

## Viewpoint: Coronavirus journal—Anatomy of a pandemic



he first case of what we now know to be COVID-19 was diagnosed on November 17, 2019 in Hubei province in China. Six weeks later, on December 31, China reported a cluster of cases of pneumonia in the city of Wuhan, the capital of Hubei province. One week later, Chinese health authorities confirmed that this outbreak was associated with a novel coronavirus, SARS-CoV-2.

Wuhan is a provincial hub in central China with a population of 11 million. The virus was [carried by travelers](#) from Wuhan to other cities in China, Hong Kong, South Korea, Taiwan and elsewhere in Asia and beyond, with major outbreaks arising relatively early in Iran and Italy. The virus is now present in more than 200 countries.

The first case of infection in the United States was reported on January 20 in a nursing home outside of Seattle. The virus has spread throughout the US, with New York City and state the epicenter. Sizable outbreaks are present in many other large cities, including New Orleans, Los Angeles, Seattle, Detroit, Atlanta, St. Louis, Denver, Houston, Dallas, Baltimore and Washington, DC; in regions such as southern Florida, southwest Connecticut, and across New Jersey; and even in less populated sections of Louisiana and Georgia. The U.S. has by far the largest number of confirmed cases. Italy and Spain have reported far fewer cases but have more fatalities.

[For frequently updating statistics and charts, visit [OurWorldInData](#) and the [Financial Times](#).]

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In order to make sense of the constantly-increasing numbers and understand where we are headed, it helps to examine what we know so far about the COVID-19 pandemic in light of the core principles and concepts used in the study of infectious diseases and epidemiology generally.

Epidemiologists are taught to think about any disease outbreak in terms of person, place, the agent (in this case, the virus), and time. It is the interaction of all of these factors that determines the extent of an outbreak. Understanding the nature of the interaction of the agent, SARS-CoV-2, with *its* environment holds the key to controlling an outbreak.

### The agent

While the SARS-CoV-2 virus is a new infection in humans, and there is a lot we don't know about it, we quickly learned several basic facts.

Infected persons are capable of spreading the virus for several days before the onset of symptoms, and some carriers may be totally asymptomatic. (These have been dubbed “super-spreaders.”) On average, without any intervention, a carrier will infect between 2.0 and 2.5 people. This is called the reproductive number, or  $R_0$ . For comparison, the seasonal flu has an  $R_0$  of 1.3. As long as the  $R_0$  is greater than 1, the virus will continue to spread.

SARS-CoV-2 has an incubation period of 1-14 days, compared to 1-4 days for the seasonal flu. Because of the long incubation period, infected persons can spread the virus for a substantial period of time. Another consequence of the long incubation period is that the numbers of cases that are diagnosed represent only a fraction of those who are infected with the virus. This means that when we use the number of diagnosed cases as an indicator, we are several weeks behind where the infection actually is.

In addition, it should be noted that, although the highest hospitalization rates and death rates are seen in older people and those with pre-existing conditions, the infection can do serious damage to young people's lungs and cause death. We have known since January from the information coming out of Wuhan that this is a very [destructive pathogen](#), possibly because it infects both the upper and lower respiratory tracts.

[hubei super tease](#)

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Staff members line up at attention as they prepare to spray disinfectant at Wuhan Railway Station in Wuhan in China's central Hubei province on March 24, 2020. – China announced on March 24 that a lockdown would be lifted on more than 50 million people in central Hubei province where the COVID-19 coronavirus first emerged late last year. (Photo by STR / AFP) /

China OUT (Photo by STR/AFP via Getty Images)

## **Time — exponential growth**

From January 21 to March 1, the number of cases was growing but had only reached the double digits. However, soon after, the curve started to bend upwards and became progressively steeper. In 27 days (from 3/2/20 to 3/29/20) the number of cases ballooned from 118 to 161,800 — over a thousand-fold increase. This is exponential growth. For every day that is lost, you are higher up on an ever-steepening epidemic curve.

The overall statistics for the U.S. as whole are playing out in cities and towns throughout the country, with varying rates of growth, depending on when the outbreak was seeded, the local characteristics (e.g., population density), personal behavior, and state and local policies.

## **Tamping down spread of the virus**

To bend the epidemic curve downward, you need to reduce the  $R_0$ . Anything that reduces the opportunities for infection will reduce the  $R_0$ . This is the logic behind the guidelines calling for “social distancing,” practicing careful hygiene, isolating infectious individuals, and “lockdowns” (closing schools and places of work). In addition, steps, such as those taken in mid-March in New York City, to close museums, theaters, and restaurants and cancel meetings further limited opportunities for transmission.

Roughly, [90% of the United States](#) is on some form of lockdown as a result of haphazard decisions by governors and mayors. Some states have either partial restrictions or no restrictions. However, we now have plenty of evidence that the time to enact restrictions on contact, is as soon as the first cases are detected, before spread pushes the curve upwards. Clearly, given the tendency toward exponential growth, the earlier these kinds of actions are taken and the more comprehensive they are, the lower on the curve the virus will be slowed or stopped.

Evidence from multiple countries shows that efforts to reduce the spread of infection are able to flatten the epidemic curve. However, there is the likelihood that a second wave of infection will occur when restrictions are relaxed, and carriers of the virus seed new outbreaks. This has occurred in China and is happening in [Singapore](#) after both countries appeared to have quashed the pandemic. Until an effective vaccine becomes available, localities will have to be on the alert for new infections and be ready to reintroduce control measures.



Credit: Reuters

## Need for testing

Owing to the lag between infection and the appearance of symptoms and because new foci of infection are seeded and develop for weeks before being recognized, widespread testing is crucial. The test that detects the virus can be used in two different ways. First, is clinical testing of those with symptoms and their contacts to confirm the presence of the coronavirus. This makes possible isolating patients during the infectious period and tracing their contacts.

Second, [we urgently need to know](#) the extent of infection in the general population. For this, we need testing of a random sample of the population. This type of survey should be carried out now.

Estimates of the death rate from COVID-19 range from 1 to 3.4%. However, because testing is badly skewed toward those who are sick, the case fatality rate (the number of deaths among those who are infected/the total number infected with the virus) could be seriously over-estimated. There are indications that, in fact, the [case-fatality rate is below 1.0](#). This means that the number one priority should be conducting a survey of a random sample of the population.

There is another kind of testing that will be essential when the first wave of the outbreak has been brought under control. This is serological testing of representative samples of the population in order to determine who has antibodies to the virus — a sign that a person has been infected and has successfully mounted an immune response. Without this kind of testing, we are in the dark about what proportion of the

population has had the infection and survived.

Furthermore, those who have recovered from the virus are expected to have a least short-term immunity to the virus (lasting several years) and could, thus, be able to return to work and move freely, without endangering those who are still susceptible.

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## **Murky modeling**

On March 3, at the White House COVID-19 briefing, government scientists cited figures suggesting that the coronavirus could kill between 100,000 and 240,000 Americans, under the best-case scenario (adherence to social distancing measures and a nationwide lock down). Within two days, the numbers were already being revised upward because of state intransigence on closings. The projections indicated that without stay-at-home restrictions on people's movements the toll could be as high as 2.2 million.

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The White House did not specify the time period over which these deaths were to take place, and modelers at universities were mystified by what they believe are lowball projections. Asked about the models, Anthony Fauci, the director of the National Institute of Allergy and Infectious Diseases, [commented](#) that there are too many variables at play in the pandemic to make the models reliable: "I've

looked at all the models. I've spent a lot of time on the models. They don't tell you anything. You can't really rely upon models."

## **China's deception**

Any account of the response to the COVID-19 outbreak has to start with the fact that, as late as mid-January, China, with the full-throated agreement of the WHO, argued that there was no evidence of person-to-person transmission. Local government officials in Wuhan were slow to report news of the outbreak to Beijing and detained doctors and journalists who tried to notify the world of the growing outbreak.

During the month of January, even as State Department and CDC officials were warning of an impending global crisis, more than [300,000 travelers](#) came to the U.S. from China. On January 24, the CDC [confirmed](#) two cases of the novel coronavirus in the U.S. from people who had returned from Wuhan. U.S. intelligence agencies warned that China was concealing the extent of the outbreak and relayed those warnings [directly to President Trump](#). But he insisted that China was [being candid](#) and had the virus [under control](#). Secretary of Health and Human Services Alex Azar, Center for Disease Control head Robert Redfield, and Anthony Fauci [all recommended](#) a travel ban, but Trump rebuffed them.

Finally, on January 31, at the insistent [urging of HHS and lobbying by Senator Tom Cotton of Arkansas](#), and after numerous airlines had suspended service to China, President Trump stopped the few remaining flights to the U.S. from China. It was only a partial shutdown; the policy prohibited non-U.S. citizens, other than the immediate family of U.S. citizens and permanent residents, who had traveled to China within the prior two weeks from entering the U.S.

The partial ban came late, but it was an important step in slowing down the spread of the virus. However, it was accompanied by no other measures.





Credit: Associated Press/Kathy Willens

## Aftermath

As if there were not enough variables involved in the viral pandemic and the human response to it, our handling of the pandemic has been marked by bureaucratic bungling, politicization of the issue, and a failure to learn from the experience of other countries. Further, the outbreak has sparked an epidemic of misinformation about the virus that has fed on distrust of experts. A favorite meme, perpetrated most aggressively by the [President](#) himself and [FOX News](#) as recently as mid-March, has been to trivialize COVID-19, by likening it to the seasonal flu, even though it is more transmissible and has a much higher hospitalization rate than seasonal flu.

Rather than taking charge of the crisis, from the first, President Trump has consistently downplayed the seriousness of the outbreak, delivered false messages, and shown little evidence that he has any real grasp of, or interest in, what is happening, leading to many [video montages](#) of his repeated inaccurate statements. Instead, he has been preoccupied with the stock market, including his personal financial situation, the coming election, his poll numbers, and even his [popularity on Facebook](#). This has left us without a leader who is capable of showing empathy for people and an understanding of the impact of the crisis on their lives.

Infectious disease experts have warned for decades that sooner or later a new virus would jump from an animal host to humans or that a known virus would mutate, acquiring a high enough transmissibility and lethality to become a pandemic that could kill millions of people worldwide. In 2018 and 2019, the Johns Hopkins Center for Health Security gathered public-health experts, business leaders, and U.S. government officials for simulations of the devastating humanitarian, political, social, and economic consequences of fictional novel coronaviruses that left tens of millions dead around the world.

The Obama Administration had prepared an extensive report warning that a pandemic worse than the crippling 1918 Spanish flu was possible, and it was presented to the incoming Administration in 2016. Before Trump's inauguration, [incoming officials were told such a pandemic](#) would likely lead to shortages of ventilators and that a coordinated national response would be "paramount," according to documents obtained by Politico.

The warnings went unheeded, and under Trump's direction and consistent with his goal of reducing the size of almost all government agencies, in 2018 the White House ordered the pandemic preparedness group on the National Security Council be [disbanded](#). When asked about this, [Trump professed](#) to have no knowledge of the change.

On other fronts as well, there have been depressing failures to do things that advanced countries in Asia and some in Europe have been able to deploy on the needed scale. Over the weekend of January 11-12, the Chinese authorities had shared the full genome of the coronavirus, as detected in samples taken from the first patients. And the WHO and countries like Taiwan and South Korea quickly developed tests to detect the virus. However, here the development of a test was bungled by the CDC and the FDA.

Testing of people with symptoms is still not available in many places, and it can take more than a week to get results — in spite of what the President repeatedly insists on saying. This means that for over two months, many people infected with the virus have not been identified, and their contacts have not been traced, leading to further spread.

In the U.S., stocks of personal protective equipment (PPE) and ventilators are [woefully inadequate](#), and hospitals and states are competing on the open market for these indispensable products, both among themselves and with FEMA. Reports from hospitals in different cities tell of medical workers having to reuse the same mask throughout the day, rather than changing it after each patient contact.

A report in the *New York Times* on April 2 revealed that the strategic ventilator stockpile is depleted and



that the maintenance contract for a store of roughly 10,000 ventilators held in reserve by the federal government was allowed to lapse, and that a significant proportion of the [ventilators do not work](#).

Even with all of the failures and lost time, it looks like a majority of the country is finally coming around to grasping the need to comply with measures to control the virus. Places that have been slow to embrace lockdowns will likely be spurred to greater compliance, as more cases begin to appear in their localities and after witnessing the spikes from New York City to rural Louisiana.

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Emergency field hospital in New York's Central Park.

## What lies ahead

Today we face a crisis of staggering proportions affecting every resident, particularly health care workers, as well as the economy. But, because there are so many unknowns about the novel virus, no one can say how the next months and year will play out. We desperately need to learn the extent of infection in the general population by undertaking testing of a random sample of the population. Once this is accomplished, a second survey of a random sample of the population for antibodies to the virus will provide crucial information enabling decisions about a return to normal life.

Numerous other crucial questions need answers:

- What percentage of carriers is asymptomatic?
- How many people are dying *with* the virus rather than *from* the virus, i.e., people who would have died within a short period time even without infection?

- What proportion of deaths had one or more pre-existing medical conditions?

Until this crucial information is available, all we can do is follow the prescriptions of scientists who have devoted their careers to the study of viruses and outbreaks and learn from the experience of other countries that are ahead of us in confronting the infection. Private and public laboratories around the world are racing to develop and test treatments and vaccines. While we wait for these efforts to yield tangible results, we will all need to do everything we can to avoid acquiring the virus and adding to the burden on the medical care system. One thing the virus makes clear is that we are all in this together.

In the longer perspective, we should remember that experts have been warning for decades of a pandemic ignited by new, lethal and highly transmissible virus. SARS-CoV-2 is not the worst pathogen that was envisaged, but it is bad enough. If these warnings had been heeded, and if we had prepared better for a coming pandemic, we would not be contemplating the distressing failures on so many fronts and their tragic consequences.

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