

COVID 19 Introduction

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Lecture 12

October 19,2020

Questions about COVID

- How bad is Covid-19? Is it like the flu?
- How does it compare with past pandemics?
- What is the overall mortality and morbidity?
- How does it spread?
- Is the “cure” worse than the disease?
- How does the US compare to other countries?
- How does it impact American inequality?
- What have been our policy successes and failures?
- What would a good Covid policy look like?

Epidemics and Our Humanity

- There is something about a threat that reoccurs at the dim reaches of living memory, every fifty or one hundred years, that makes our species seem particularly small. When such a threat reappears, human suffering is combined with the sad realization that we should have seen it coming. Epidemics generally take advantage of the deepest and most highly evolved aspects of our humanity. We evolved to live in groups, to have friends, to touch and hug each other, and to bury and mourn one another. If we lived like hermits, we would not be victims of contagious disease. But the germs that kill us during times of plague often spread precisely because of who we are. And so for centuries, our response in a time of plague has been to rediscover the necessity of surrendering these aspects of our nature for a while.
 - Nicholas Christakis, *Apollo's Arrow*

Past Pandemics: The Plague

- Bubonic Plague spread in three major pandemics.
 - Plague of Justinian 541 CE to 755 CE
 - Black Death arrived in Europe in 1347 First wave lasted until 1353
 - Half the population of Europe was wiped out.
 - Waves of plague returned for the next 500 years
 - Last epidemic was in England in 1655 and in Italy 1743
 - Modern Plague in India, started in 1870 caused 13-15 million deaths in Mumbai between 1898 and 1910

Indigenous People and Epidemics in the 15th century

- Some American Indian tribes were almost entirely wiped out after European colonization, with less than 5 percent of the population left alive. Here is one indigenous account of a 1519 epidemic, possibly of measles or smallpox, that afflicted the Mayans in what is today Guatemala:

The people could not in any way control the sickness. Great was the stench of the dead. After our fathers and grandfathers succumbed, half of the people fled to the fields. The dogs and the vultures devoured the bodies. The mortality was terrible. . . . So it was we became orphans.

1918 Flu

- The 1918 flu pandemic (incorrectly labeled as originating in Spain) affected and killed many people. Perhaps thirty-nine million people died worldwide, which was 2.1 percent of the world population, and some experts put the worldwide toll as high as one hundred million (given possible misidentification of deaths and poor reporting).⁶⁹
- The United States had a cumulative death rate of 0.52 percent of the population, or 550,000 people, including one in every one hundred men between the ages of twenty-five and thirty-four (again, some estimates are higher).⁷⁰ For comparison, in the United States in 2020, that would translate to 1,721,000 deaths.

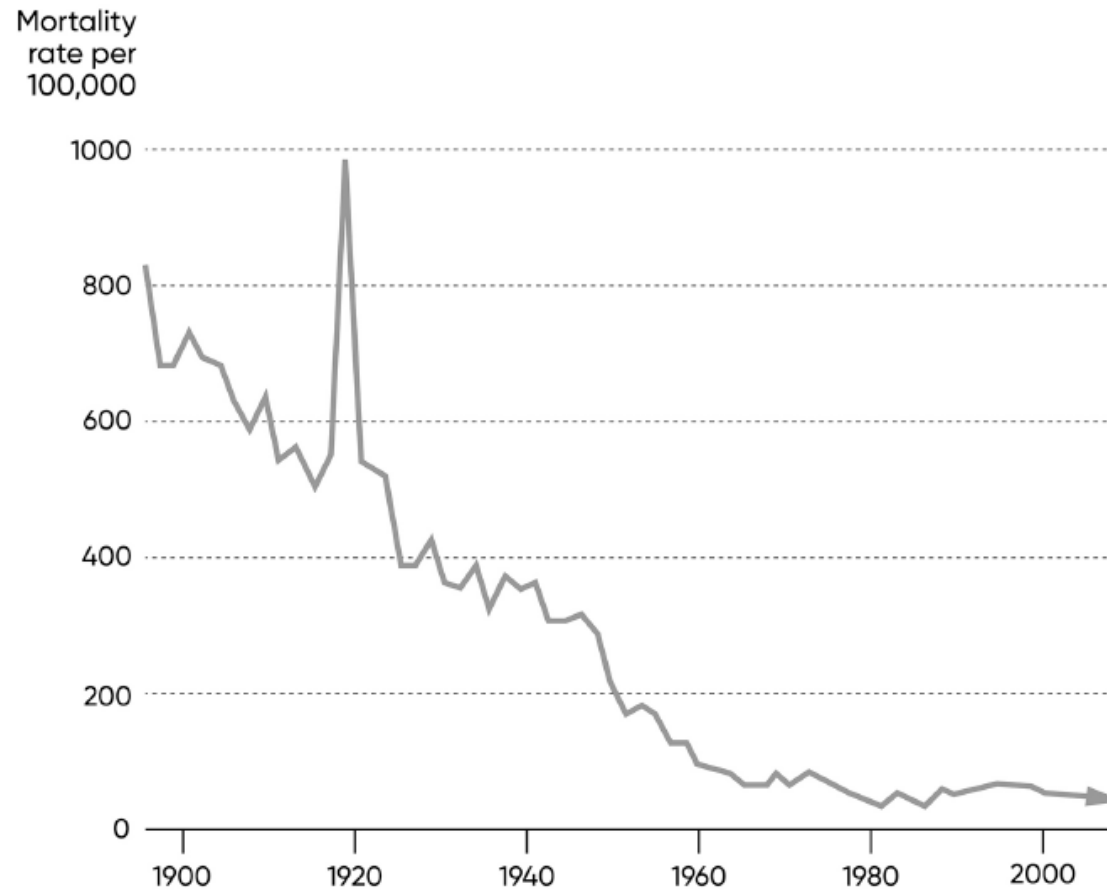


Figure 8: Mortality in the United States since 1900 has generally declined, but the spike in mortality during the 1918 influenza pandemic stands out.

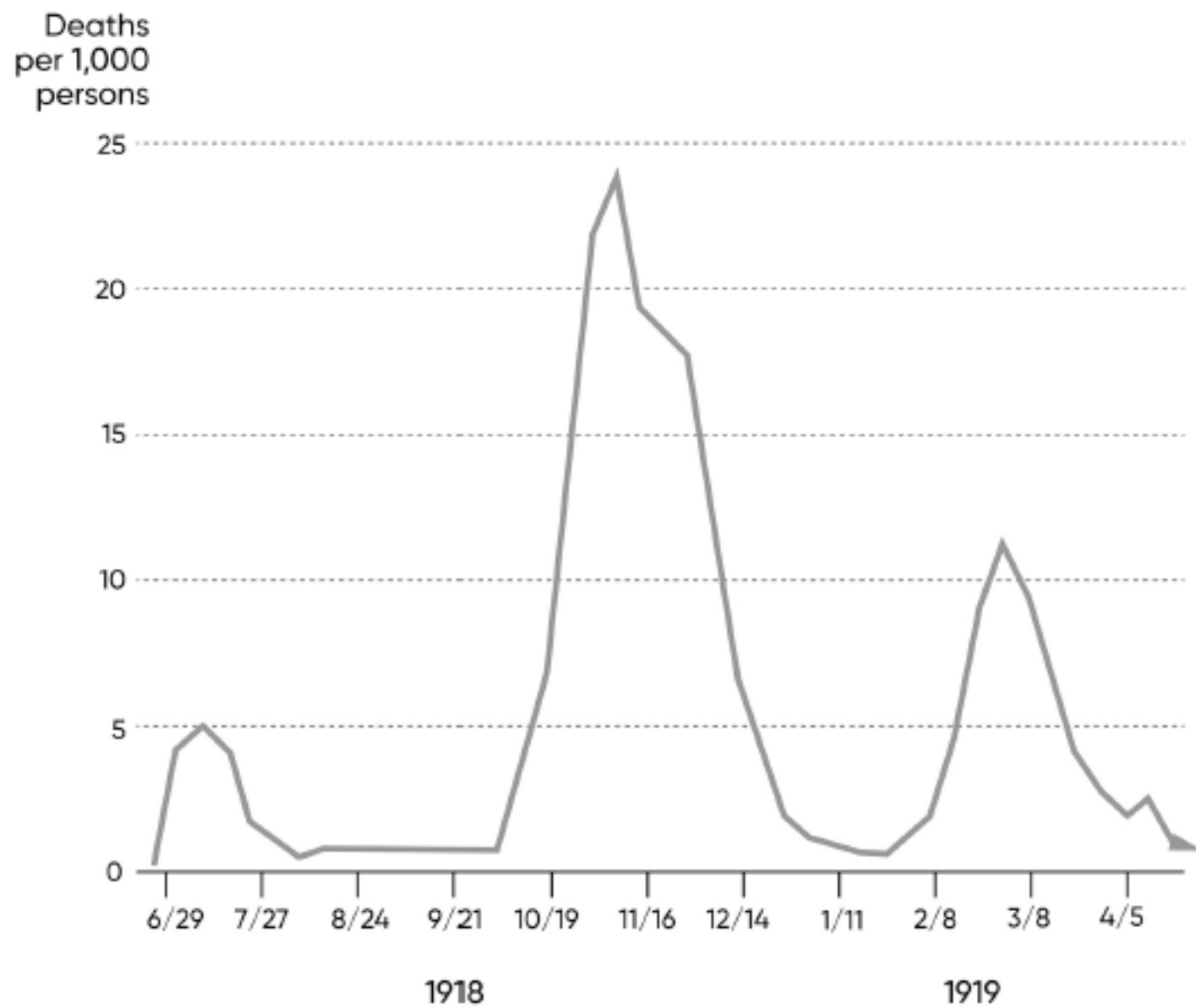


Figure 10: There were three waves of deaths during the 1918 Spanish influenza pandemic; the second wave was four times deadlier than the first.

Other Pandemics

- HIV AIDS
- Ebola
- SARS1
- Seasonal Flu

Out of the Blue?

- Everybody knows that pestilences have a way of recurring in the world; yet somehow we find it hard to believe in ones that crash down on our heads from a blue sky. There have been as many plagues as wars in history, yet always plagues and wars take people equally by surprise.
- —Albert Camus, *The Plague* (1947)

China and the beginning of the pandemic

- December 1 first identified case Wuhan
- December 30 market shut down
- January 25 Lunar New Year usually 3 billion trips
- Wuhan transport hub 12 million trips through Wuhan in January
- January 23 lockdown Wuhan and then Hubei Province
- January 25 all of China under emergency rules
- People had to stay home, only leaving once or twice a week for food
- Universal masks
- Six feet apart in lines for food
- Late March began to relax
- By April daily case count hit zero

Timeline US

- January 15 first case diagnosed in Washington state, had returned from Wuhan
- January 31 travel restrictions on China
- Feb 28 they identified the virus in the nursing home near Seattle, first patient dies
March 1
- 35 eventually died out of 101 residents and 50 workers
- 57 year old Santa Clara CA found dead Feb 8, autopsy found Covid three weeks is the average infection to death, so mid January the virus was in Bay Area
- By mid February it was clear there was community transmission but there was a shortage of tests and so the CDC said people should only be tested if they had been in contact with someone who had traveled to China
- Feb 29 travel restrictions Iran

Timeline US

- March 1 first case found in NY
- March 5 Amazon and Microsoft told workers to work from home
- March 10 Harvard announces that students have to move out, and that instruction will be virtual
- March 11 travel restrictions Europe
- March 17 governor of WA closed bars, restaurants and entertainment facilities
- March 19 governor of CA issued stay at home order
- March 19 virus in all 50 states
- March 23 Washington governor issued stay at home order
- By March 25 US had identified 68,673 cases and 1,028 deaths

Timeline US

- March 12 banned large gatherings in NY
- March 17 bars restaurants theaters closed
- March 20 NY governor issued shelter in place order effective March 22 NY had 8,452 cases
- March 25 hospitals reported apocalyptic conditions
- On March 25, some eighty-five refrigerated trailers were sent by FEMA to provide places for the bodies. 118 Rules were relaxed so that local crematories could “work around the clock
- Early April 1000 people a day dying in the city
- April 15 peak of pandemic in NYC
- April 21 NY told EMTs not to try to revive people who did not have a pulse
- May 1 COVID was the leading daily killer of people in the US

Exponential Growth and the Danger of an unchecked pandemic with no immunity

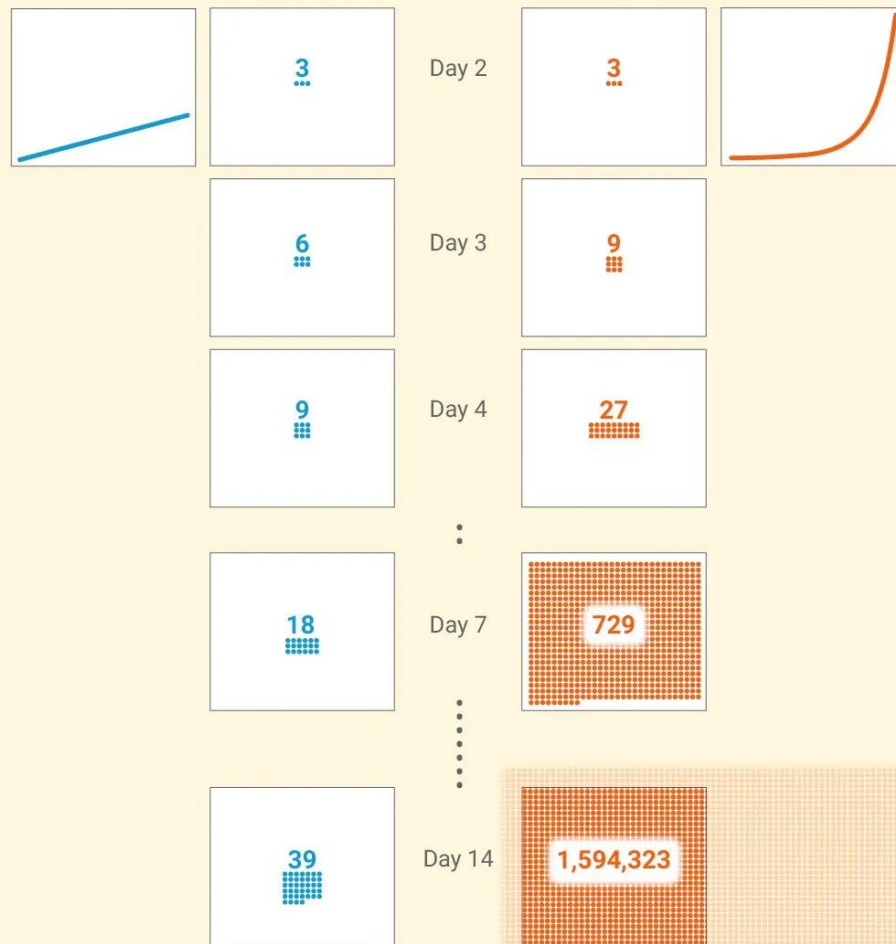
- Imagine that you are offered a deal where your money will double every three days.
- You invest \$1.00 per day.
- When will you have a million dollars?
 - 60 days
- When will you have a billion dollars?
 - 30 more days, or 90 days since you invested a dollar

How long to reach 1 million?

Our biased brains often fail to grasp just how fast exponential growth can be

Linear

Exponential



Exponential Growth Bias

- Our intuition about growth is that it is linear so we consistently underestimate exponential growth.
- This bias is present among numerate and highly educated people.
- Without intervention COVID-19 cases double every three to four days.
- It is common to show the growth of the disease on a logarithmic scale, which compounds the bias.

Flattening the Curve

- Early studies from China, Italy, the United Kingdom, and the United States all showed that roughly 20 percent of people infected with SARS-2 needed hospitalization and roughly 5 percent needed ICU care.⁷ If 5 percent of ten million people needed ICU care, that means we would need five hundred thousand ICU beds. The
- United States has only one hundred thousand such beds. No nation has the ICU-bed capacity to cope with that many seriously ill people at once. The United States also has fewer hospital beds per capita than other industrialized countries; the U.S. has 2.9 beds per 1,000 people, whereas South Korea has 11.5, Japan has 13.4, Italy has 3.4, Australia has 3.8, and China has 4.2.⁸

Policy Responses

- Around the world most countries reacted with a lockdown—limiting movement, closing businesses and schools.
- Then policies diverged.

Shelter in Place

- People began to physically distance before being told or ordered to do so. For example, analyses of foot traffic in stores and bookings at restaurants across the world revealed that those began to decline a couple of weeks before collective NPI policies were implemented.
- Each country had different distancing policies, different laws and cultures, and different rates of COVID-19; but restaurant bookings all fell to zero over the course of fifteen days as the epidemic struck. Parents also began to withdraw their children from school before official closings were announced. By the time the New York City public schools were shuttered, a substantial percentage of children were already staying home.
- An analysis of cell phone mobility data that the *Washington Post* revealed that the peak of our collective efforts to stay at home came on April 7, when Americans spent 93 percent of their time in their homes, up from 72 percent on March 1.

Plague of Justinian

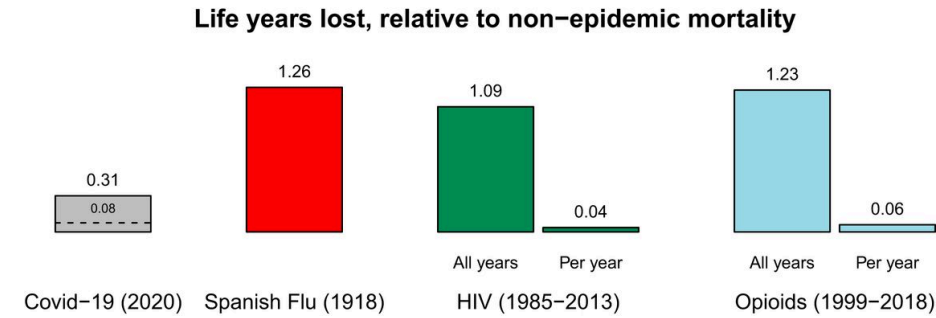
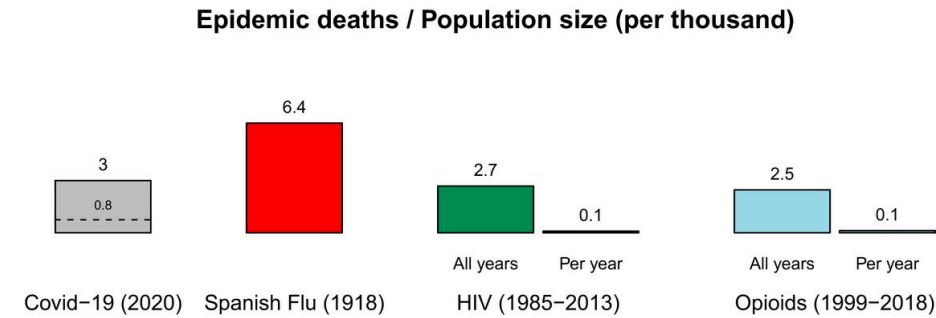
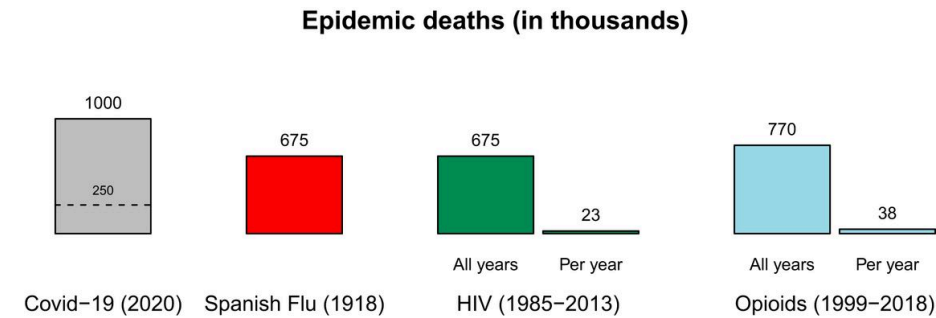
- Priest and historian John of Ephesus noted as much during the plague of Justinian, over fifteen hundred years ago:
 - And in all ways everything was brought to naught, was destroyed and turned into sorrow. . . . [And] buying and selling ceased and the shops with all their worldly riches beyond description and moneylenders' large shops closed. The entire city then came to a standstill as if it had perished. . . . Thus, everything ceased and stopped.

An over-reaction?

“Just the flu”

- It's important to remember that what has happened so far reflects the changes we made beginning in March. We did flatten the curve.
- COVID changes mortality not just through actual cases, but in the reactions we make—driving less, getting fewer cancer screens.
- A better estimate is increase in all cause mortality over previous years, especially since early cases were not diagnosed.
- Important to differentiate individual risk and population risk.
- The risk is not just from mortality but also from morbidity.

Mortality of COVID-19 scenario compared to past US epidemics according to different measures.



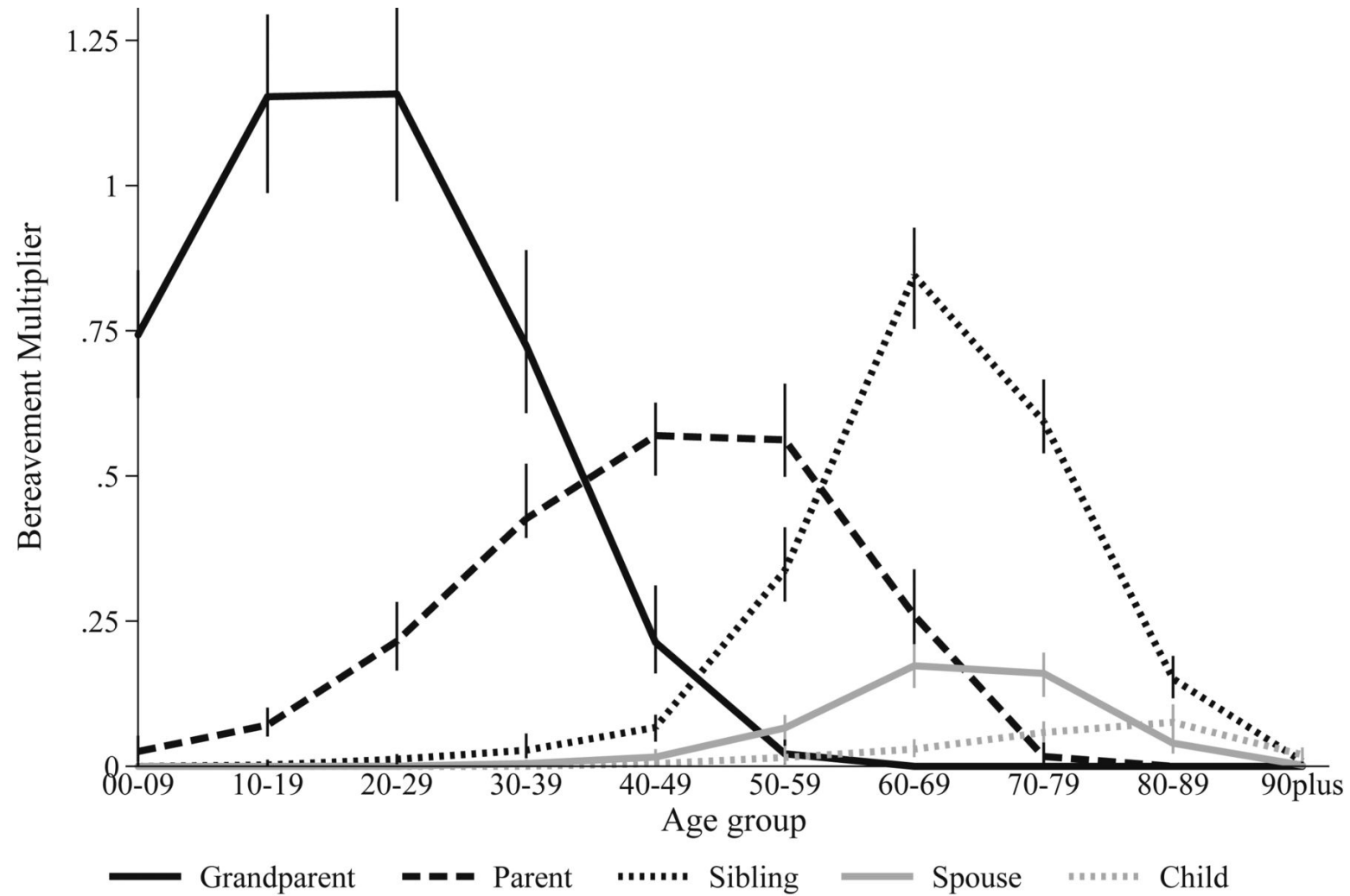
Joshua R. Goldstein, and Ronald D. Lee PNAS
2020;117:36:22035-22041



Deaths Offstage

- Furthermore, with COVID-19, what little the media could capture visually about the deaths—such as shrouded bodies piled on a nursing-home floor or in the back of a truck—had a surreal, disembodied feel. Thus, because so many sick people were sequestered in health-care facilities or were alone at home with no one to document their suffering when they died, and because reports focused mostly on visible signs of the economic collapse (with pictures of shuttered stores or lines at food banks), Americans did not see how the virus did its awful work. The deaths and even the mourning for COVID-19 victims occurred strangely offstage, making them harder to appreciate.
- For every hundred thousand people who die, there are a million people who were close to them and ten million people who knew them personally.⁸³ Slowly but surely, as the deaths mount, we will see that this is a problem that affects us all.

The age pattern of bereavement burden by type of kin who died.



Ashton M. Verdery et al. PNAS 2020;117:30:17695-17701

PNAS

Calculating the Costs of COVID

- The virus kills some people directly, by infecting them, and others indirectly, by, for example, prompting people to delay going to the hospital for other conditions and thus needlessly dying, or by increasing suicides as a result of depression due to job loss or social isolation. But the pandemic also saved some lives too.
- For instance, motor-vehicle fatalities fell during the winter and spring of 2020, as fewer people were on the road; there were fewer deaths due to complications from noncritical medical procedures, as hospitals had canceled elective procedures; fewer babies were born premature (possibly because their homebound mothers were under less physical stress or were less exposed to all pathogens); and fewer people lost their lives to respiratory conditions, as air pollution was reduced due to the cessation of manufacturing activities.

Individual vs. Population Risk

- US population of 300 million
 - Each year about 3 million people die of all causes.
 - Crude Death Rate 9.1 people per thousand
- IF 1 million people die of COVID in one year
 - Crude Death Rate would rise to 12.1 per thousand
- The average person's absolute risk of dying of COVID would remain small 3 out of a thousand.
- This level of mortality would surpass all threats to life a person faced that year, making COVID the number one killer.

Individual Risk

- Risk of Death 1%
- Risk of Hospitalization 20%
- The risk for a 40 year old who is hospitalized is 2 to 4%
- The risk of death for a 70 year old hospitalized with a heart attack is about the same—2 to 4%
- At every age, being hospitalized for COVID puts you at higher risk of death than being hospitalized for a heart attack.

Individual vs. Population Risks

- At baseline young people face a very low risk of death in the US in any given year.
- If you worry about a child drowning or being hit by a car or falling out a window, you should worry about COVID more. The risk is higher of dying of COVID.
- In a normal year an 80 year old man has a 5% chance of dying in the year of 5%.

Risk

- Overall, mortality among those under twenty is very low, on the order of between one and three people dying out of ten thousand who get sick. For patients in their late fifties, this rises to about one in one hundred. For patients eighty or older, it rises to about one in five.
- Young people may have nonlethal complications that might leave them with long-term pulmonary, neurological, cardiac, or renal morbidity. And of course, with millions of people infected in the United States, there have been and will be cases of young people dying.
- Overall, men suffer 50 percent more mortality than women.⁴⁸

Differential Impact by Race

- According to data from the CDC through May 28, 2020, Hispanics and African-Americans in the United States were roughly three times as likely to become infected with SARS-2 and two times as likely to die from it as whites. These trends are evident across rural areas, suburban counties, and cities. For example, 40 percent of infected people living in Kansas City, Missouri, are black or Hispanic, though they make up only 16 percent of the state's population. Blacks and Hispanics make up 20 percent of the population in Kent County, Michigan, but represent 63 percent of COVID-19 cases.⁶⁶
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- Accounting for the age difference between blacks and whites made the comparisons even worse. That is, blacks are younger than whites, on average, and should have a lower death rate for this reason alone. In one national study, correcting for this revealed that, overall, they had 3.8 times the risk of dying as whites.⁶⁷ Interestingly, the differential impact of the virus according to race varied across states, even after adjusting for age. In Kansas, blacks were 8.1 times more likely to die than whites; in New York, 4.5 times; in Mississippi, 3.4 times; and in Massachusetts, 2.1 times.

Differential Mortality by Race

- Looking just at New York, two out of every one thousand black residents in that state died. This was driven largely by the mortality in New York City itself, where the rate approached three out of one thousand blacks dying within a few months! Just as a reference point, consider that an average forty-year-old American has a risk of dying from *all causes* in the *entire upcoming year* of about two per one thousand.
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- But when these figures were adjusted for age, Hispanics actually had a 2.5 times increased risk of death compared with whites.⁶⁹ In New York State during the first few months, one out of every one thousand Hispanic residents died from the virus, and once again, this was driven by mortality in New York City, where the rate exceeded two per one thousand Hispanic residents. In New York City as of April 11, 2020, Hispanics accounted for 34 percent of the deaths but were 29 percent of the population
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- A nationwide analysis revealed that American Indians represented 1 percent of the population but 2 percent of the deaths as of July 2020.⁷²

Differential Mortality by Race

- Much of the difference in the destructiveness of COVID-19 along ethno-racial lines has to do with other risk factors of dying from or contracting the disease. For example, it's known that hypertension, diabetes, obesity, and cardiovascular disease all increase the risk of mortality among those infected with SARS-2, and these conditions are much more prevalent in most minority populations. There is no doubt that some, and perhaps even most, of the disparity in mortality outcomes might be explained by these factors. Furthermore, household arrangements in minority and nonminority groups might also help explain the difference; in the United States, 26 percent of African-Americans and 27 percent of Hispanics live in multigenerational families with co-resident grandparents; only 16 percent of whites do

Public Health and the Virus

- Most public health orders come from the Governors
- Public Health boards operate at the city, town and county level
- The CDC had been the gold standard of

Spread of the Virus

- R_0 (R Naught) is the degree to which it is infectious in the absence of attempts to control it. For each person who gets infected how many other people on average does that individual infect?
- R_e (R E) is the effective reproduction rate. It reflects the real-time spread of the epidemic later in its course, when the population is no longer “naive.” The R_e is susceptible to human responses
- The R_e declines naturally as an epidemic proceeds because susceptible people become infected and either die or survive and acquire immunity (to a greater or lesser extent). It can also vary with the weather, typically up in the winter, down in the summer.

Spread of the Virus

- Measles is one of the most infectious diseases known, with an R_0 estimated to be 12 to 18 (that is, a single infected person typically can infect somewhere between twelve and eighteen other people). Chicken pox is 10 to 12. Smallpox is 3.5 to 6. Ebola is 1.5 to 1.9. Seasonal influenza ranges from 0.9 to 2.1
- SARS2 is 3.0. But there is some new research suggesting that there is a great deal of variation in individuals, with many spreading very little and some who are super spreaders.

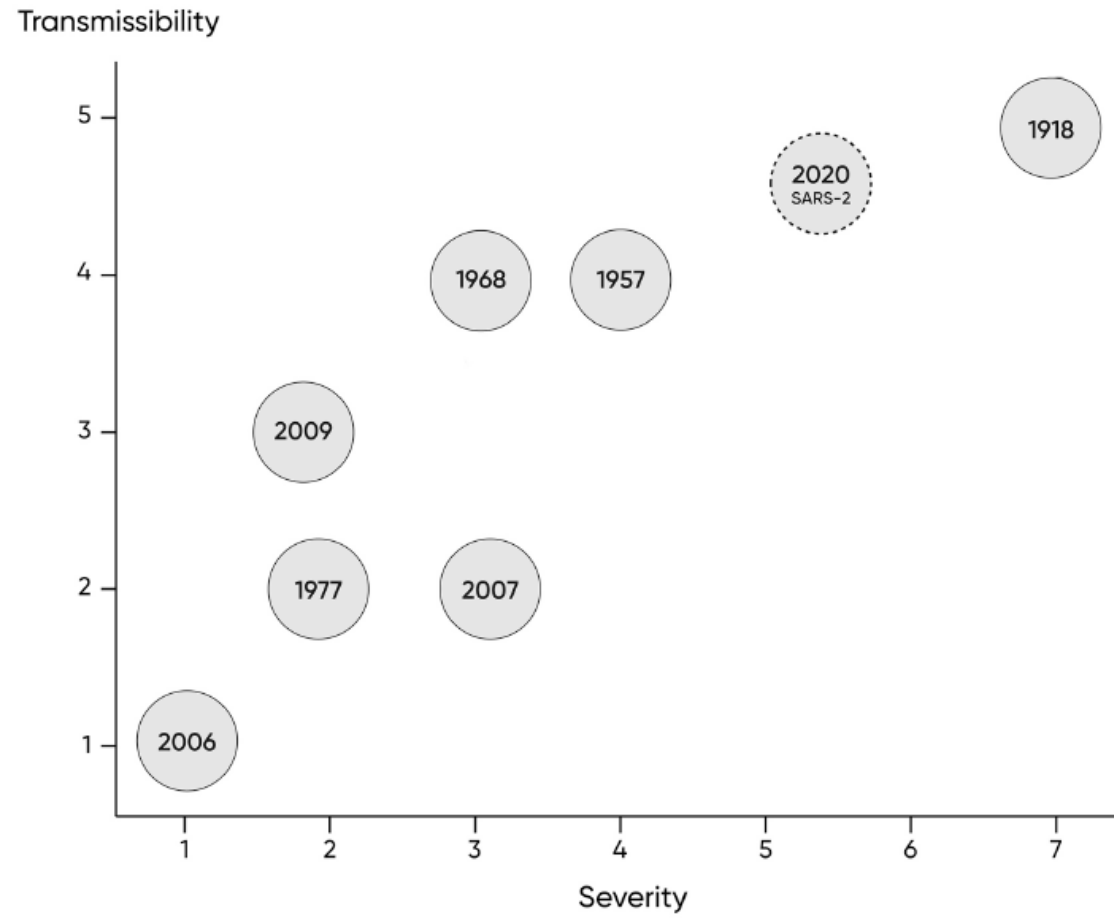


Figure 9: Graphing a century of respiratory pandemics in terms of their transmissibility and severity (lethality) showed that the basic epidemiology of SARS-2 made it a serious threat.

Difficulties in Controlling the Virus

- The time between when a person is infected and starts to show symptoms is the *incubation period*. It is 2-14 days and typically about 6-7 days.
- But with SARS2 a person becomes infectious 2-4 days before they are symptomatic. It looks like people are most infectious 1-2 days before they show symptoms.
- 20% of people never show symptoms, but they can still spread the virus.

Nonpharmaceutical interventions (NPIs)

- Individual Level
 - Hand washing, wearing masks, self-isolating, stop handshaking, physical distancing
- Collective Actions
 - Closing borders, shutting schools, banning large gatherings, disinfecting public spaces, testing and contact tracing, quarantines, providing public education, issuing stay at home orders.
- Some actions affect the transmissibility of the pathogen.(masks, disinfecting surfaces, handwashing)
- Others modify human interactions to deprive opportunity to spread

Masks

- Masks can be worn to protect a wearer from the *ingress* of viral particles, but this typically requires a more specialized mask like an N95 respirator (though, to be clear, cloth masks do help). Still, any mask can be worn to protect others from the *egress* of viral particles by dampening the propulsive force of droplets leaving a person's mouth.
- Masks also protect the wearer in other ways. For one, masks keep us from touching our faces. People touch their faces roughly once every four minutes
- For instance, a mask with just 50 percent efficacy in reducing droplet transmission worn by just 50 percent of people can reduce the R_e from 2.4 to about 1.35—roughly the level of seasonal influenza. This means that, if there were one hundred cases of such an infection at the beginning of the month, in a no-mask scenario, there would be 31,280 cases at the end of the month; but in a mask scenario, there would be only 584.

1918 Similar Issues Arose of People Refusing to Wear Masks

- One announcement from the Red Cross explicitly stated, “The man or woman or child who will not wear a mask now is a dangerous slacker.” The governor of California described mask-wearing as the “patriotic duty” of every American.

Tests

- Many other countries around the world had started testing for the virus by early 2020, but the United States had not. We made three types of mistakes.
 - First, and most important, the CDC released a test kit that was flawed, and when the error was detected, the response was unnecessarily slow.
 - Second, the FDA refused to allow hospital labs to develop their own tests, even though most elite hospitals in the United States could do this and were eager to do so.
 - Third, the Department of Health and Human Services took its time to work with outside labs to increase the availability of commercial tests, for which there was a huge market, and did not get it done until it was too late.
- It's not as if the CDC had not succeeded in similar situations before; during the 2009 H1N1 pandemic, the CDC developed and shipped over one million tests throughout the United States just two weeks after the virus was discovered.⁶¹

School Closing: Why Do It?

Many debates miss the point.

- Reactive Closure
 - When there are active cases
- Proactive Closure
 - When there is community spread, to slow it.
- Primary purpose school closing is prevent social mixing not to protect children
-
- By radically decreasing social interactions in a community, closing schools can have a powerful effect (even if, as in the case of SARS-2, children are relatively spared becoming sick). In part, it works by keeping the kids from acting as vectors (which they can indeed be with SARS-2), and in part it works by forcing *parents* to stay home. When epidemiologists develop models to assess the impact of school closures, they sometimes include a parameter that captures what fraction of the parents in a community must stay home as a result

School Closing

- In American schools, the millions of children and adults are in far closer daily physical proximity, and for longer durations (thirty-five or more hours per week), than are adults in most workplaces. The impact of banning occasional large gatherings like sporting events or religious services does not even come close to that of school closure. Because of this, school closures are the most consequential NPI that can be employed, short of requiring everyone to stay home.
- Dr. Tom Frieden, the former head of the CDC, would later estimate that if New York had adopted widespread physical-distancing measures even a week or two earlier, the death toll might have been reduced by 50 to 80 percent

Controlling the Virus at considerable cost

- Late April by the Pew Charitable Trusts found that, overall, 43 percent of adults reported that they or someone in their household had either lost a job or taken a pay cut as a result of the pandemic.
- Since March 60 million unemployment claims have been filed.
- The proportion of US adults who report symptoms of depression or anxiety has averaged approximately 40% since April 2020; the comparable figure in early 2019 was 11.0

Economic Cost of COVID 19

David Cutler and Lawrence Summers JAMA

16 TRILLION DOLLARS

Table. Estimated Economic Cost of the COVID-19 Crisis

| Category | Cost (billions), US\$ |
|-----------------------------|-----------------------|
| Lost GDP | 7592 |
| Health loss | |
| Premature death | 4375 |
| Long-term health impairment | 2572 |
| Mental health impairment | 1581 |
| Total | 16 121 |
| Total for a family of 4 | 196 475 |
| % of annual GDP | 90 |

Abbreviation: GDP, gross domestic product.

Coronavirus in the United States

Seven-day average of daily new cases per 100,000 people



March 15



April 15



May 15



June 15



July 15



August 15



September 15



October 15



<https://www.nytimes.com/interactive/2020/us/coronavirus-us-cases.html>

COVID-19 and Excess All-Cause Mortality in the US and 18 Comparison Countries

Bilinski and Emmanuel JAMA 2020

- While the US had a lower COVID-19 mortality rate than high-mortality countries during the early spring, after May 10, all 6 high-mortality countries had fewer deaths per 100 000 than the US. For instance, between May 10 and September 19, 2020, Italy's death rate was 9.1/100 000 while the US's rate was 36.9/100 000. If the US had comparable death rates with most high-mortality countries beginning May 10, it would have had 44 210 to 104 177 fewer deaths (22%-52%) (Table 1). If the US had comparable death rates beginning June 7, it would have had 28% to 43% fewer reported deaths (as a percentage overall).

COVID-19 and Excess All-Cause Mortality in the US and 18 Comparison Countries

Bilinski and Emmanuel JAMA 2020

- After the first peak in early spring, US death rates from COVID-19 and from all causes remained higher than even countries with high COVID-19 mortality. This may have been a result of several factors, including weak public health infrastructure and a decentralized, inconsistent US response to the pandemic.

Table 1. COVID-19 Mortality in the US Compared With That of Other Countries^a

| Country | Date COVID-19 cases surpassed 1 per million | COVID-19 deaths per 100 000 | | |
|--|---|---------------------------------|--------------------|--------------------|
| | | Since the start of the pandemic | Since May 10, 2020 | Since June 7, 2020 |
| Low mortality (COVID-19 deaths, <5/100 000) | | | | |
| South Korea | 2/20/20 | 0.7 | 0.2 | 0.2 |
| Japan | 2/23/20 | 1.2 | 0.7 | 0.5 |
| Australia | 3/1/20 | 3.3 | 2.9 | 2.9 |
| Moderate mortality (COVID-19 deaths, 5-25/100 000) | | | | |
| Norway | 2/29/20 | 5.0 | 1.0 | 0.5 |
| Finland | 3/2/20 | 6.1 | 1.4 | 0.3 |
| Austria | 3/1/20 | 8.6 | 1.7 | 1.0 |
| Denmark | 3/4/20 | 10.9 | 2.1 | 0.8 |
| Germany | 3/1/20 | 11.3 | 2.4 | 0.9 |
| Israel | 3/2/20 | 14.0 | 11.2 | 10.6 |
| Switzerland | 2/29/20 | 20.6 | 2.8 | 1.2 |
| Canada | 3/6/20 | 24.6 | 12.4 | 4.0 |
| High mortality (COVID-19 deaths, >25/100 000) | | | | |
| The Netherlands | 3/3/20 | 36.2 | 5.2 | 1.5 |
| France | 3/1/20 | 46.6 | 7.5 | 3.2 |
| Sweden | 2/29/20 | 57.4 | 23.5 | 10.3 |
| Italy | 2/23/20 | 59.1 | 9.1 | 3.1 |
| United Kingdom | 3/3/20 | 62.6 | 16.3 | 5.0 |
| Spain | 2/29/20 | 65.0 | 8.6 | 4.6 |
| Belgium | 3/2/20 | 86.8 | 12.4 | 4.2 |
| United States | 3/7/20 | 60.3 | 36.9 | 27.2 |

Table 1. COVID-19 Mortality in the US Compared With That of Other Countries^a

| Country | Date COVID-19 cases surpassed 1 per million | COVID-19 deaths per 100 000 | | | Excess US COVID-19 deaths (% of reported deaths) | | |
|--|---|---------------------------------|--------------------|--------------------|--|--------------------|--------------------|
| | | Since the start of the pandemic | Since May 10, 2020 | Since June 7, 2020 | Since the start of the pandemic | Since May 10, 2020 | Since June 7, 2020 |
| Low mortality (COVID-19 deaths, <5/100 000) | | | | | | | |
| South Korea | 2/20/20 | 0.7 | 0.2 | 0.2 | 196 161 (99) | 120 625 (61) | 88 771 (45) |
| Japan | 2/23/20 | 1.2 | 0.7 | 0.5 | 194 711 (98) | 119 090 (60) | 87 939 (44) |
| Australia | 3/1/20 | 3.3 | 2.9 | 2.9 | 187 661 (94) | 111 747 (56) | 79 849 (40) |
| Moderate mortality (COVID-19 deaths, 5-25/100 000) | | | | | | | |
| Norway | 2/29/20 | 5.0 | 1.0 | 0.5 | 182 099 (92) | 118 074 (59) | 87 655 (44) |
| Finland | 3/2/20 | 6.1 | 1.4 | 0.3 | 178 373 (90) | 116 698 (59) | 88 432 (45) |
| Austria | 3/1/20 | 8.6 | 1.7 | 1.0 | 170 247 (86) | 115 874 (58) | 86 066 (43) |
| Denmark | 3/4/20 | 10.9 | 2.1 | 0.8 | 162 600 (82) | 114 438 (58) | 86 669 (44) |
| Germany | 3/1/20 | 11.3 | 2.4 | 0.9 | 161 393 (81) | 113 422 (57) | 86 521 (44) |
| Israel | 3/2/20 | 14.0 | 11.2 | 10.6 | 152 393 (77) | 84 676 (43) | 54 529 (27) |
| Switzerland | 2/29/20 | 20.6 | 2.8 | 1.2 | 130 654 (66) | 112 205 (57) | 85 402 (43) |
| Canada | 3/6/20 | 24.6 | 12.4 | 4.0 | 117 622 (59) | 80 631 (41) | 76 235 (38) |
| High mortality (COVID-19 deaths, >25/100 000) | | | | | | | |
| The Netherlands | 3/3/20 | 36.2 | 5.2 | 1.5 | 79 318 (40) | 104 177 (52) | 84 514 (43) |
| France | 3/1/20 | 46.6 | 7.5 | 3.2 | 45 142 (23) | 96 763 (49) | 78 947 (40) |
| Sweden | 2/29/20 | 57.4 | 23.5 | 10.3 | 9581 (5) | 44 210 (22) | 55 607 (28) |
| Italy | 2/23/20 | 59.1 | 9.1 | 3.1 | 4136 (2) | 91 604 (46) | 79 120 (40) |
| United Kingdom | 3/3/20 | 62.6 | 16.3 | 5.0 | −7459 (−4) | 67 927 (34) | 73 103 (37) |
| Spain | 2/29/20 | 65.0 | 8.6 | 4.6 | −15 204 (−8) | 93 247 (47) | 74 163 (37) |
| Belgium | 3/2/20 | 86.8 | 12.4 | 4.2 | −87 057 (−44) | 80 475 (41) | 75 572 (38) |
| United States | 3/7/20 | 60.3 | 36.9 | 27.2 | | | |

Table 2. Excess All-Cause Mortality in the US Compared With That in Other Countries^a

| Country | Excess all-cause mortality per 100 000 | | | Excess US deaths from all causes (% of reported deaths) | | |
|--|--|--------------------|--------------------|---|--------------------|--------------------|
| | Since the start of the pandemic | Since May 10, 2020 | Since June 7, 2020 | Since the start of the pandemic | Since May 10, 2020 | Since June 7, 2020 |
| Moderate mortality (COVID-19 deaths, 5-25/100 000) | | | | | | |
| Norway | -2.6 | -4.3 | -2.1 | 235 610 (100) | 102 598 (44) | 63 952 (27) |
| Denmark | 5.1 | 1.9 | 1.8 | 218 664 (93) | 96 375 (41) | 57 910 (25) |
| Israel | 8 | 7.5 | 5.4 | 209 376 (89) | 77 932 (33) | 46 091 (20) |
| Germany | 10.0 | 1.4 | -0.2 | 202 547 (86) | 97 905 (42) | 63 952 (27) |
| Canada | 13.3 | -3.7 | -7.6 | 192 009 (81) | 102 598 (44) | 63 952 (27) |
| Switzerland | 17.0 | -3.6 | -2.7 | 179 545 (76) | 102 598 (44) | 63 952 (27) |
| Austria | 17.1 | 3.2 | 1.4 | 179 208 (76) | 92 042 (39) | 59 375 (25) |
| Finland | 19.1 | 8.7 | 5.4 | 172 706 (73) | 74 116 (31) | 46 264 (20) |
| High mortality (COVID-19 deaths, >25/100 000) | | | | | | |
| Sweden | 50.8 | 14.9 | 3.7 | 68 540 (29) | 53 429 (23) | 51 864 (22) |
| France | 51.5 | 5.9 | 2.6 | 66 167 (28) | 83 301 (35) | 55 512 (24) |
| The Netherlands | 55.1 | 0.1 | -0.7 | 54 282 (23) | 102 157 (43) | 63 952 (27) |
| Belgium | 67.8 | -4.6 | -6.4 | 12 638 (5) | 102 598 (44) | 63 952 (27) |
| United Kingdom | 94.5 | 13.7 | -1.2 | -75 196 (-32) | 57 659 (24) | 63 952 (27) |
| Spain | 102.2 | 2.1 | 1.8 | -100 768 (-43) | 95 784 (41) | 57 948 (25) |
| United States | 71.6 | 31.2 | 19.4 | | | |

^a Data on deaths are through July 25, 2020 (week 30, n = 235 610 excess US deaths compared with 145 546 reported COVID-19 deaths). Countries lacking publicly available all-cause mortality data through this time are omitted. Excess deaths were estimated by week, compared with 2015-2019, beginning when a country surpassed 1 COVID-19 case per million population. In columns 3-5, due to large sample sizes, all mortality rates are statistically significantly different from the corresponding US mortality rates ($P < .001$). Scenarios in the last 3 columns assume that compared with the country in a given row:

(A) the US had a comparable cumulative mortality rate; (B) the US excess all-cause mortality rate was unchanged until May 10 (week 20, n = 133 012 deaths), when it became comparable to the other country's death rate; and (C) the US excess all-cause mortality rate was unchanged until June 7 (week 24, n = 171 659 deaths), when it became comparable to the other country's death rate. Totals are truncated to avoid exceeding US estimated deaths. Due to reporting lags, these data include less follow-up time than Table 1, which in some cases produces lower cumulative death rates.