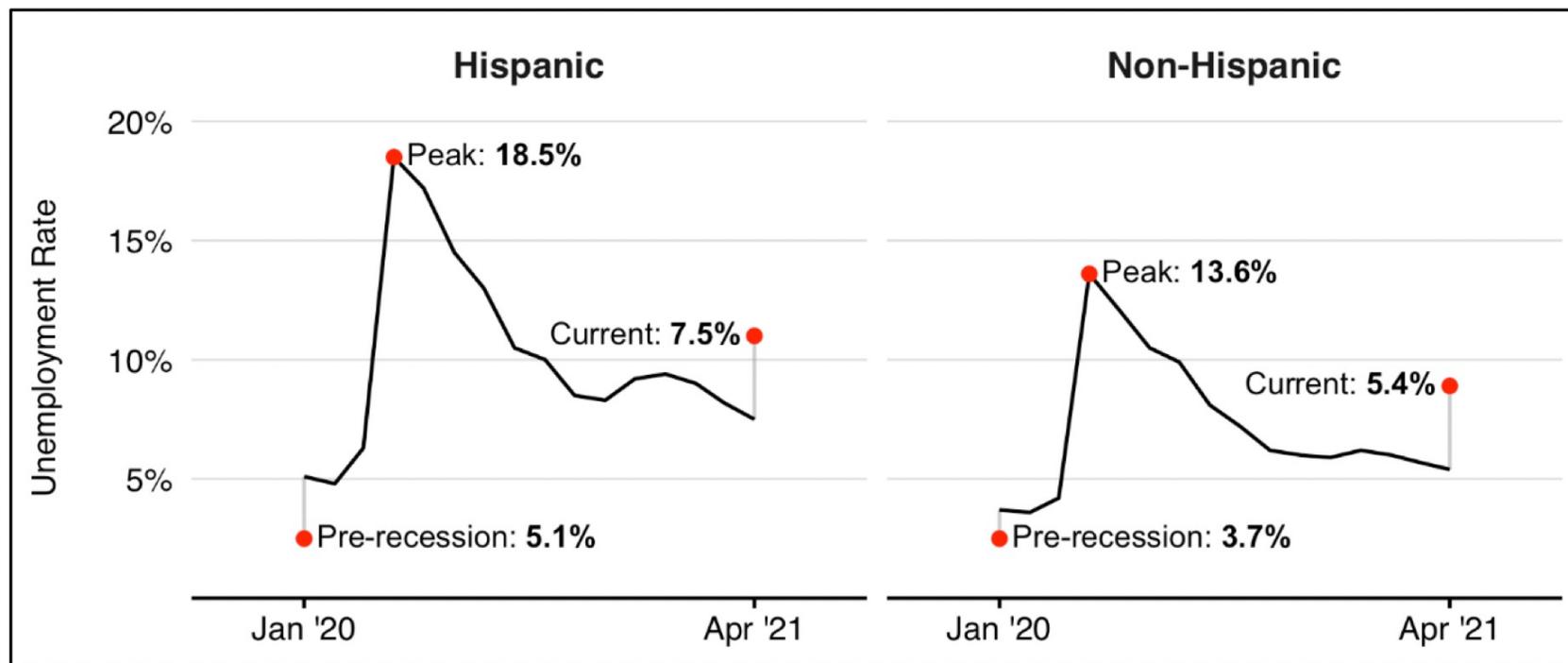
**Figure 7. Unemployment Rates by Racial Group**  
 Seasonally adjusted monthly data, January 2020 to April 2021



**Source:** Created by CRS using data from the Bureau of Labor Statistics (BLS). Extracted using the Labor Force Statistics data series at <https://www.bls.gov/data/>.

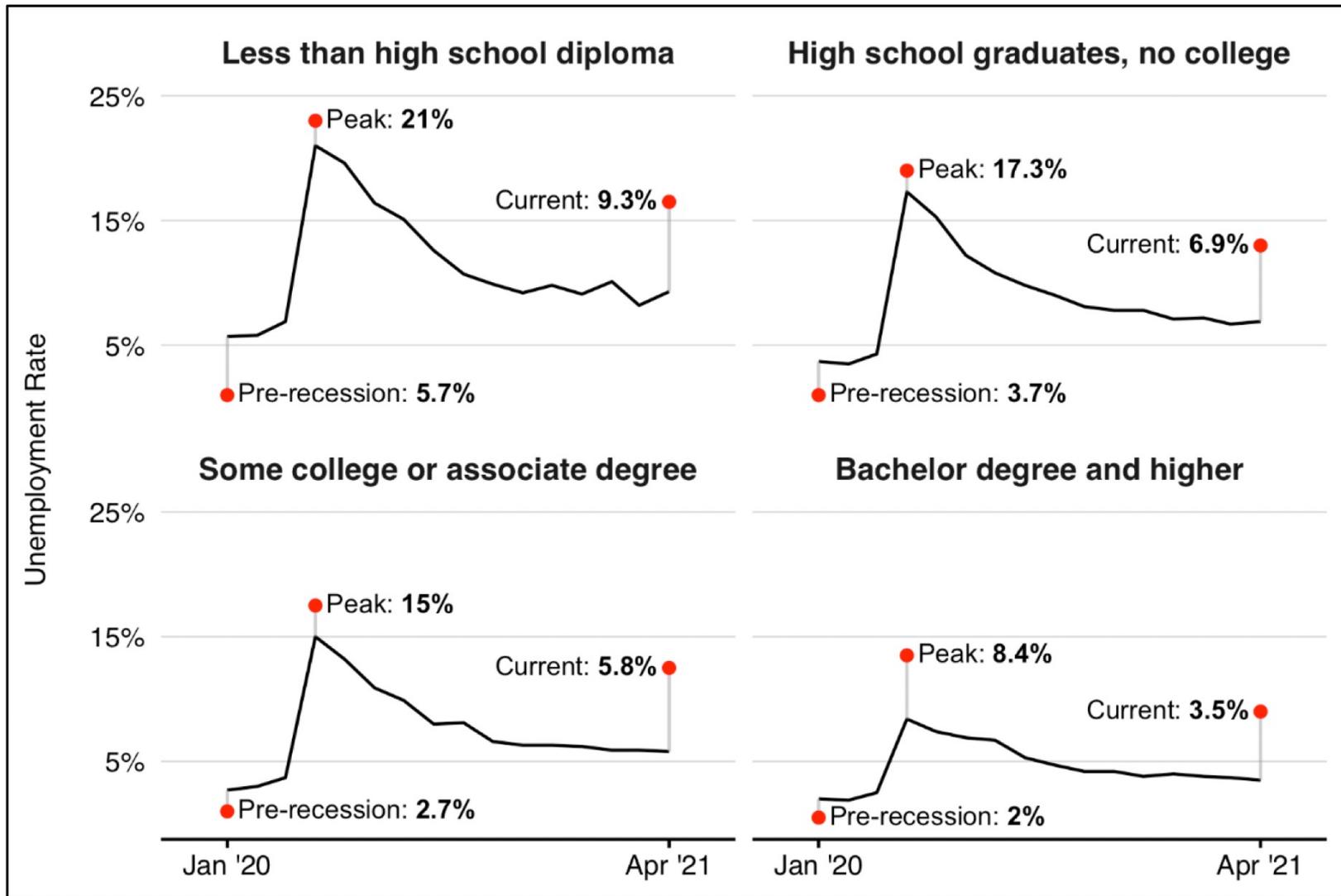
**Notes:** Black and Asian workers experienced their peak unemployment rate in May 2020. White workers peak rate occurred in April 2020.

**Figure 8. Unemployment Rates by Hispanic Origin**  
Non-seasonally adjusted monthly data, January 2020 to April 2021



**Source:** Created by CRS using data from the Bureau of Labor Statistics (BLS). Extracted using the Labor Force Statistics data series at <https://www.bls.gov/data/>.

**Figure 9. Unemployment Rates by Education**  
 Seasonally adjusted monthly data, January 2020 to April 2021



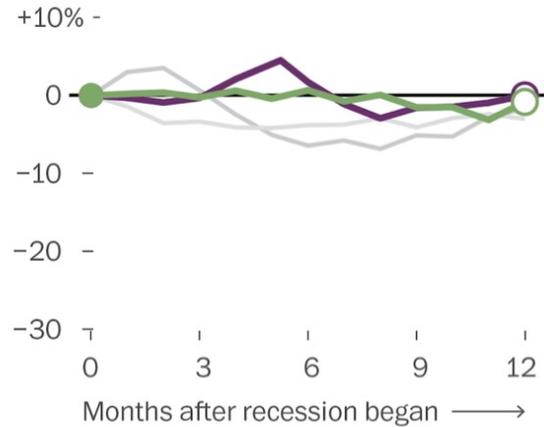
**Source:** Created by CRS using data from the Bureau of Labor Statistics (BLS). Extracted using the Labor Force Statistics data series at <https://www.bls.gov/data/>.

**Notes:** All groups experienced their peak unemployment rate in April 2020.

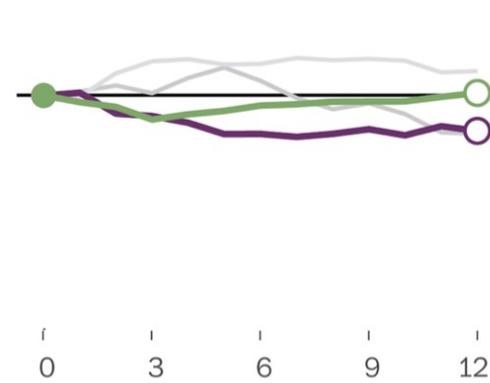
# The coronavirus crisis is different

Job growth (or loss) since each recession began, based on weekly earnings

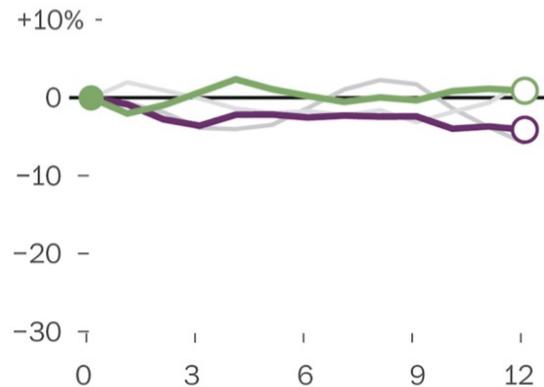
## 1990 recession



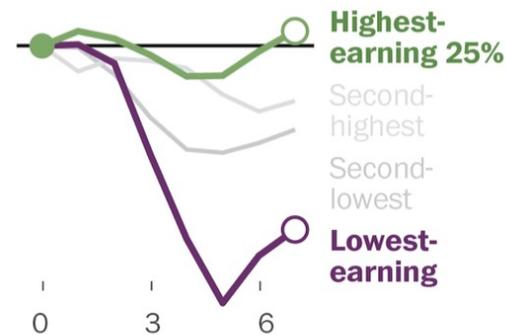
## 2001 recession



## 2008 recession



## Coronavirus crisis



Notes: Based on a three-month average to show the trend in volatile data.

Source: Labor Department via IPUMS, with methodology assistance from Ernie Tedeschi of Evercore ISI

THE WASHINGTON POST

"All the News  
That's Fit to Print"

# The New York Times

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MONDAY, JUNE 1, 2020

## TWIN CRISES AND SURGING ANGER CONVULSE U.S.

### Pandemic Leaves Nation's Nerves on the Edge

By JACK HEALY  
and DIONNE SEARCEY

They are parallel plagues ravaging America: The coronavirus. And police killings of black men and women.

Jimmy Mills's life has been upended by both. His barbershop in Midtown Minneapolis was one of many small, black-owned businesses that have struggled to survive the pandemic. But Mr. Mills was hopeful because, after two months shut down, he was due to reopen next week.

Then early on Friday, the working-class neighborhood where Mr. Mills has cut hair for 12 years went up in flames as chaotic protests over the death of George Floyd and police killings of African-Americans engulfed Minneapolis and cities across the country.

"To have corona, and then this — it's like a gut shot," Mr. Mills, 56, said.

The upheaval set off by a video capturing Mr. Floyd's agonizing last minutes as a white police officer kneels on his neck is pulsing through an America already ragged with anger and anxiety. Emotions are raw over the toll of a pandemic that has killed more than 100,000 people across the country and cost millions of jobs.

Minneapolis residents said outrage and protests in the aftermath of the killing of George Floyd were a result of a community being tested repeatedly in recent weeks by both police violence and the virus — and in ways that put America's deep racial inequalities in stark relief.

The outbreak has inflicted disproportionate economic and health tolls on racial minorities and immigrants in Minneapolis and

Continued on Page A11



CHANG W. LEE/THE NEW YORK TIMES



VICTOR J. BLUE FOR THE NEW YORK TIMES

**CLASHES** Protesters in Brooklyn on Saturday, top, and the police in Minneapolis moving to disperse a rally. Shows of force by law enforcement did little to bring calm to many cities across the nation.

### Videos From Protests Deepen Scrutiny of Aggressive Police Tactics

By SHAILA DEWAN and MIKE BAKER

Demonstrations continued across the United States on Sunday as the nation braced for another grueling night of unrest over police shootings and the death of George Floyd, amid growing concern that aggressive law enforcement tactics intended to impose order were instead inflaming tensions.

Videos showed police officers in recent nights using batons, tear gas and rubber bullets on protesters, bystanders and journalists, often without warning or seemingly unprovoked. The footage, which has been shared widely online, highlighted the very complaints over police behavior that have drawn protests in at least 75 cities across the United States.

In Salt Lake City, officers in riot gear trying to clear onlookers showed a man with a cane to the ground.

In Brooklyn, two police S.U.V.s plowed into protesters.

And in Minneapolis, where there have been six consecutive nights of protests and clashes, a video appeared to show officers yelling at people on their stoops to get inside and firing paint canisters at them. "Light them up," one officer said.

As crowds began gathering again in cities on Sunday, President Trump resisted calls to address the tensions rolling the country. Instead he used Twitter to criticize local Democratic leaders for not doing more to control

the protests.

Mayors and police chiefs spent the day explaining, defending and promising full investigations into the actions of officers seen on the disturbing videos.

"I didn't like what I saw one bit. I did not want to ever see something like that," said Mayor Bill de Blasio of New York, who also complimented the city's police officers for generally showing a "tremendous amount of restraint."

Military vehicles in recent nights have moved down city streets as phalanxes of officers in full riot gear fired clouds of noxious gas. Yet the show of force showed little sign that it would bring calm.

Instead, some people said, it was escalating tensions, and breaking the cycle would now be more difficult.

Mass demonstrations are among the most difficult situations that the police have to manage. They must balance constitutional liberties with the safety of officers and the public. Crowds are unpredictable and, in recent days, sometimes hostile. Too much force can escalate the situation — but so can too little.

Not all protests have erupted in violence, with some police forces showing a more positive relationship with their communities. In Petersburg, Va., Chief Kenneth Miller and a handful of police officers appeared alongside protesters to show solidarity.

Continued on Page A12

### Trump Offers No Calming Words As Tumult Reaches White House

By PETER BAKER and MAGGIE HABERMAN

WASHINGTON — Inside the White House, the mood was bristling with tension. Hundreds of protesters were gathering outside the gates, shouting curses at President Trump and in some cases throwing bricks and bottles. Nervous for his safety, Secret Service agents abruptly rushed the president to the underground bunker used in the past during terrorist attacks.

The scene on Friday night, described by a person with firsthand knowledge, added to the sense of unease at the White House as demonstrations spread after the brutal death of a black man in police custody under a white officer's knee. While in the end officials said they were never really in danger, Mr. Trump and his family have been rattled by protests that turned violent two nights in a row near the Executive Mansion.

After days in which the empathy he expressed for George

Floyd, the man killed, was overshadowed by his combative threats to ramp up violence against looters and rioters, Mr. Trump spent Sunday out of sight, even as some of his campaign advisers were recommending that he deliver a nationally televised address before another night of possible violence. The building was even emptier than usual as some White House officials planning to work were told not to come in case of renewed unrest.

But while some aides urged him to keep off Twitter while they mapped out a more considered strategy, Mr. Trump could not resist blasting out a string of messages on Sunday once again berating Democrats for not being tough enough and attributing the turmoil to radical leftists.

"Get tough Democrats Mayors and Governors," he wrote. Referring to his presumptive Demo-

Continued on Page A15

### Black Voters' Message to Democrats: Back to Normal Won't Do

By ASTEAD W. HERNDON

COLUMBIA, S.C. — In an on-camera address after a week of destructive protests, former vice president Joseph R. Biden Jr. pleaded with his audience to imagine life for black people in America. Imagine, he said, "if every time your husband or son, wife or daughter left the house, you feared for their safety?" Imagine the police called on you for sitting in Starbucks.

"The anger and frustration and the exhaustion, it's undeniable," he said.

Exhaustion. For many black Americans across the country, what a year this month has been. The coronavirus pandemic has continued to disproportionately

kill black people, and a spate of high profile killings in recent months in Georgia, Kentucky, and Minnesota, the latter two at the hands of the police, led to widespread demonstrations nationwide.

Protests shook more than three dozen cities on Saturday as crowds expressed outrage over the death of George Floyd, a black security guard who was killed in police custody in Minneapolis. Demonstrators shut down freeways, set fires and battled police batons and tear gas, the pain and frustration of the moment spilling out into the streets.

In Columbia, the city where Mr. Biden delivered his victory speech after the South Carolina primary just over three months ago, demonstrators on Saturday

### A Demand for Lasting Change as Protests Sweep Streets

said they were demanding more than what it seemed like an election in November would deliver. Not only justice for the death of George Floyd, but change in political and economic power that would prevent the death of another black person in police custody, another brutal video going viral.

"I'm tired of coming out here," said Deven Moon, a 21-year-old Columbia resident, one of hundreds who participated in the

peaceful protests in the city. "I'm tired of feeling forced to do all this."

It dawned on Sierra Moore, 24, who attended the protests carrying a homemade sign that read "No Justice, No Peace," that she and her grandmother have been protesting the same issues over the course of a century.

She looked at the racially diverse group of thousands, which gathered for a short program on the State House steps before leading a march to the local police station.

Next to her was another sign: "Respect my existence or expect my resistance."

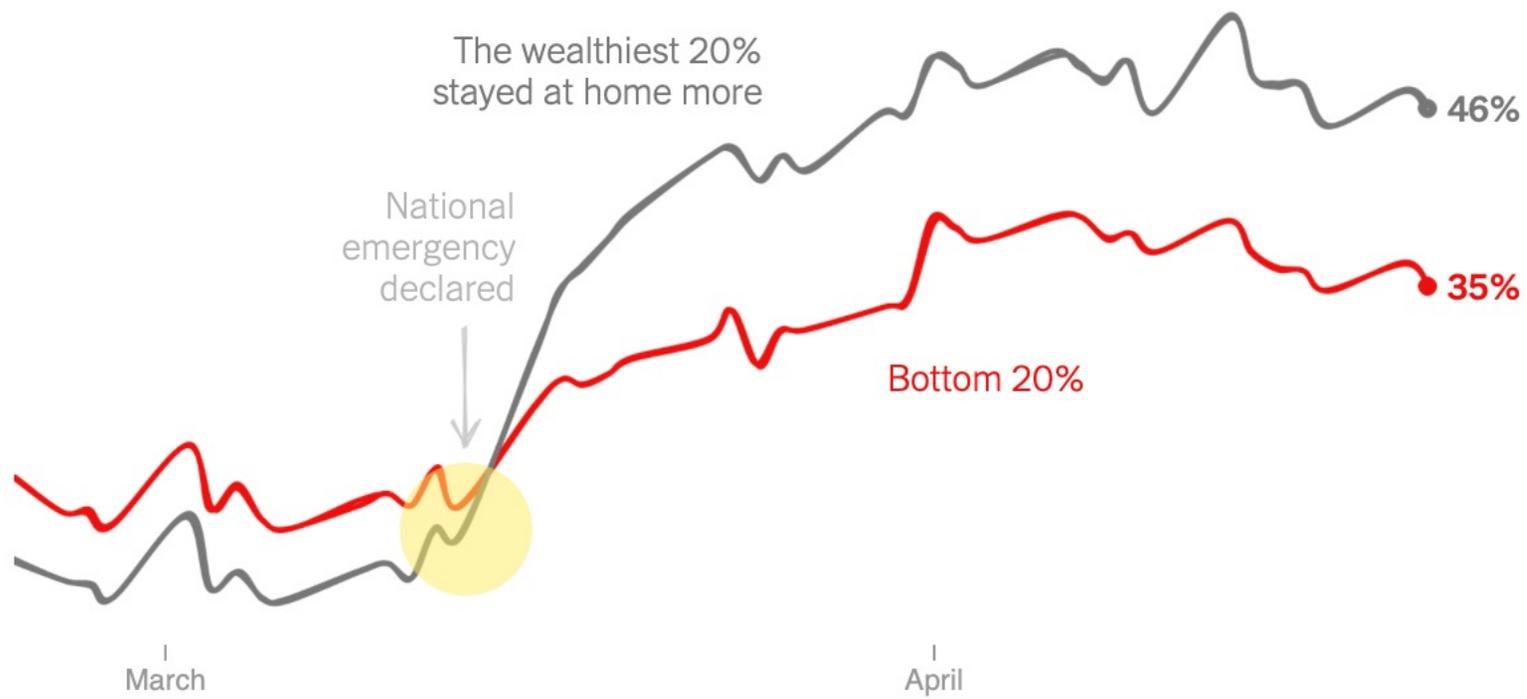
"I just don't think that's how change happens," Ms. Moore said of voting. "They've been telling us

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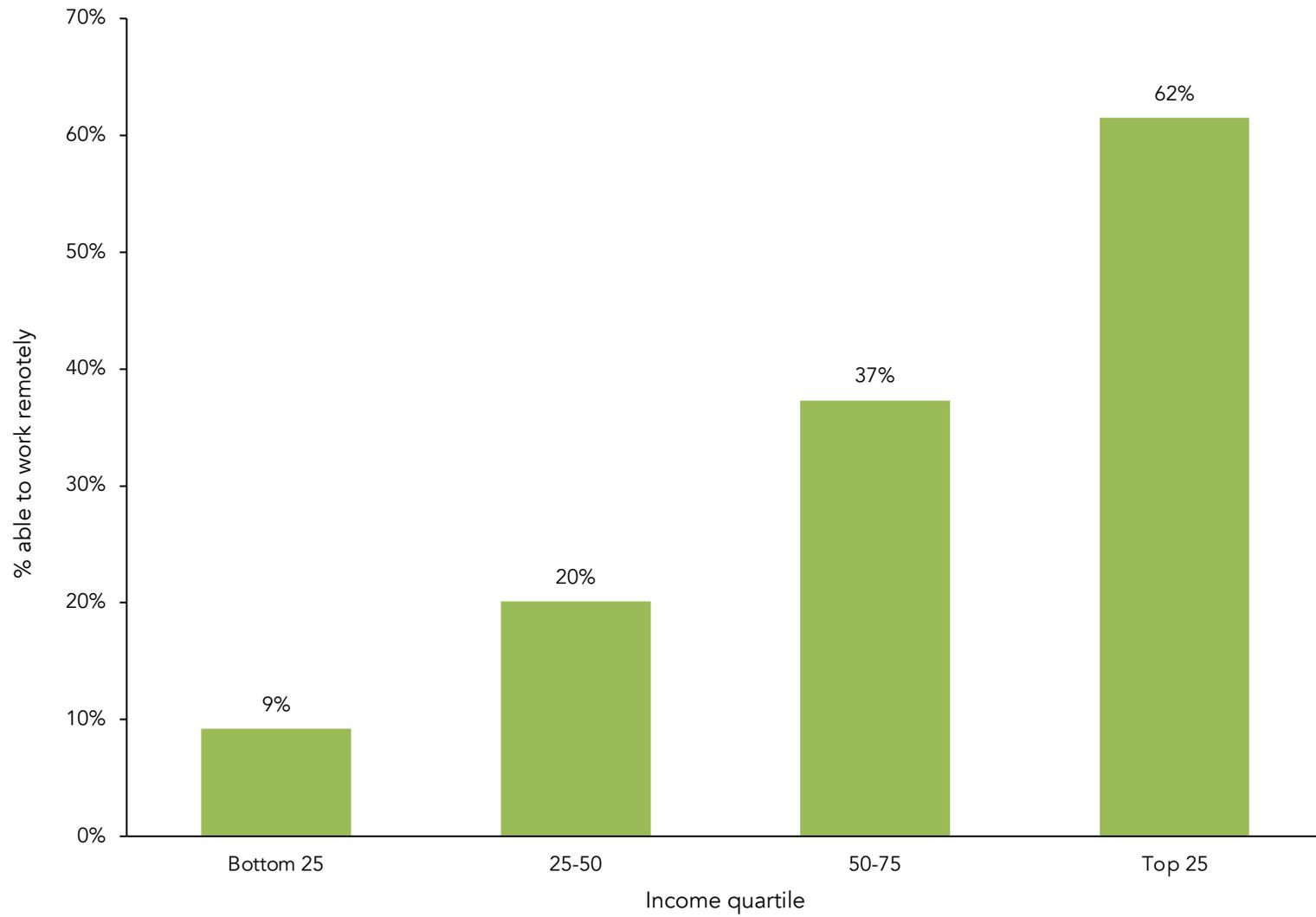
3. Why did it all go so wrong?

Unnecessary risk of getting COVID

## Share of population staying at home, by income group

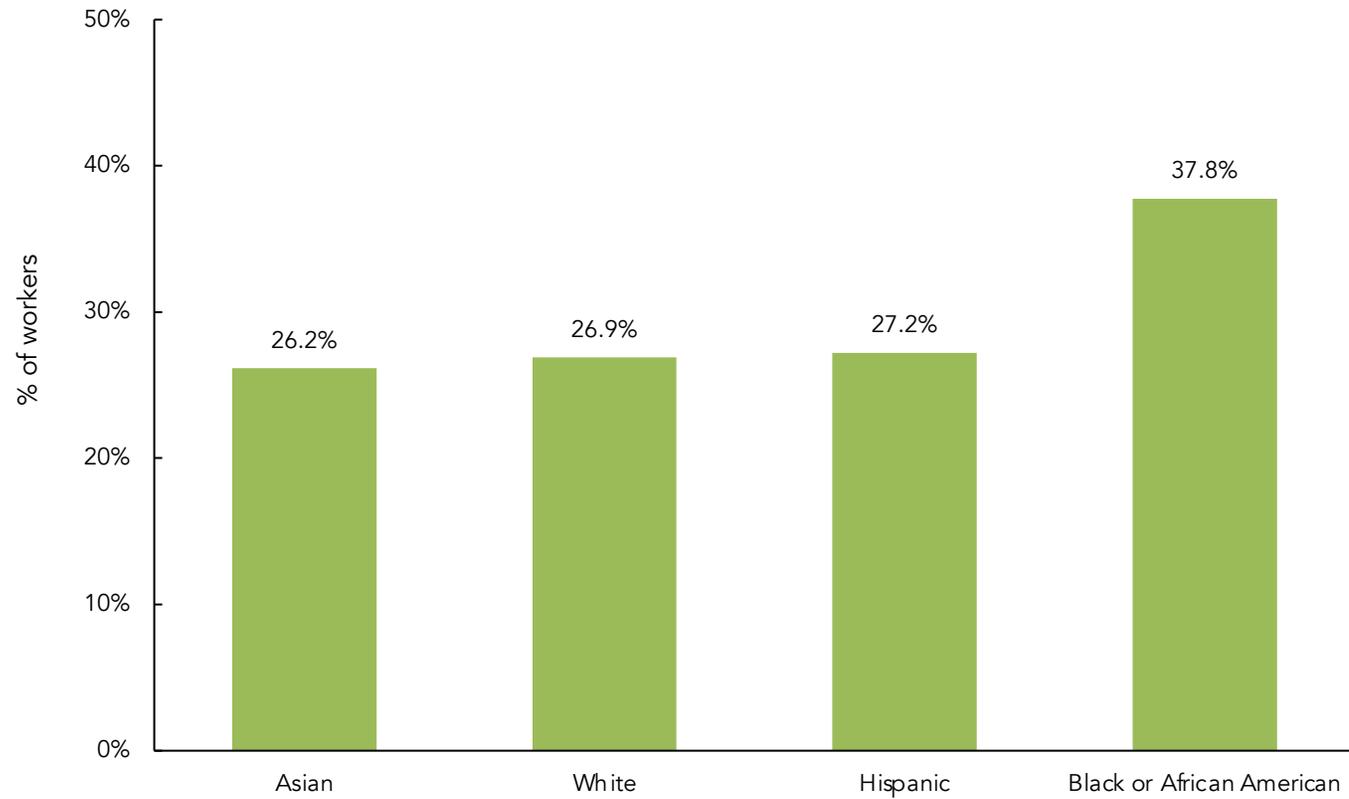


# Ability to work remotely



Data: Bureau of Labor Statistics

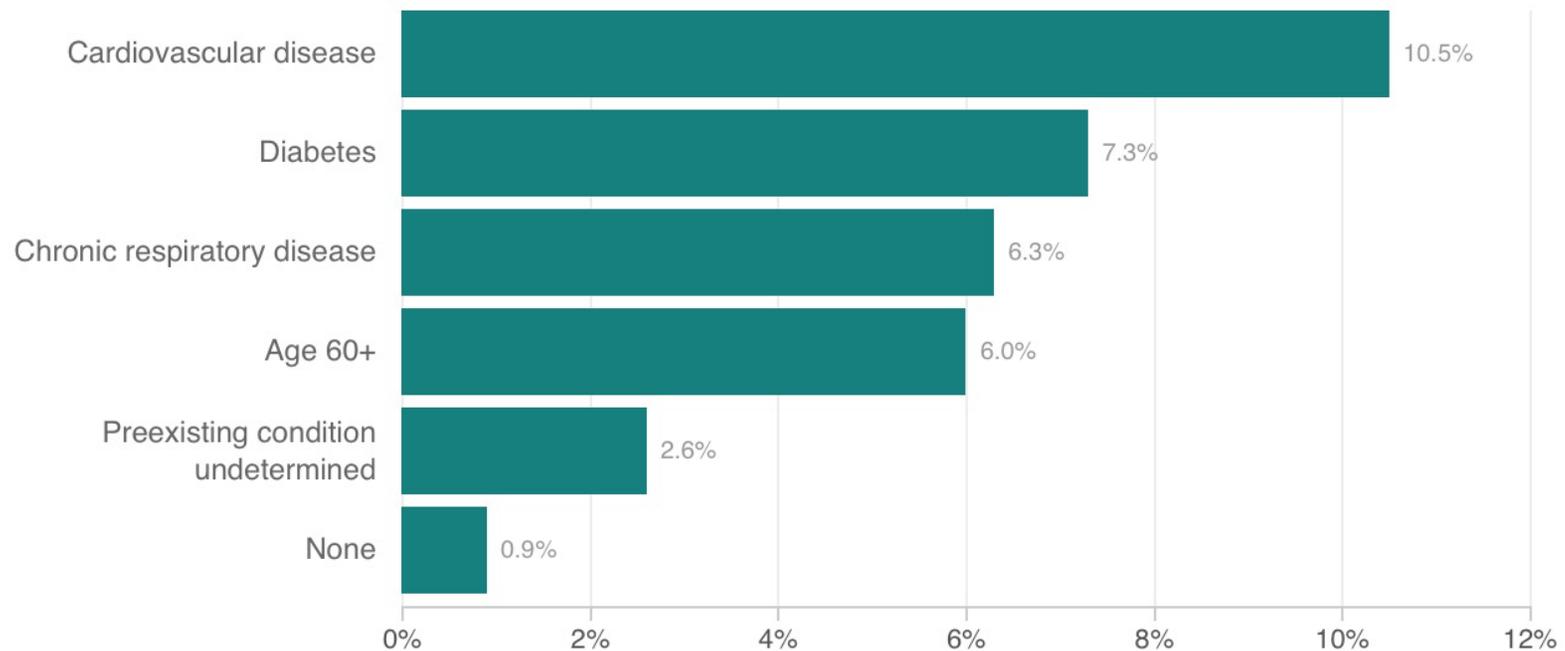
# Likely employed in essential industry



Data: Bureau of Labor Statistics

Unnecessary risk of severe COVID

## Death Rate For COVID-19 Patients In China Higher For Those With Underlying Conditions

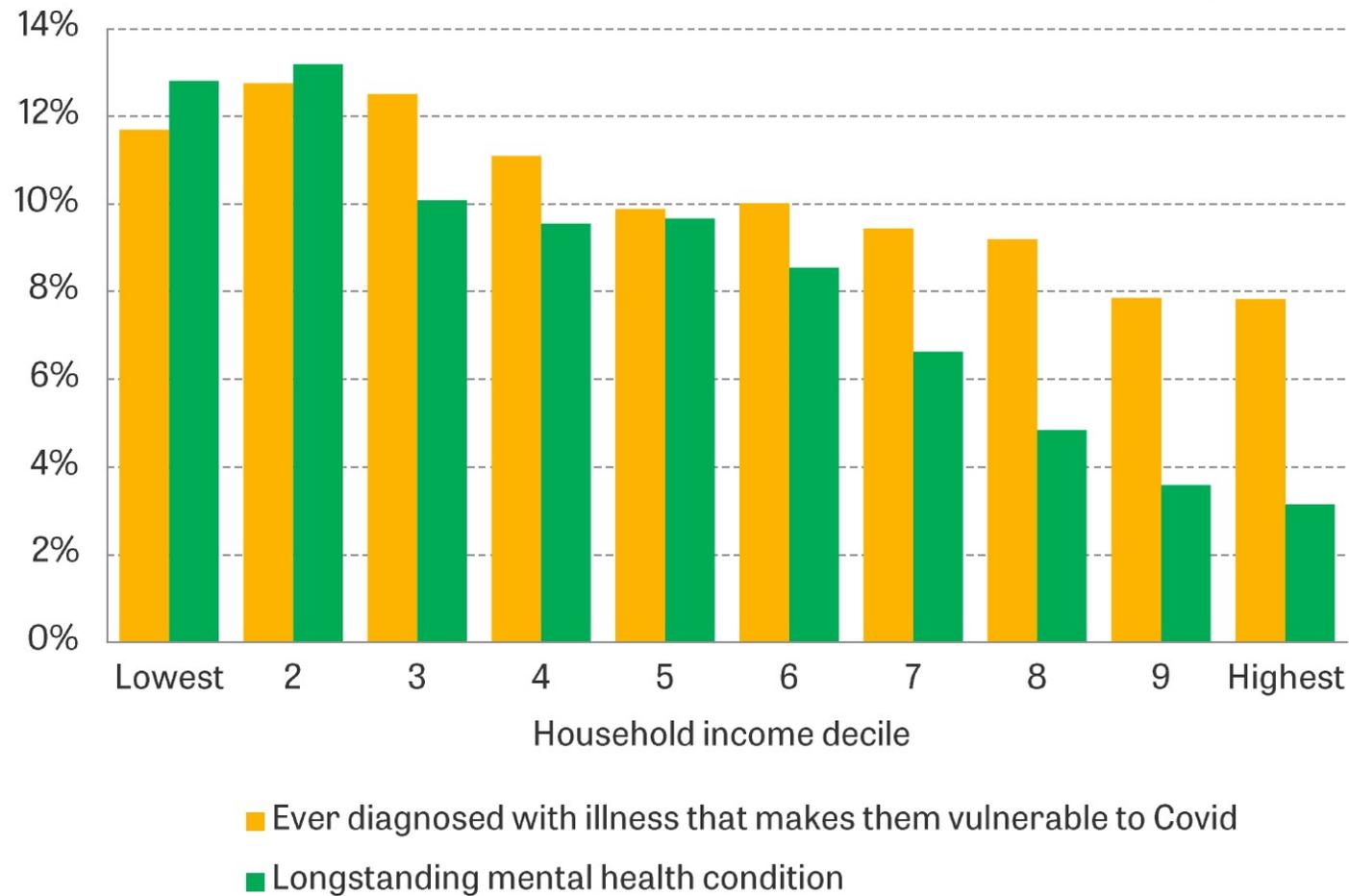


**Notes:** Preexisting condition death rates based on 504 deaths out of 20,812 cases.

*Source: Chinese CDC*

*Credit: Ruth Talbot/NPR and Chris Zubak-Skees/Center for Public Integrity*

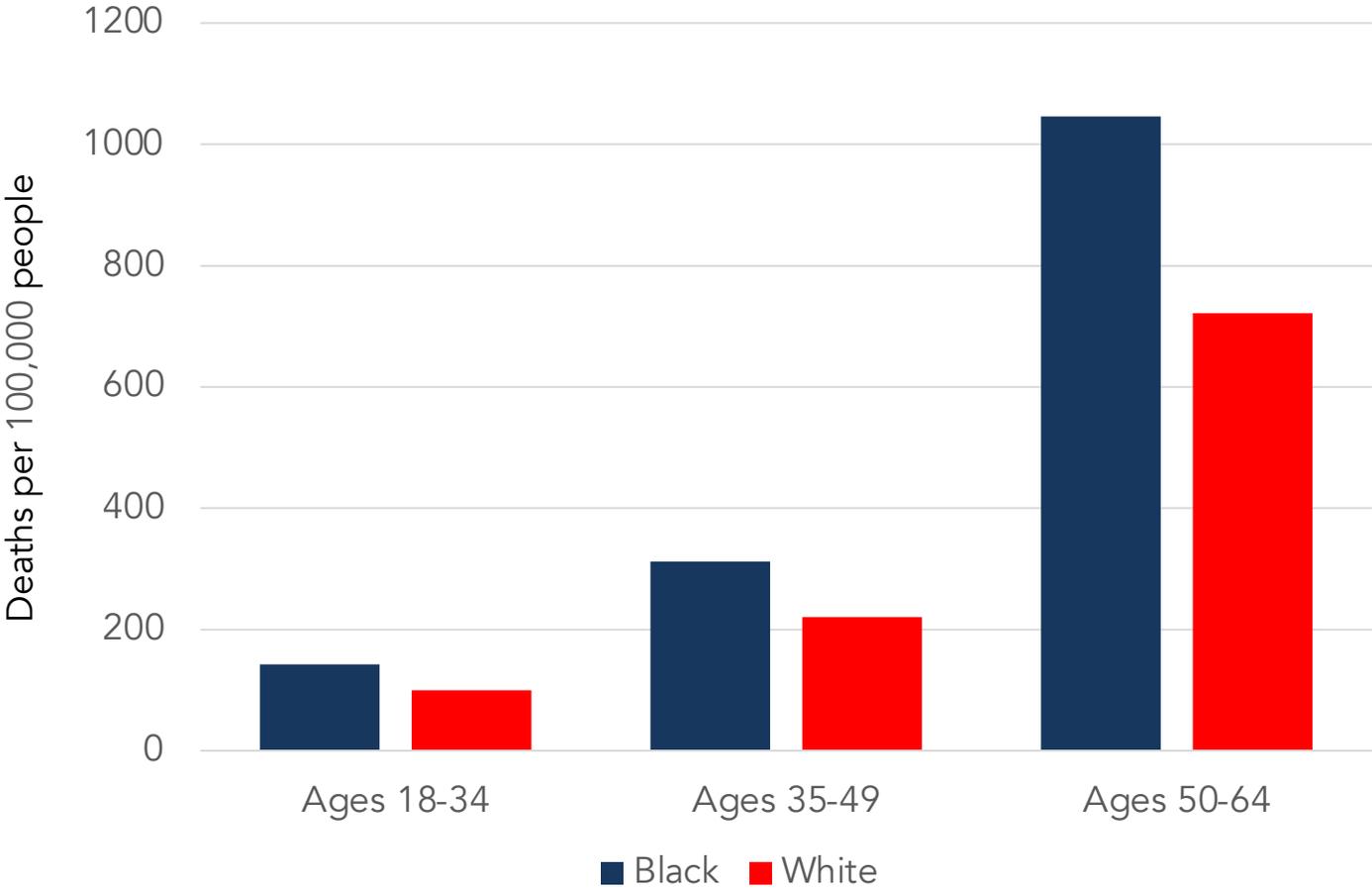
**Figure 16. Medical vulnerability to COVID-19 or the effects of social isolation, by income**



Note: Diagnoses include asthma, congestive heart failure, coronary heart disease, emphysema, chronic bronchitis, cancer or malignancy, diabetes and high blood pressure. Mental health based on self-reported mental health condition lasting or expected to last over 12 months. Deciles based on equivalised net household incomes, using modified OECD equivalence scale.

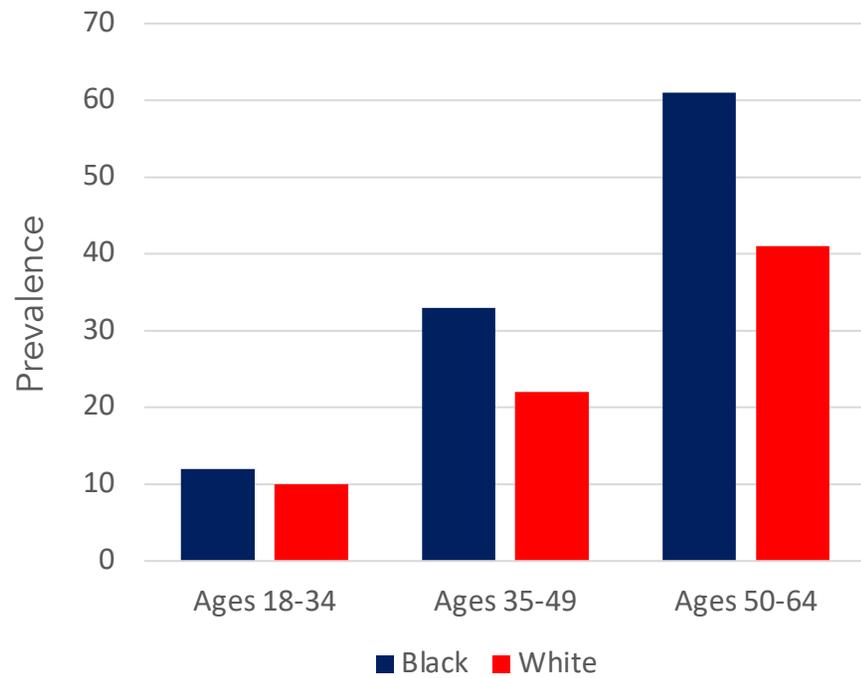
Source: Authors' calculations using UK Household Longitudinal Survey wave 9 (ever diagnosed) and Family Resources Survey 2018–19 (mental health).

# African American v. White mortality rate

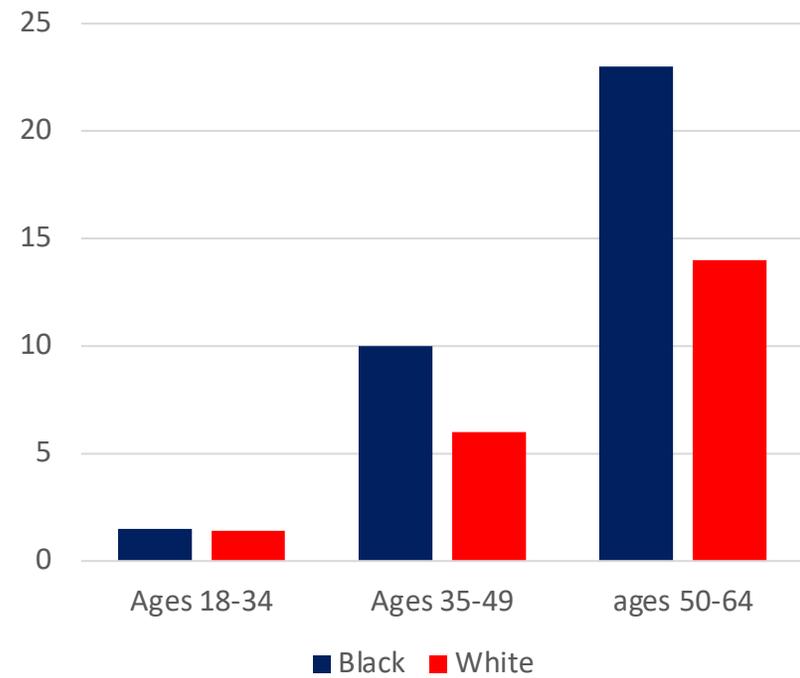


Vital Signs: African American Health. Centers for Disease Control and Prevention Web site. <https://www.cdc.gov/vitalsigns/aahealth/index.html> Accessed October 3, 2019.

## High blood pressure



## Diabetes





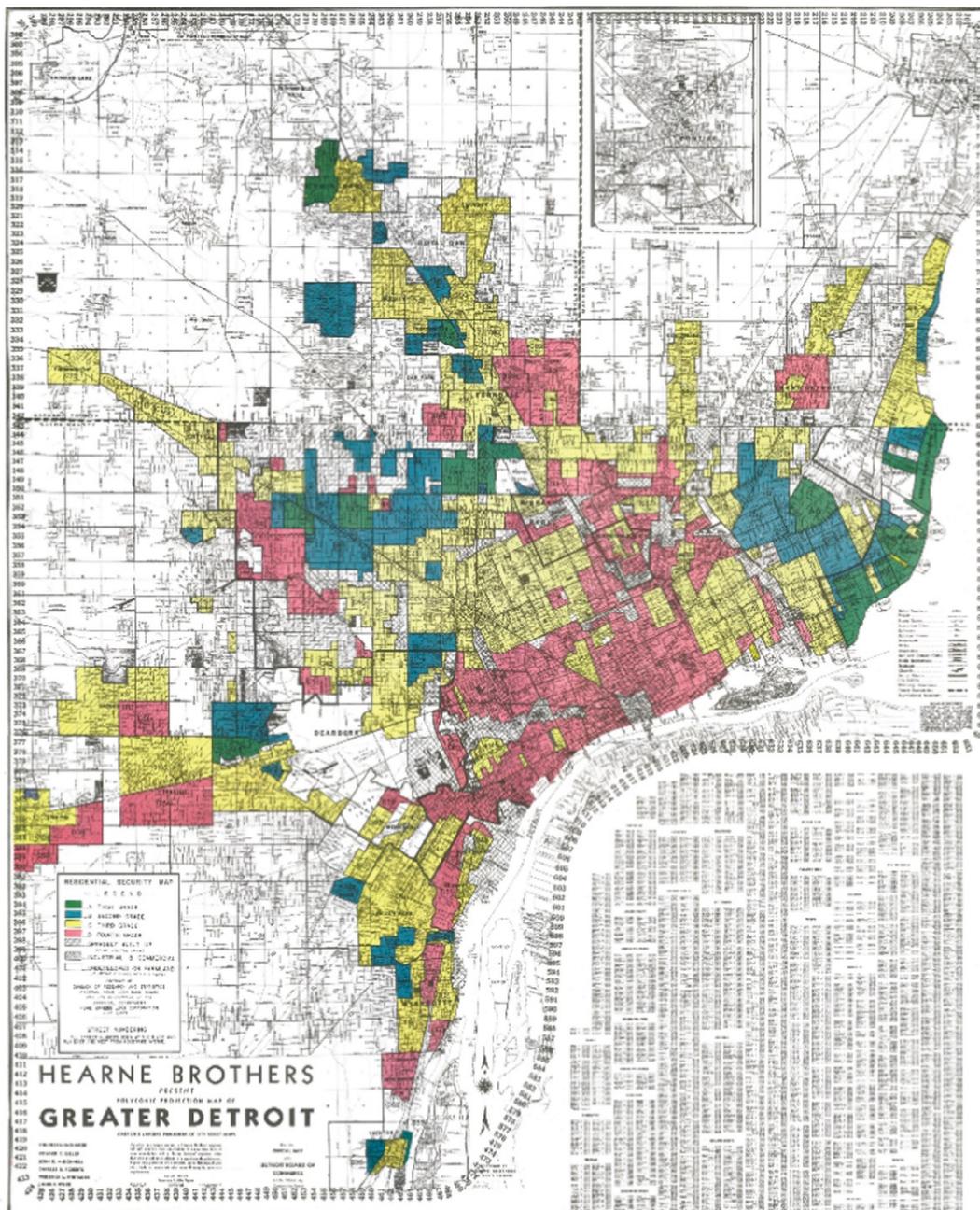


Fig. 1. Detroit home owners loan corporation redlining map, 1939.

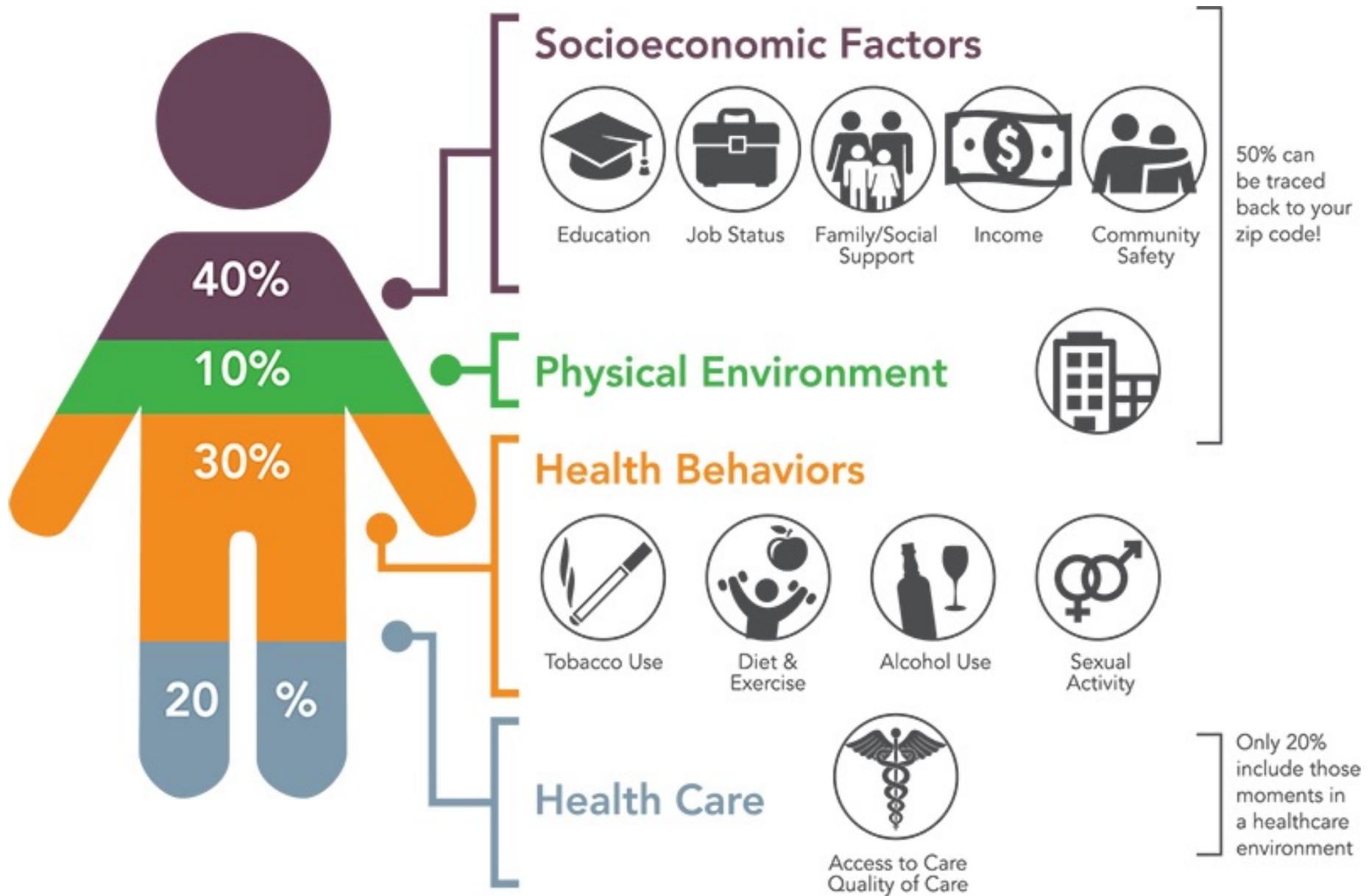
McClure E, Feinstein L, Cordoba E, Douglas C, Emch M, Robinson W, Galea S, Aiello AE. The legacy of redlining in the effect of foreclosures on Detroit residents' self-rated health. *Health and Place*. 2019;55:9-19. PMID: 30448354. <https://doi.org/10.1016/j.healthplace.2018.10.004>

4. Why did we get it wrong?

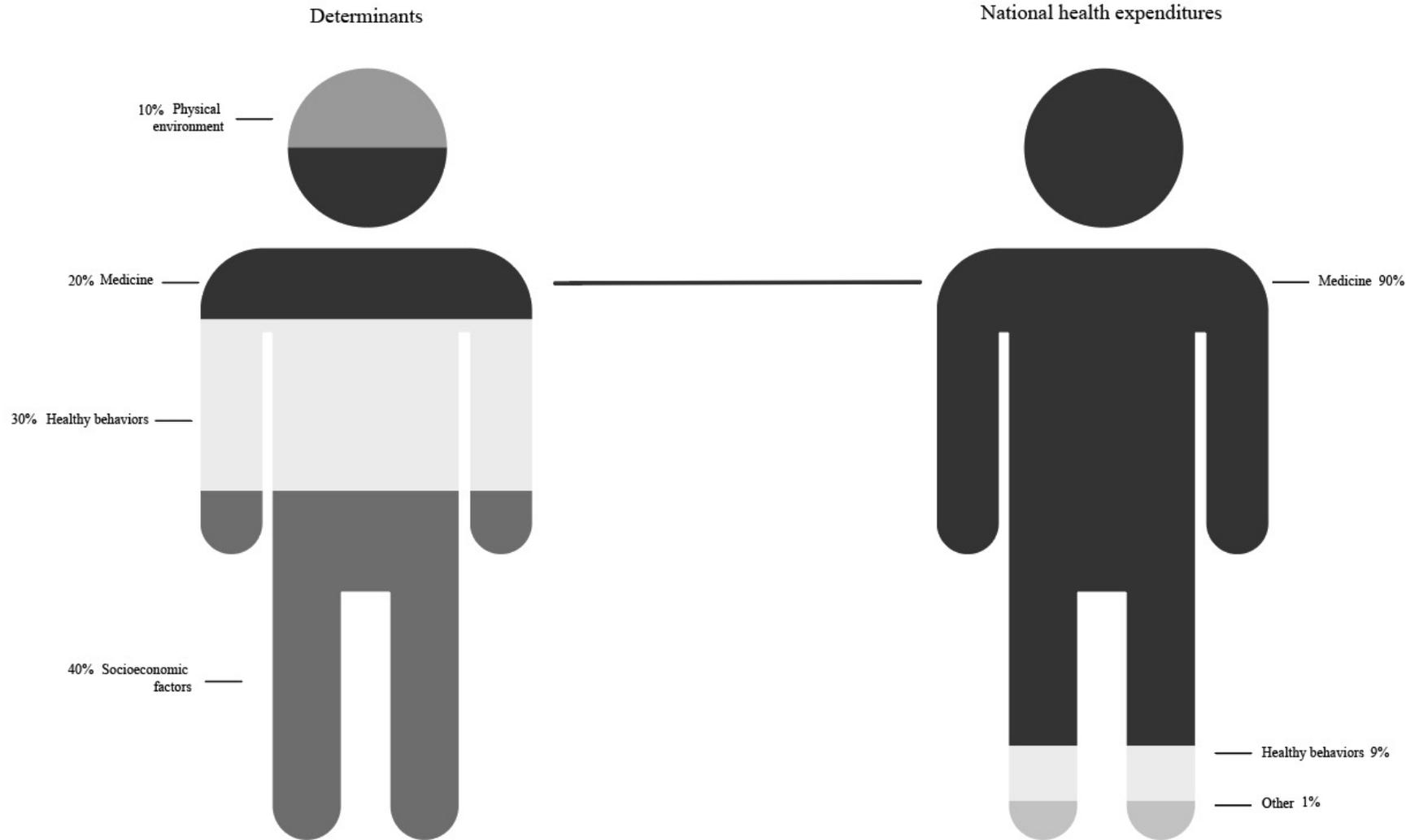
Underinvestment in what makes us healthy



<https://www.americanbluesscene.com/blind-willie-johnson-4f31196c00097/>

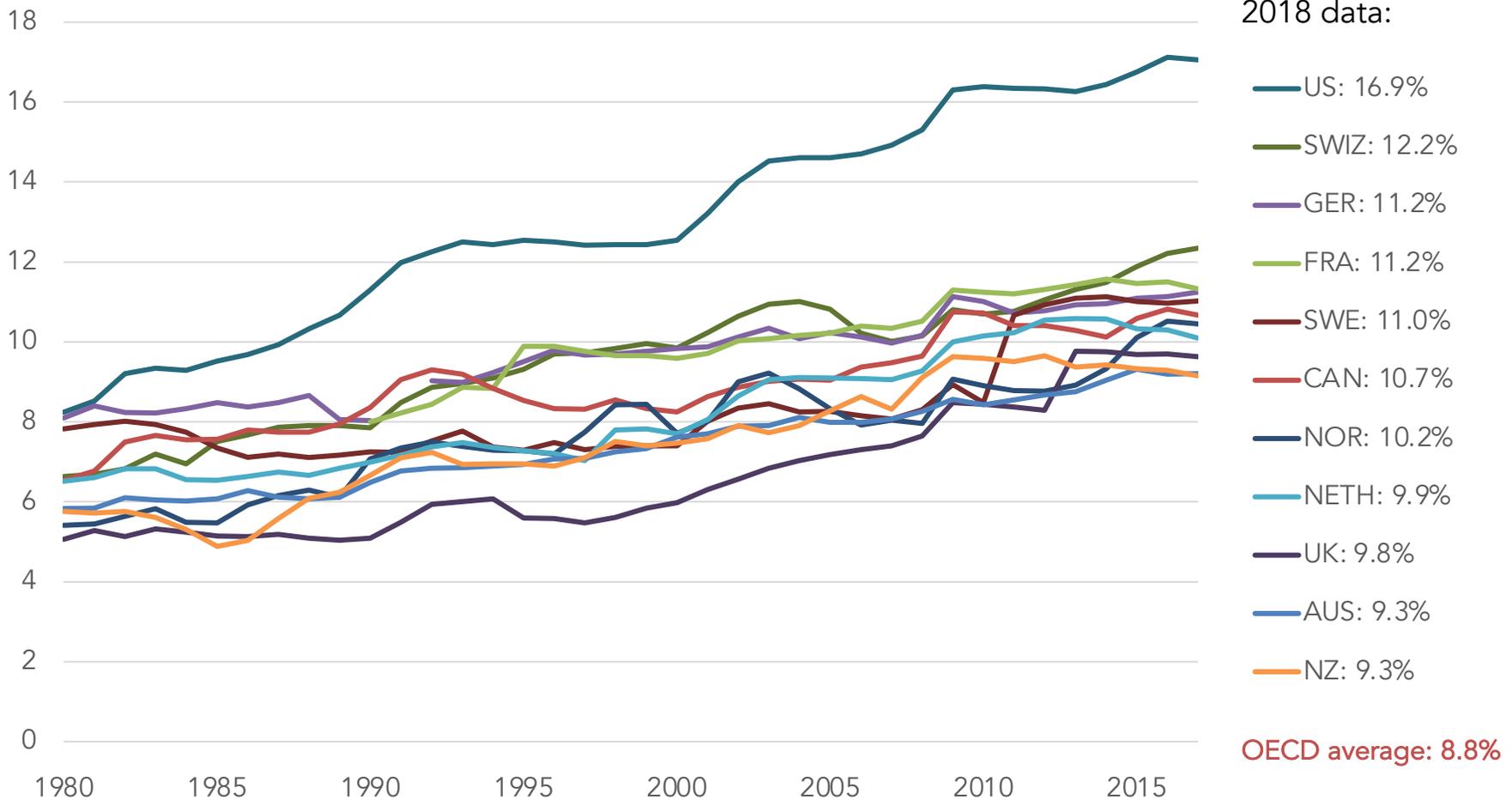


# The spending mismatch: health determinants vs. health expenditures



# Health Care Spending as a Percent of GDP, 1980–2018

Percent (%) of GDP, adjusted for differences in cost of living

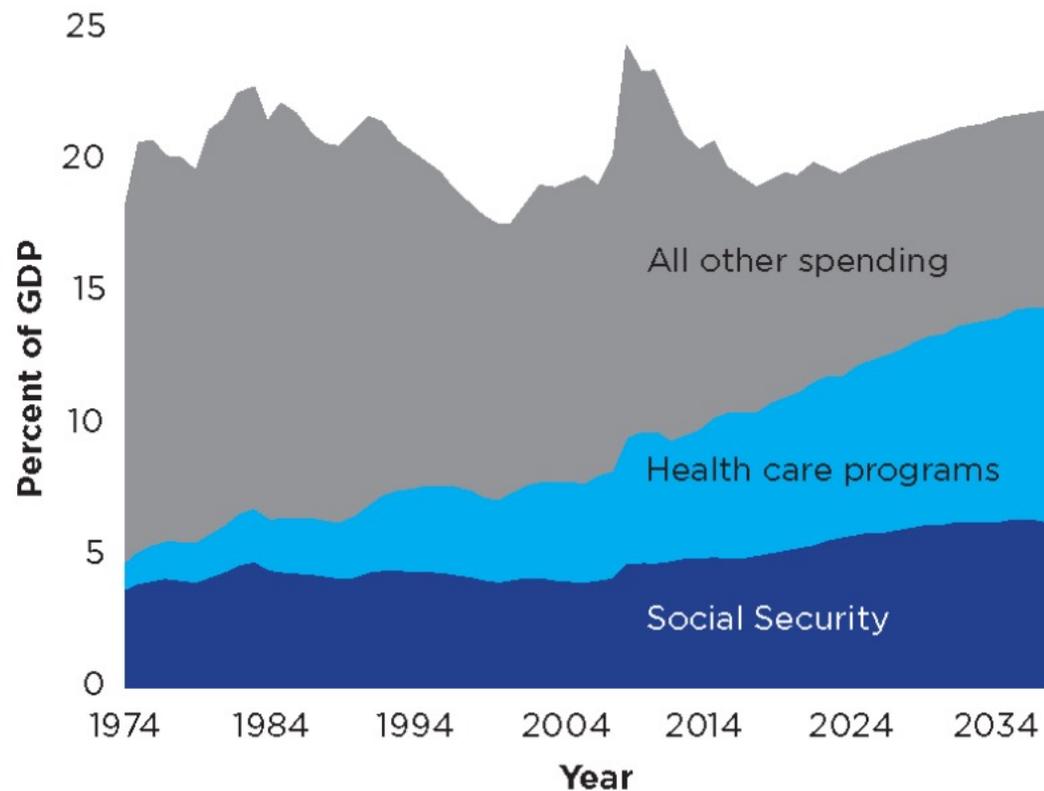


Notes: Current expenditures on health. Based on System of Health Accounts methodology, with some differences between country methodologies. GDP = gross domestic product. OECD average reflects the average of 36 OECD member countries, including ones not shown here. \* 2018 data are provisional or estimated.

Data: OECD Health Statistics 2019.



Source: Roosa Tikkanen and Melinda K. Abrams, *U.S. Health Care from a Global Perspective, 2019: Higher Spending, Worse Outcomes* (Commonwealth Fund, Jan. 2020).

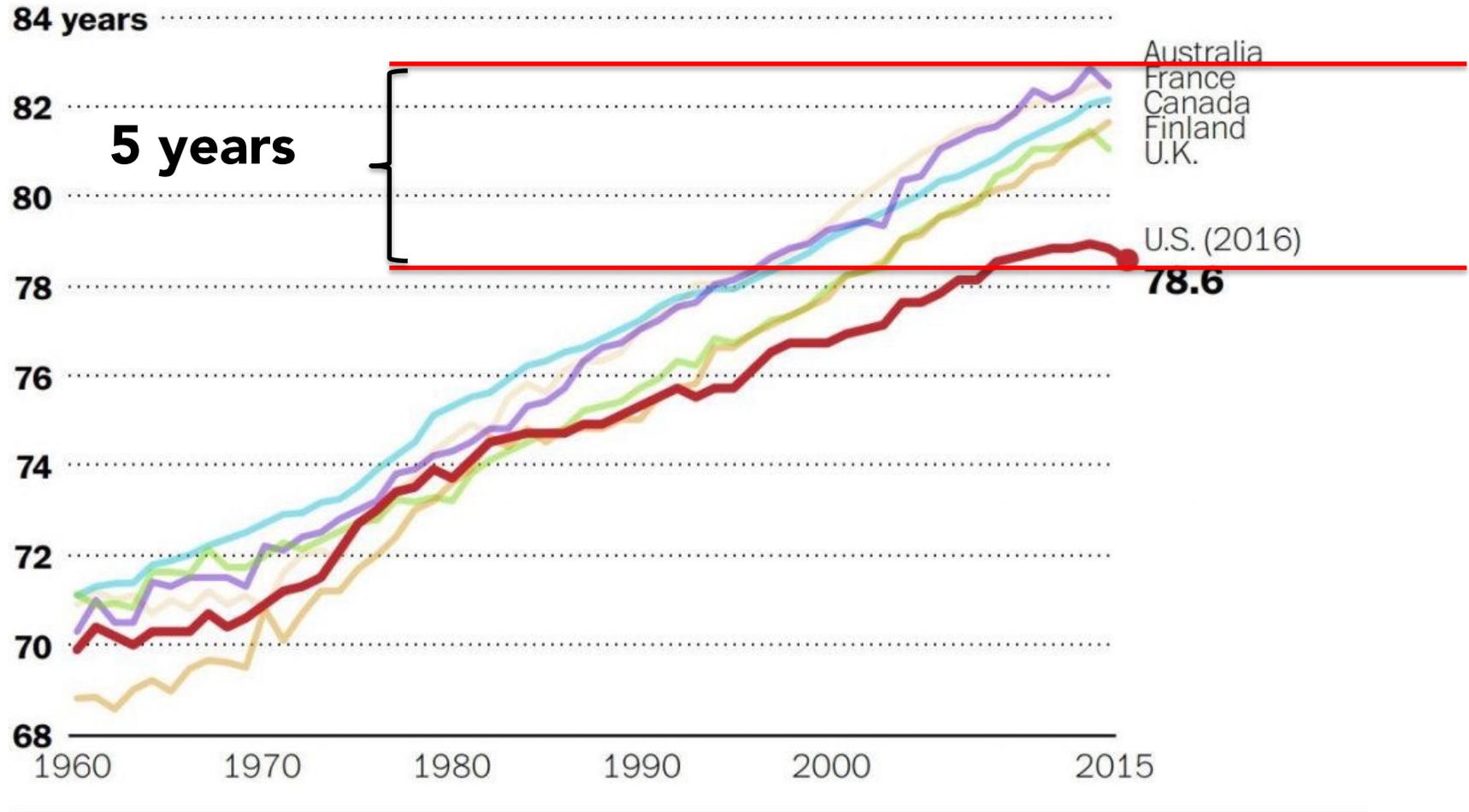


**Figure 3 |** Historical and projected federal spending: health care and other programs.

SOURCE: Data from Congressional Budget Office.

# American exceptionalism

Life expectancy at birth, selected OECD countries

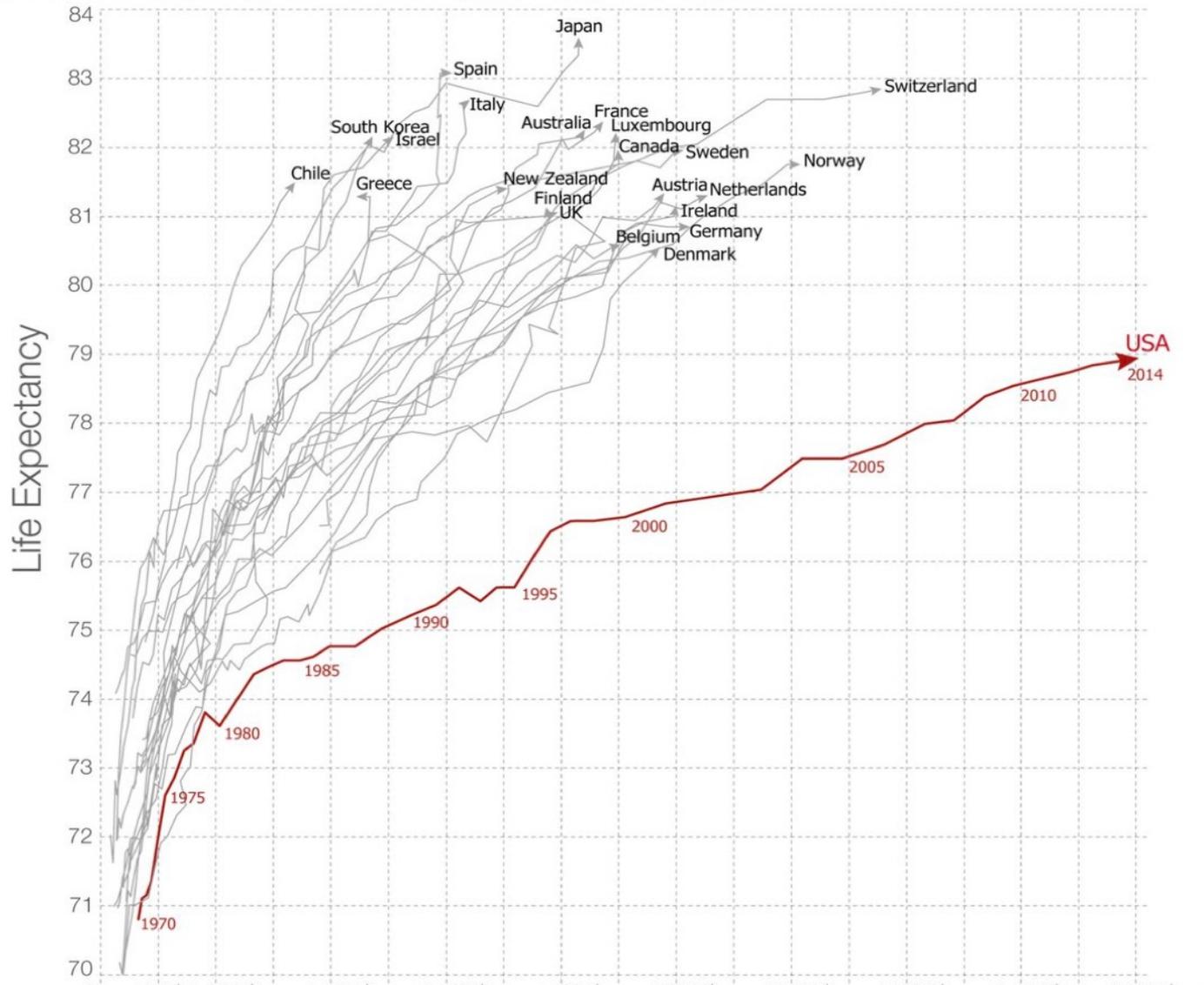


Source: OECD, U.S. Census Bureau

# Life expectancy vs. health expenditure over time (1970-2014)

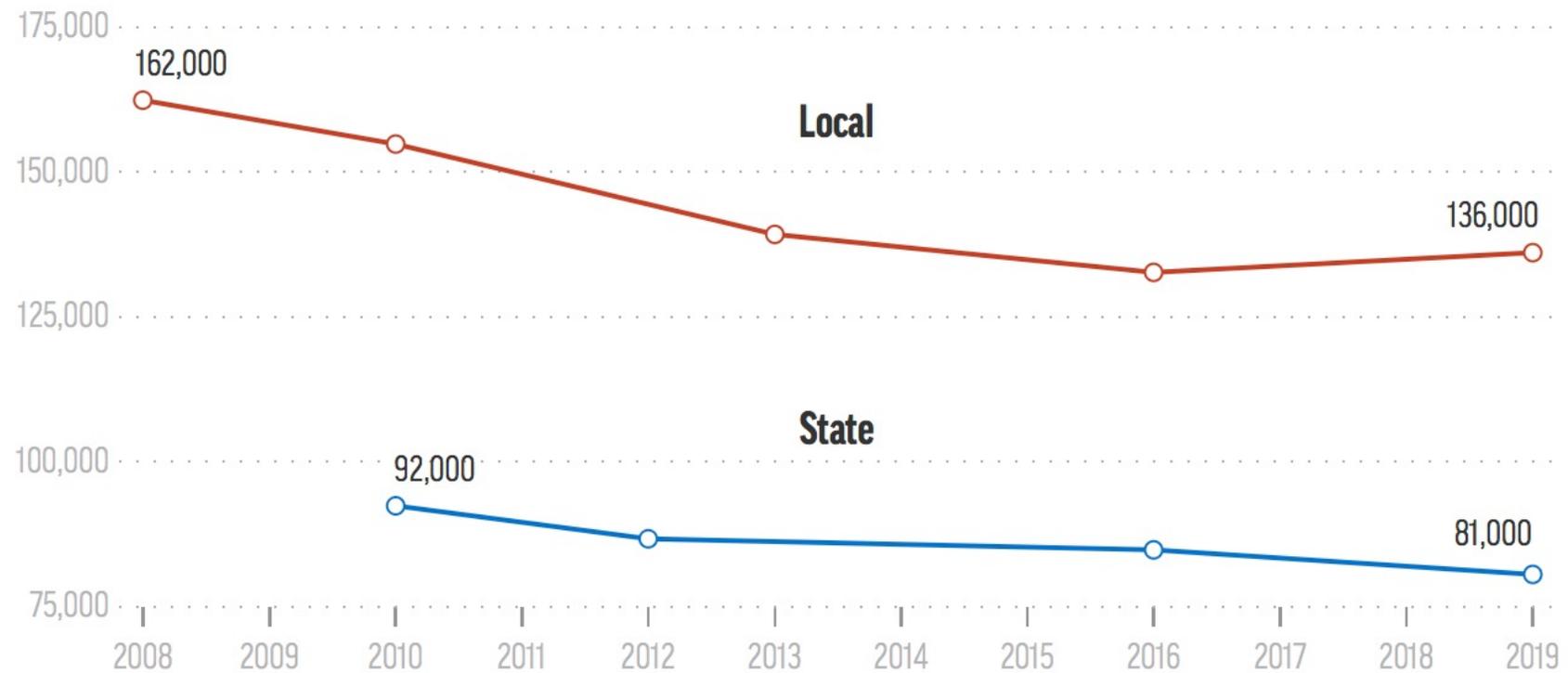


Health spending measures the consumption of health care goods and services, including personal health care (curative care, rehabilitative care, long-term care, ancillary services and medical goods) and collective services (prevention and public health services as well as health administration), but excluding spending on investments. Shown is total health expenditure (financed by public and private sources).



Underinvestment in what may have helped

# State and local public health workforces have shrunk



State figures are for full-time equivalent employees in state public health agencies excluding Kansas, New Jersey, Texas and Wyoming, which do not have comparable data. Local figures are for full-time equivalent employees of local health departments.

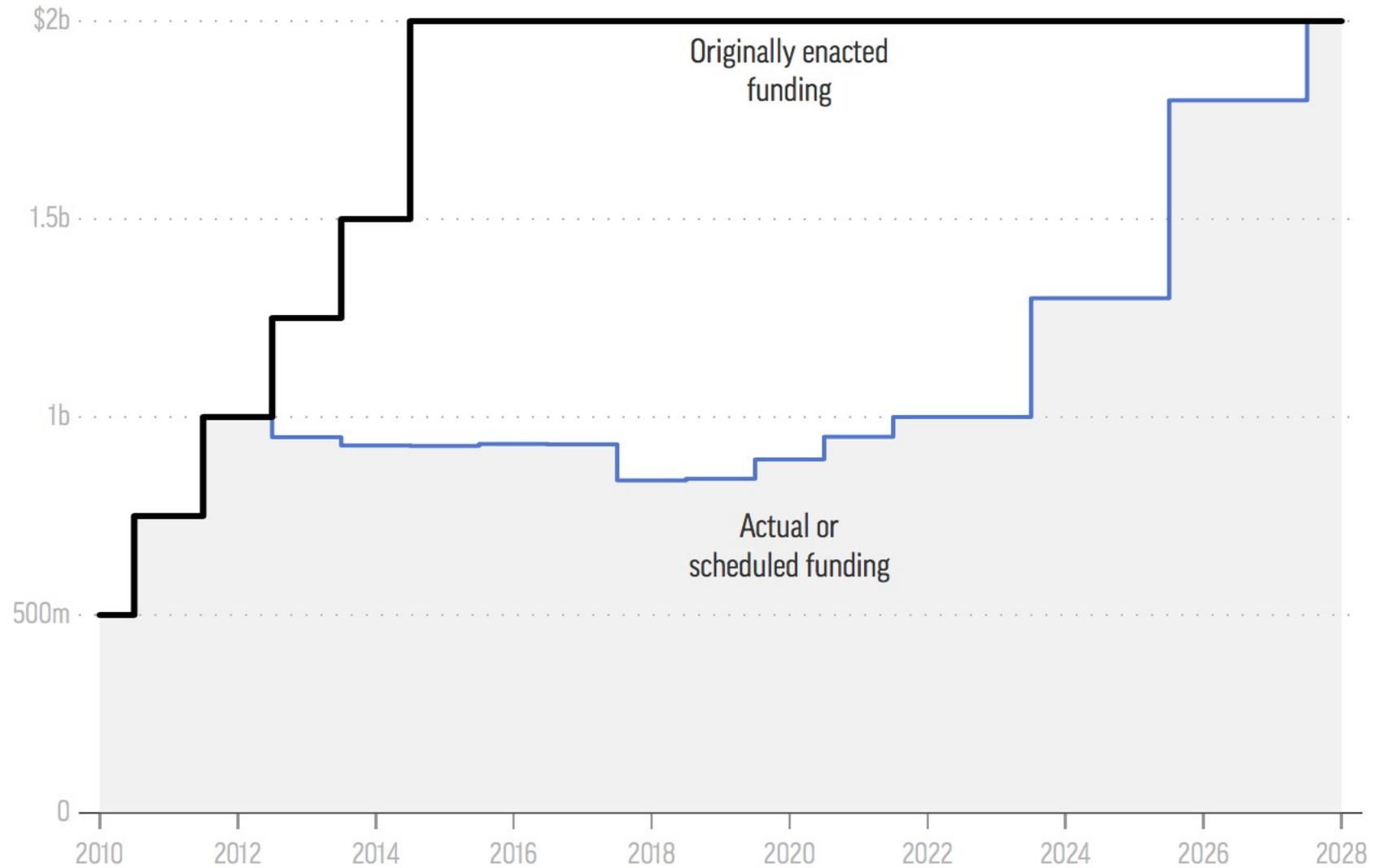
Source: Association of State and Territorial Health Officials, National Association of County and City Health Officials /

Graphic: Hannah Recht/KHN, Francois Duckett/AP





# Federal Prevention and Public Health Fund faces shortfalls

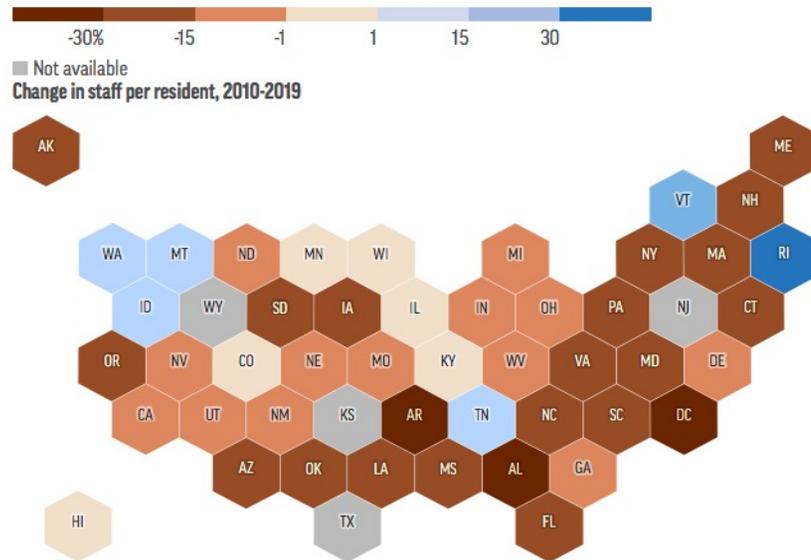


Source: Trust for America's Health / Graphic: Hannah Recht/KHN, Francois Duckett/AP



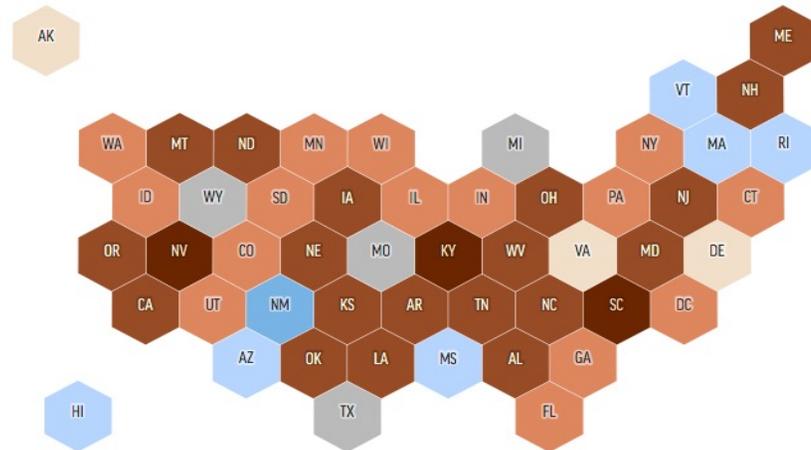
<https://khn.org/news/us-public-health-system-underfunded-under-threat-faces-more-cuts-amid-covid-pandemic/>

## Most state public health agency staffing and spending dropped



Map data: [Tilegrams/NPR](#)

## Change in expenditures per resident, 2010-2018



Staff data represents full-time equivalent employees. Expenditures are inflation-adjusted to constant 2019 dollars

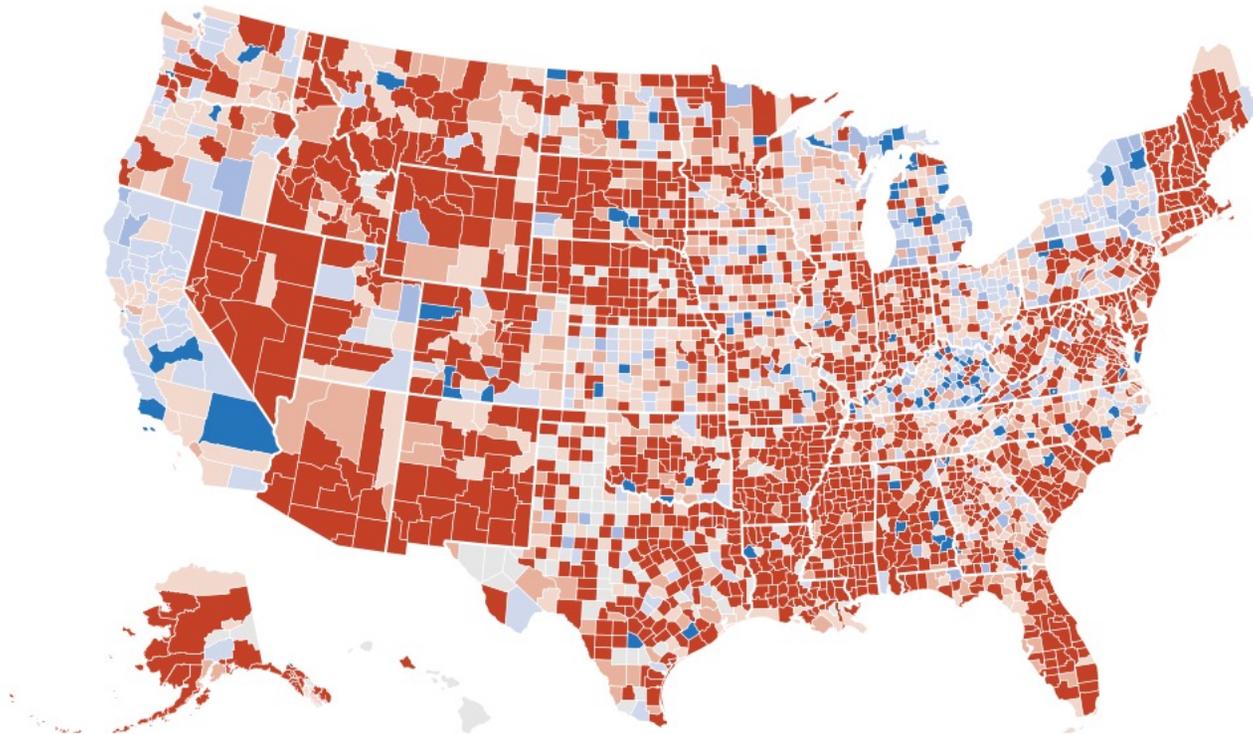
Source: Association of State and Territory Health Officials Graphics: Hannah Recht/KHN, Francois Duckett/AP

/ Map data: [Tilegrams/NPR](#)



## Most local governments spend more on policing than health

Higher spending on policing Higher spending on nonhospital health



Spending for all local governments within each county. Nonhospital health includes public health, behavioral health, medical transportation and other nonhospital health-related spending. It does not include Medicaid spending. Gray counties had no data available.

Source: State Health Expenditure Dataset project analysis of "Annual Survey of State and Local Government Finances" 2017 data / Graphic: Hannah Recht/KHN, Francois Duckett/AP



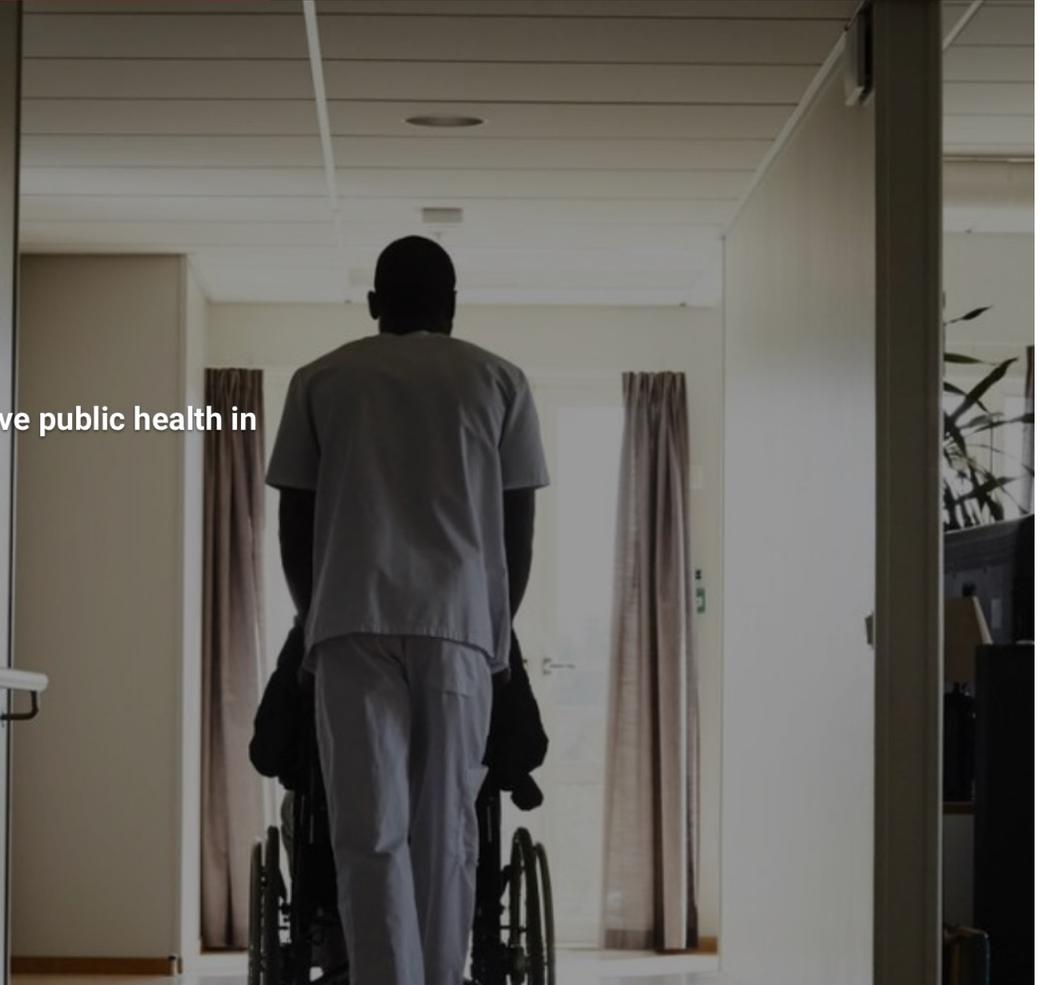
5. Seizing the Covid-19 moment of opportunity

COMMENTARY

# We Need a Health New Deal

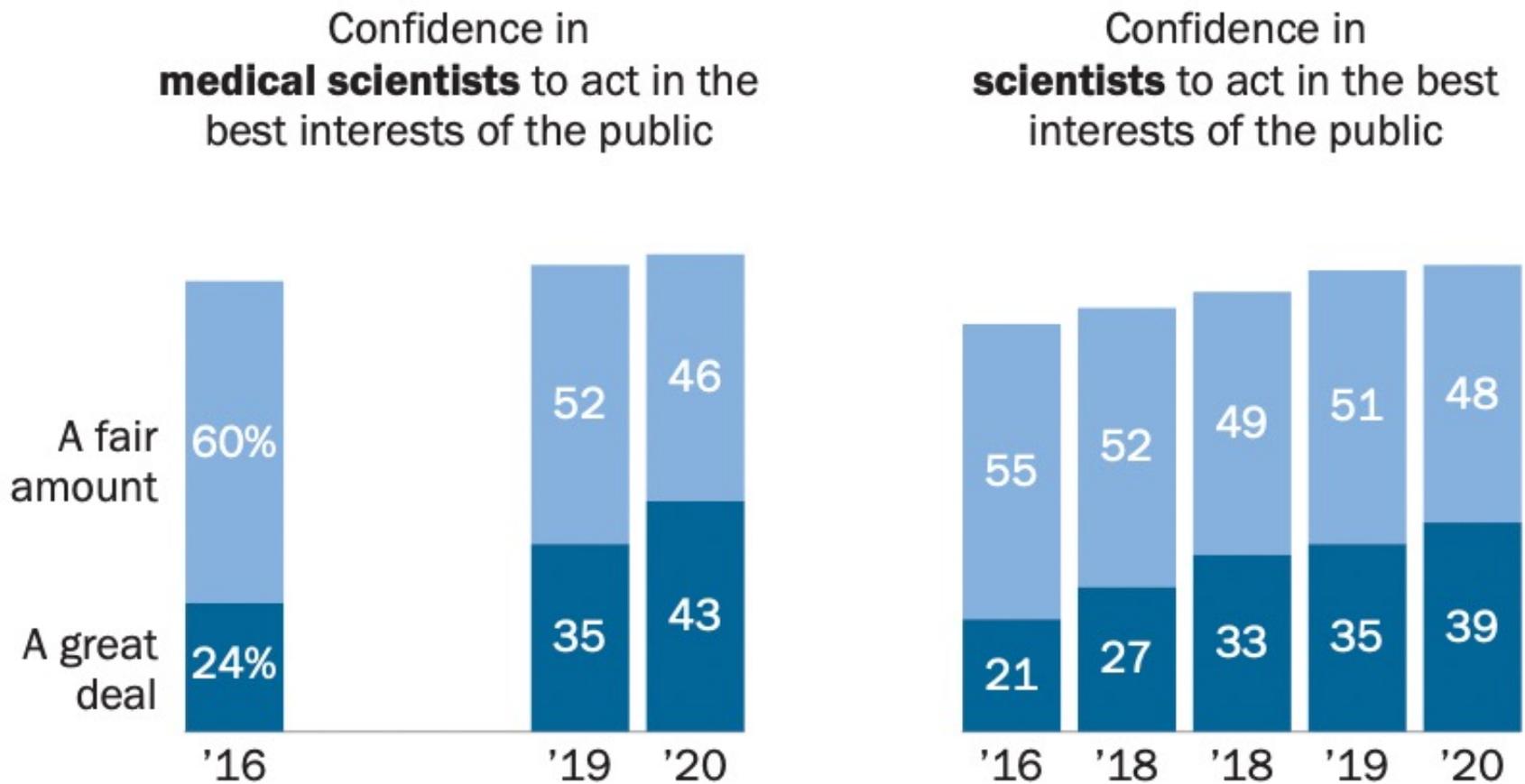
There are three priorities we need to focus on to improve public health in the U.S.

By Sandro Galea Contributor March 1, 2019, at 10:11 a.m.

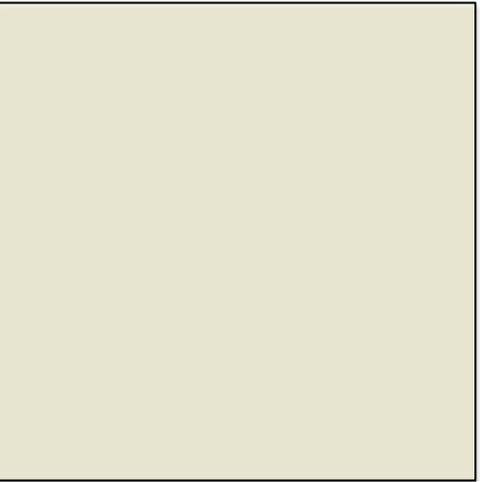
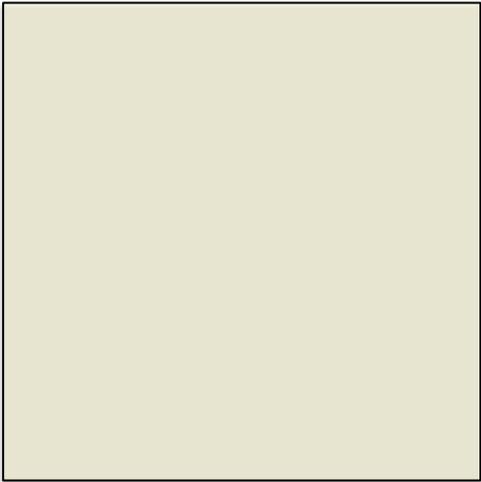
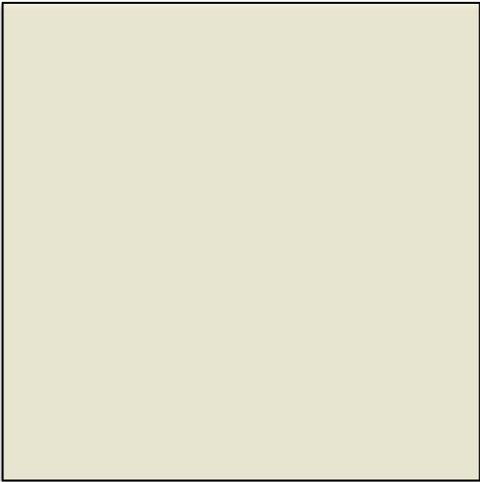
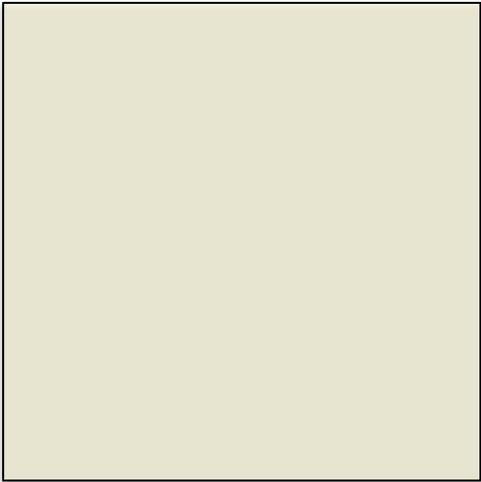


# Americans express growing confidence in medical scientists since the COVID-19 outbreak

*% of U.S. adults*



**Values that allow action**



**Knowledge that can inform action**

6. Ever better science

- a. Avoiding false certitude
- b. Acknowledging contradiction
- c. Tolerating disagreement

- a. Avoiding false certitude
- b. Acknowledging contradiction
- c. Tolerating disagreement

“ With a lot at stake, it is wise to be humble when faced with fundamental limitations. Dynamic models are usable as long as they take into account the uncertainty of the assumptions on which they are based and the data they are led by. If this is not the case, the results are on a par with assumptions or guesses. ”



# The effects of communicating uncertainty on public trust in facts and numbers

Anne Marthe van der Bles<sup>a,b,c,1</sup>, Sander van der Linden<sup>a,b,d,1</sup>, Alexandra L. J. Freeman<sup>a,b</sup>, and David J. Spiegelhalter<sup>a,b</sup>

<sup>a</sup>Winton Centre for Risk and Evidence Communication, University of Cambridge, Cambridge CB3 0WA, United Kingdom; <sup>b</sup>Department of Pure Mathematics and Mathematical Statistics, University of Cambridge, Cambridge CB3 0WA, United Kingdom; <sup>c</sup>Department of Social Psychology, University of Groningen, 19712 TS Groningen, The Netherlands; and <sup>d</sup>Cambridge Social Decision-Making Lab, Department of Psychology, University of Cambridge, Cambridge CB2 3RQ, United Kingdom

Edited by Arild Underdal, University of Oslo, Oslo, Norway, and approved February 20, 2020 (received for review August 7, 2019)

**Uncertainty is inherent to our knowledge about the state of the world yet often not communicated alongside scientific facts and numbers. In the “posttruth” era where facts are increasingly contested, a common assumption is that communicating uncertainty will reduce public trust. However, a lack of systematic research makes it difficult to evaluate such claims. We conducted five experiments—including one preregistered replication with a national sample and one field experiment on the BBC News website (total  $n = 5,780$ )—to examine whether communicating epistemic uncertainty about facts across different topics (e.g., global warming, immigration), formats (verbal vs. numeric), and magnitudes (high vs. low) influences public trust. Results show that whereas people do perceive greater uncertainty when it is communicated, we observed only a small decrease in trust in numbers and trustworthiness of the source, and mostly for verbal uncertainty communication. These results could help reassure all communicators of facts and science that they can be more open and transparent about the limits of human knowledge.**

communication | uncertainty | trust | posttruth | contested

Our knowledge is inherently uncertain. The process by which we gather information about the state of the world is characterized by assumptions, limitations, extrapolations, and generalizations, which brings imprecisions and uncertainties to the facts, numbers, and scientific hypotheses that express our understanding of the world around us. However, despite the fact that scientists and other producers of knowledge are usually well-aware of the uncertainties around their findings, these are often not communicated clearly to the public and other key stakeholders (1). This lack of transparency could potentially compromise important decisions people make based on scientific or statistical evidence, from personal medical decisions to government policies.

Recent societal developments do not seem to encourage more openness about uncertainty: It has been suggested that we are living in a “posttruth” era in which facts, evidence, and experts are deeply mistrusted (2). Cross-national survey studies suggest that in many countries, trust in institutions and governments is in decline (3–5). Although the underlying causes of changes in trust are likely to be complex and varied, it has been suggested that one way to potentially repair and restore public trust in science, evidence, and official statistics is to be more open and transparent about scientific uncertainty (2). However, it is often assumed that communicating uncertainty transparently will invite criticism, can signal incompetence, or even decrease public trust in science (1, 6–8). In fact, as summarized by the National Academies of Sciences, Engineering, and Medicine report on science communication, “as a rule, people dislike uncertainty [...] people may attribute uncertainty to poor science [...] and] in some cases, communicating uncertainty can diminish perceived scientific authority” (ref. 7, pp. 27–28). For example, research by Johnson and Slovic (9) found that for some respondents, uncertainty “evoked doubt about agency trustworthiness” (p. 490), and that “despite

the general sense of honesty evoked [by uncertainty] . . . this did not seem to offset concerns about the agency’s competence” (p. 491). In fact, partly for these reasons, Fischhoff (1) notes that scientists may be reluctant to discuss the uncertainties of their work. This hesitation spans across domains: For example, journalists find it difficult to communicate scientific uncertainty and regularly choose to ignore it altogether (10, 11). Physicians are reluctant to communicate uncertainty about evidence to patients (12), fearing that the complexity of uncertainty may overwhelm and confuse patients (13, 14). Osman et al. (15) even go as far as to argue explicitly that “the drive to increase transparency on uncertainty of the scientific process specifically does more harm than good” (p. 131).

At the same time, many organizations that produce and communicate evidence to the public, such as the European Food Safety Authority, have committed themselves to openness and transparency about their (scientific) work, which includes communicating uncertainties around evidence (16–19). These attempts have not gone without criticism and discussion about the potential impacts on public opinion (15, 20). What exactly do we know about the effects of communicating uncertainty around facts, numbers, and science to the public?

## Significance

**Does openly communicating uncertainty around facts and numbers necessarily undermine audiences’ trust in the facts, or the communicators? Despite concerns among scientists, experts, and journalists, this has not been studied extensively. In four experiments and one field experiment on the BBC News website, words and numerical ranges were used to communicate uncertainty in news article-like texts. The texts included contested topics such as climate change and immigration statistics. While people’s prior beliefs about topics influenced their trust in the facts, they did not influence how people responded to the uncertainty being communicated. Communicating uncertainty numerically only exerted a minor effect on trust. Knowing this should allow academics and science communicators to be more transparent about the limits of human knowledge.**

Author contributions: A.M.v.d.B., S.v.d.L., A.L.J.F., and D.J.S. designed research; A.M.v.d.B., S.v.d.L., and A.L.J.F. performed research; A.M.v.d.B. and S.v.d.L. analyzed data; and A.M.v.d.B., S.v.d.L., A.L.J.F., and D.J.S. wrote the paper.

The authors declare no competing interest.

This article is a PNAS Direct Submission.

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Data deposition: The datasets collected and analyzed in this paper are available on the Open Science Framework (<https://doi.org/10.17605/OSF.IO/MT657>).

<sup>1</sup>To whom correspondence may be addressed. Email: a.m.van.der.bles@rug.nl or sander.vanderlinden@psychol.cam.ac.uk.

This article contains supporting information online at <https://www.pnas.org/lookup/suppl/doi:10.1073/pnas.1913678117/-DCSupplemental>.

First published March 23, 2020.



# The effects of communicating uncertainty on public trust in facts and numbers

Anne Marthe van der Bles<sup>a,b,c,1</sup>, Sander van der Linden<sup>a,b,d,1</sup>, Alexandra L. J. Freeman<sup>a,b</sup>, and David J. Spiegelhalter<sup>a,b</sup>

<sup>a</sup>Winton Centre for Risk and Evidence Communication, University of Cambridge, Cambridge CB3 0WA, United Kingdom; <sup>b</sup>Department of Pure Mathematics and Mathematical Statistics, University of Cambridge, Cambridge CB3 0WA, United Kingdom; <sup>c</sup>Department of Social Psychology, University of Groningen, 19712 TS Groningen, The Netherlands; and <sup>d</sup>Cambridge Social Decision-Making Lab, Department of Psychology, University of Cambridge, Cambridge CB2 3RQ, United Kingdom

Edited by Arild Underdal, University of Oslo, Oslo, Norway, and approved February 20, 2020 (received for review August 7, 2019)

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Author contributions: A.M.v.d.B., S.v.d.L., A.L.J.F., and D.J.S. designed research; A.M.v.d.B., S.v.d.L., and A.L.J.F. performed research; A.M.v.d.B. and S.v.d.L. analyzed data; and A.M.v.d.B., S.v.d.L., A.L.J.F., and D.J.S. wrote the paper.

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First published March 23, 2020.

- a. Avoiding false certitude
- b. Acknowledging contradiction
- c. Tolerating disagreement

**Vox**



**You do not need a mask  
to avoid coronavirus.**

**Masks are only useful if you already  
have a respiratory infection and want  
to avoid spreading it to others.**

Source: CDC





**Vox**   
@voxdotcom



We've deleted two tweets from March about mask-wearing. Though we replied with an update when CDC guidance changed to recommend masks, recent replies suggest the time frame of the update was unclear.

To ensure current public health guidance is clear, we deleted the tweets.

3:18 PM · Dec 21, 2020 · TweetDeck

---

**34** Retweets   **149** Quote Tweets   **300** Likes

---

- a. Avoiding false certitude
- b. Acknowledging contradiction
- c. Tolerating disagreement

# Great Barrington Declaration

As infectious disease epidemiologists and public health scientists we have grave concerns about the damaging physical and mental health impacts of the prevailing COVID-19 policies, and recommend an approach we call Focused Protection.

[READ THE  
DECLARATION](#)

[SIGN THE  
DECLARATION](#)

[CURRENT SIGNATURE COUNT](#)

<a href="#">FRANÇAIS</a>	<a href="#">PORTUGUÊS</a>	<a href="#">ESPAÑOL</a>	<a href="#">ITALIANO</a>
<a href="#">DEUTSCH</a>	<a href="#">SVENSKA</a>	<a href="#">РУССКИЙ</a>	<a href="#">עברית</a>
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<a href="#">УКРАЇНСЬКИЙ</a>	<a href="#">CATALÀ</a>	<a href="#">한국어</a>	<a href="#">BAHASA INDONESIA</a>
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## Herding People to Slaughter: The Dangerous Fringe Theory behind the Great Barrington Declaration and Push toward Herd Immunity

DERRICK Z. JACKSON, FELLOW | OCTOBER 23, 2020, 5:19 PM EDT

[Like 9.3K](#) [Tweet](#) [SHARE](#)

Officials at the highest levels are discussing the possibility of caving in on controlling the coronavirus and instead letting it run rampant



“ Adopting measures to protect the vulnerable should be the central aim of public health responses to COVID-19. By way of example, nursing homes should use staff with acquired immunity and perform frequent testing of other staff and all visitors. Staff rotation should be minimized. Retired people living at home should have groceries and other essentials delivered to their home. When possible, they should meet family members outside rather than inside. A comprehensive and detailed list of measures, including approaches to multi-generational households, can be implemented, and is well within the scope and capability of public health professionals. ”

# Philly's school reopening plan is put on hold after an outcry: 'We should not have to teach students to death'

Principals, teachers, parents, and students blasted the plan developed by Superintendent William R. Hite Jr., saying it would neither keep children and staff safe nor offer a robust educational experience.



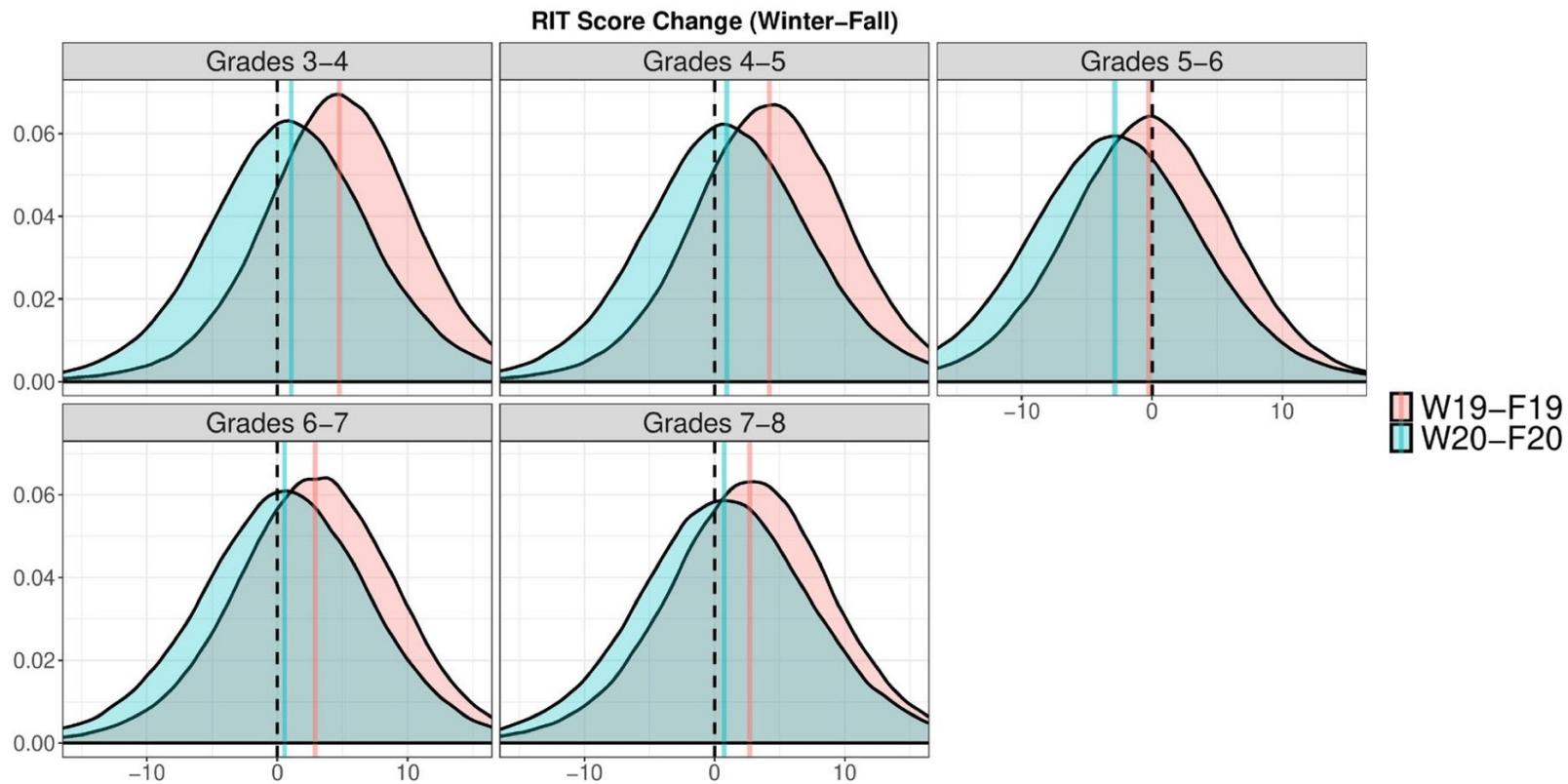
Superintendent William Hite Jr. wants Philly schools to open two days a week to most students. Hite, shown in this file photo, heard an earful about his school reopening plan at a school board r... [Read more](#)

ADVERTISEMENT

## 7. The challenges to our approaches

- a. The complexity of the system
- b. Our biases and privileged perspectives
- c. Epistemic arrogance

- a. The complexity of the system
- b. Our biases and privileged perspectives
- c. Epistemic arrogance



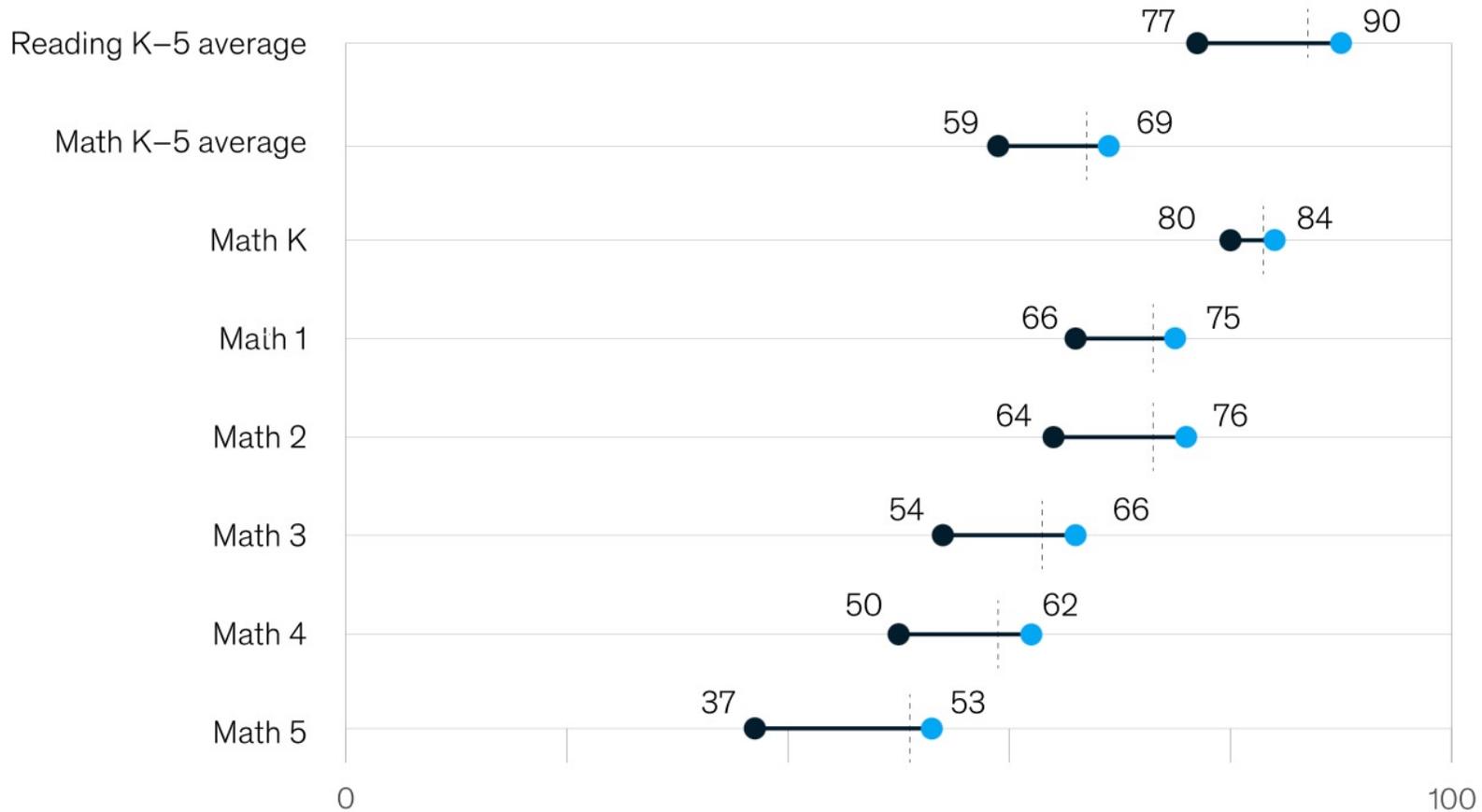
**nwea**RESEARCH

*Figure 3: Distribution of within-student change from winter 2019–fall 2019 vs. winter 2020–fall 2020 in math. Note: The vertical red and blue lines display the median growth estimate for winter 2019–fall 2019 and winter 2020–fall 2020 respectively. The black dashed line represents zero growth (e.g., winter and fall test scores were equivalent).*

# Most students are falling behind, but students of color are faring worse.

**Amount students learned in the 2019–20 school year, % of historical scores<sup>1</sup>**

● Schools with >50% students of color    All schools average    ● Schools with >50% white students



<sup>1</sup>Percent of an “average” year of learning gained by students in 2019–20 school year, where 100% is equivalent to historical matched scores over previous 3 years. Source: Curriculum Associates

CALIFORNIA



## Schools in more affluent areas move faster to reopen than those in low-income communities



First-grader Braylen Coleman has her temperature checked by teacher's aide Firoozeh Borjian as she arrives at Alta Vista Elementary School in Redondo Beach. (Al Seib / Los Angeles Times)

By PALOMA ESQUIVEL, MELISSA GOMEZ, HOWARD BLUME

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CORONAVIRUS, VACCINES AND PANDEMIC >

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As underserved areas grapple with vaccine inequities, Sean Penn's nonprofit joins effort to get doses to residents

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LAUSD coronavirus testing reveals 177 infections prior to first campus openings

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COVID-19 vaccine supply rebounds as L.A. County hopes to rapidly immunize more residents

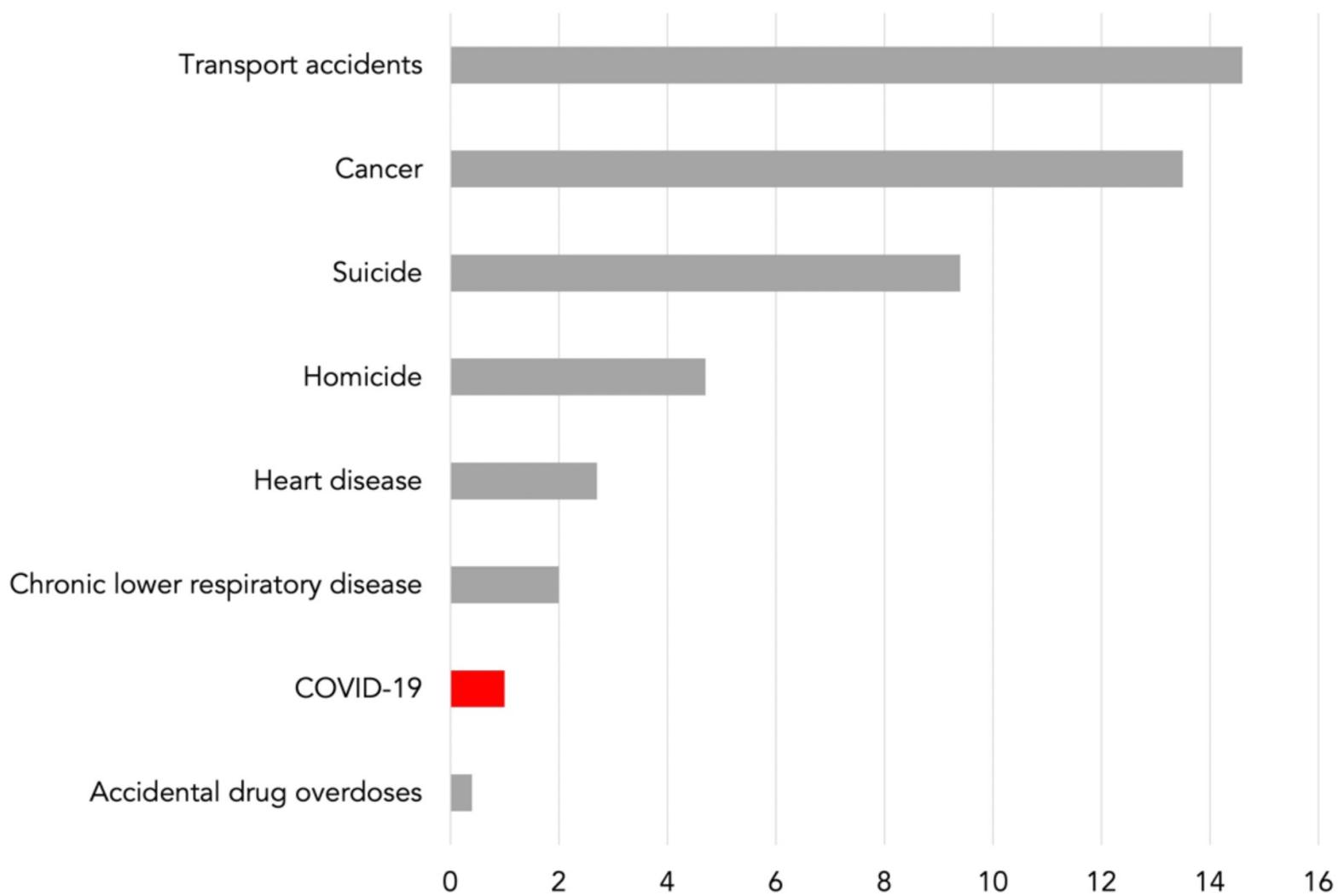
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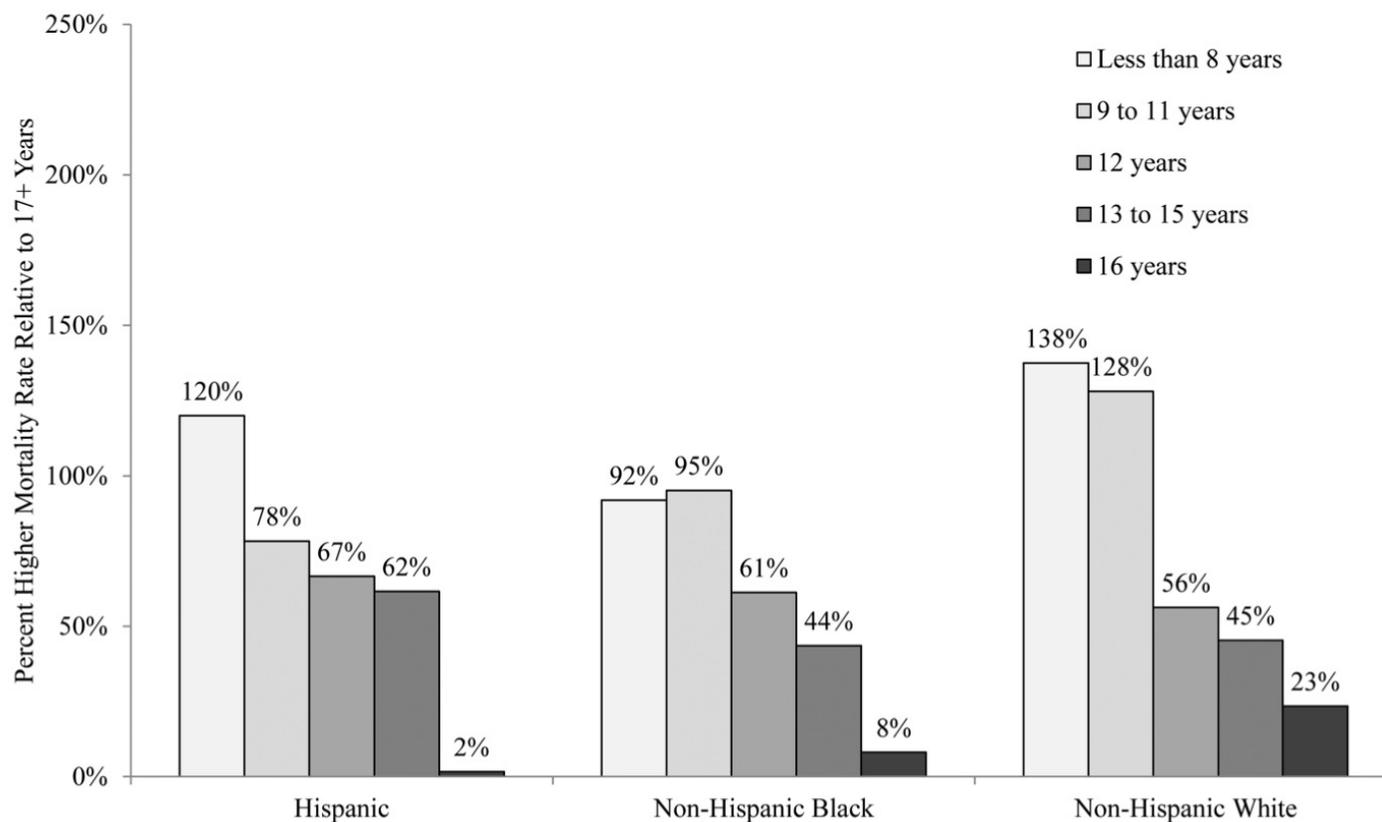
Tracking reopenings

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Latest on vaccines and pandemic

### Mortality rate per million by cause in children ages 5-14



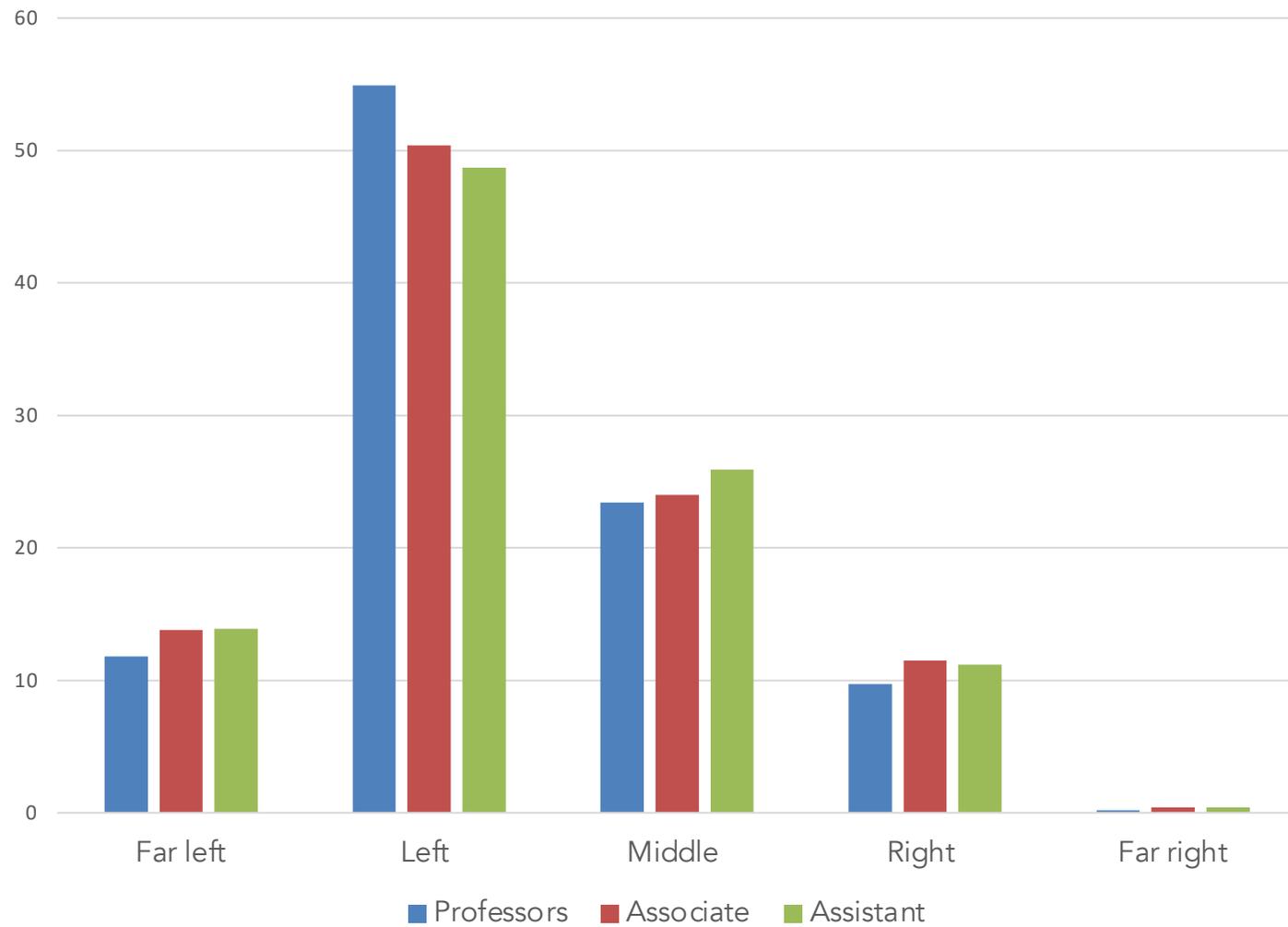


Source: Robert A. Hummer and Joseph T. Lariscy, "Educational Attainment and Adult Mortality," in *International Handbook of Adult Mortality*, ed. Richard G. Rogers and Eileen M. Crimmins (NY: Springer, 2011)

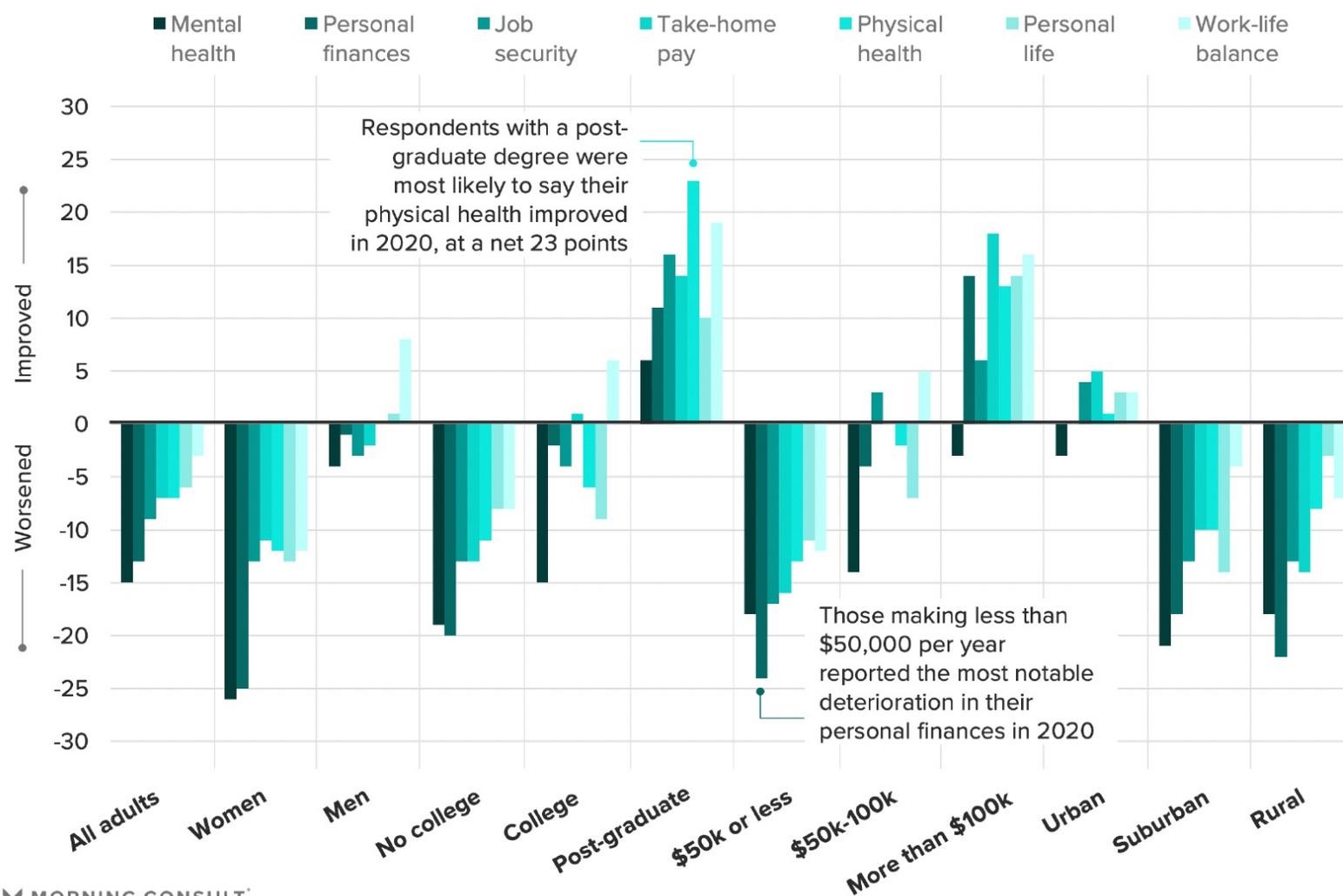
**Figure 5.**  
**Mortality Rate Differences Relative to Persons with 17+ Years of Education, U.S. Women**  
**by Race/Ethnicity**



- a. The complexity of the system
- b. Our biases and privileged perspectives
- c. Epistemic arrogance



## Share who said the following factors improved for them in 2020 minus the share who said those factors have worsened:

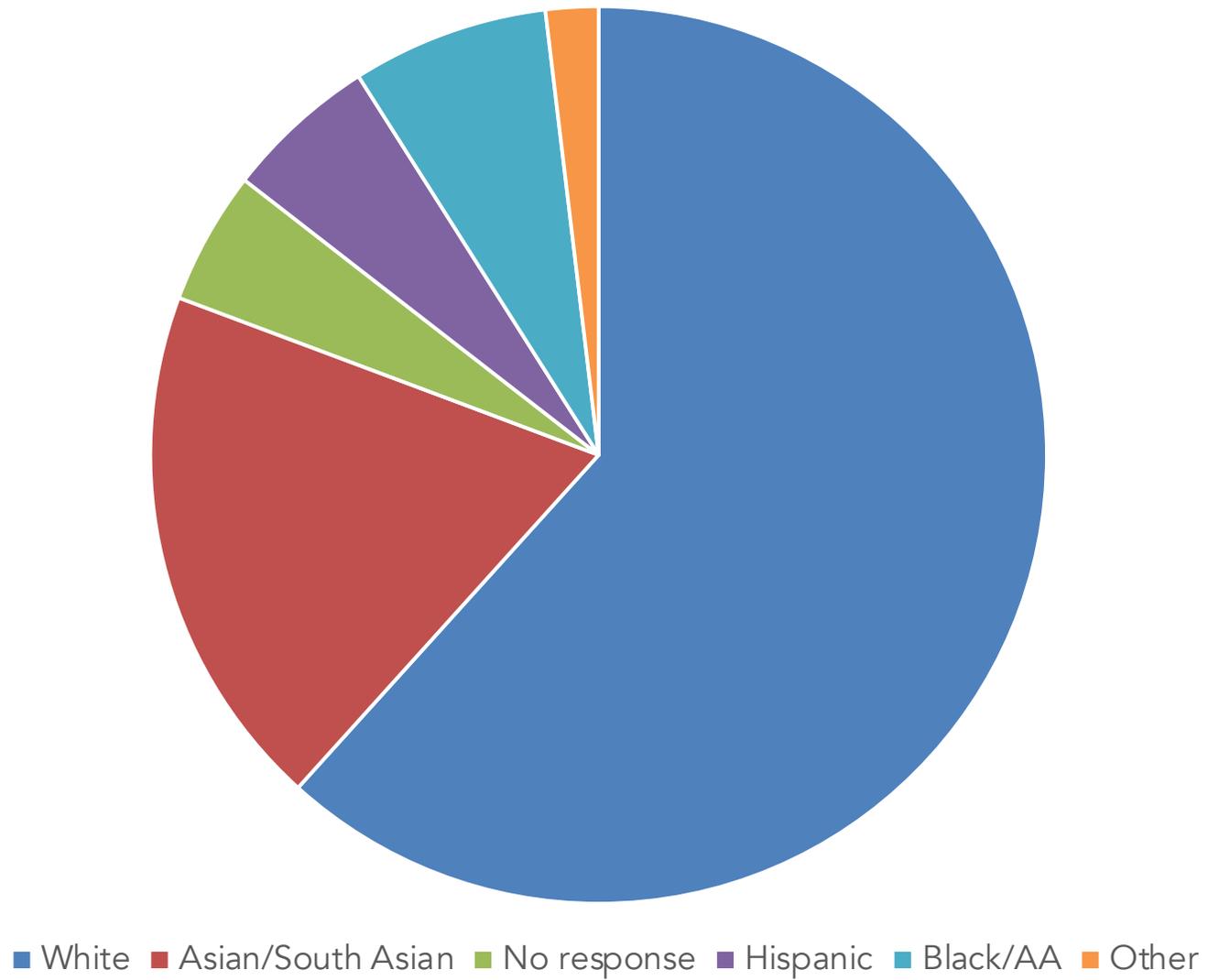


MORNING CONSULT

Poll conducted Dec. 17-20, 2020, among 2,200 U.S. adults, with a margin of error of +/-2%.

<https://morningconsult.com/2021/01/19/an-inaugural-inflection-point-ushering-in-a-new-era-of-marketing-amid-a-polarized-public/>

# Epidemiologists today



- a. The complexity of the system
- b. Our biases and privileged perspectives
- c. **Epistemic arrogance**

“

Epistemic arrogance is the tendency to overestimate our ability to predict when we're overconfident in our knowledge. ”

● **TheUpshot**

## *What 635 Epidemiologists Are Doing for Thanksgiving*

Those who are gathering with family or friends are taking precautions or rethinking their holiday rituals altogether. Most are staying home.



*W. D. Williams*

*“And it was so typically brilliant of you  
to have invited an epidemiologist.”*

"This book can save us if we are serious about saving ourselves."  
—Ibram X. Kendi, bestselling author of *How to Be an Antiracist*

Sandro Galea

The  
Contagion  
*Next Time*



[sandrogalea.org](http://sandrogalea.org)