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I am writing this on April 10, 2020. Twenty-five days have passed since San Francisco became the first US city to impose a stay-at-home order on its residents. It feels like six months. As the covid-19 pandemic has advanced across the planet at dizzying speed, economies and health-care systems have toppled like dominos. At this moment, a tracker run by Johns Hopkins University shows 1,617,204 confirmed cases of coronavirus infection and 97,039 deaths worldwide. That includes 18,279 deaths in Italy, 16,686 in the US, 15,843 in Spain, 12,210 in France, and 7,978 in the UK. By the time I finish writing, these numbers will all have markedly increased.

In China, by contrast, the death toll hovers at around 3,340. This week, people began emerging from lockdown in Wuhan, the city to which the outbreak was mostly contained. New York City's official toll is now 5,150, and that doesn't count people who were never tested for covid-19. In the first five days of April, 1,125 New Yorkers died on the streets or at home, an eightfold increase over the same period last year. The real toll, in other words, is surely at least double that of Wuhan, which is a larger city, and continues to climb at a terrifying rate.

Even allowing for claims that China is concealing some cases, it now seems incredible, in hindsight, that the rest of the world saw what was happening there and didn't act sooner. It seems even more incredible that more countries didn't shut everything down as soon as they saw the magnitude of the catastrophe in Italy, the first European domino to fall. Expecting the laws of viral spread to be different in New York from what they are in Lombardy or Hubei is like expecting the laws of physics to vary from place to place.

But it is in our nature to discount threats until they become personal. Yesterday I spoke to Craig Spencer, a New York City emergency room doctor who has spent time in China as well as in West Africa, where he worked on (and contracted) Ebola. He told me he knew the novel coronavirus would spread across the world as soon as he heard about the outbreak in Wuhan. Many other public health experts had spent years modeling and planning for similar pandemics. The Trump administration ran its own exercise in the fall of 2019. New York City created a ventilator stockpile in 2006, but stopped maintaining it. For all the planning by experts, the threat of a pandemic never felt real to politicians or to voters—until it became real.

This, then, is the paradox covid-19 has exposed: we are so tightly interconnected that a virus can reach each one of us, yet so insular that we cannot conceive of what happens in one place repeating itself in another. As countries close their borders, hoard supplies, and throw blame at each other, the world risks becoming more insular still, further hampering global efforts to limit climate change (see page 54).

IAN ALLEN

Gideon Lichfield is editor in chief of MIT Technology Review.

And yet this special issue on covid-19 is not unremittingly bleak. As we scrambled to produce pieces that would not feel dated by the time you read them, we realized that most of them were stories of hope amid the gloom: Herculean efforts to find a drug (page 34); scientists and technologists from all disciplines lending their expertise to the fight (page 40); blueprints for reopening society (page 8), rethinking data privacy (page 16), restarting the economy (page 70), redesigning mental health care (page 76), and safely holding an election (page 58); lessons to be learned from countries that have tackled their outbreaks more successfully (pages 30, 44, and 50); and stories of preparedness (page 64) and resilience in isolation (page 74).

These are grim times. But now that the threat is real to everyone, perhaps we can face it together.


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How we get to

NORMAL

A blueprint for living in a world with covid-19.

By Gideon Lichfield

Artwork by Rob Sheridan

AT some point covid-19 will be vanquished. By early April some 50 potential vaccines and nearly 100 potential treatment drugs were in development, according to the Milken Institute, and hundreds of clinical trials were already registered with the World Health Organization.

Even with all these efforts, a vaccine is expected to take at least 12 to 18 months to bring to market. A treatment may arrive sooner, as Antonio Regalado reports on page 34—one company, Regeneron, says it hopes to have an antibody drug in production by August—but making enough of it to help millions of people could take months more.

It could all be over more quickly if certain existing drugs, already known to be safe for other uses, prove effective in treating covid-19. Trials are now under way; we should know by the summer. On the flip side, it may be that only a vaccine delivers the knockout blow, and even then, we still don't know how long one will stay effective as the virus mutates.

That means we have to prepare for a world in which there is no cure and no vaccine for a long time. There is a way to live in this world without staying permanently shut indoors. But it won't be a return to normal; this will be, for Westerners at any rate, a new normal, with new rules of behavior and social organization, some of which will probably persist long after the crisis has ended.

In recent weeks a consensus has started to build among various groups of experts on what this new normal might look like. Some parts of the strategy will reflect the practices of contact tracing and disease monitoring adopted in the countries that have dealt best with the virus so far, such as South Korea and Singapore. Other parts are starting to emerge, such as regularly testing massive numbers of people and relaxing movement restrictions only on those who have recently tested negative or have already recovered from the virus—if indeed those people are immune, which is assumed but still not certain.

This will entail a considerable degree of surveillance and social control, though there are ways to make it less intrusive than it has been in some countries. It will also create or exacerbate divisions between haves and have-nots: those who have work that can be done from home and those who don't; those who are allowed to move about freely and those who aren't; and, especially in the US and other countries without universal health coverage, those who have medical care and those who lack it. (Though Americans can now get coronavirus tests for free by law, they may still wind up with hefty bills for related tests and treatment.)

This new social order will seem unthinkable to most people in so-called free countries. But any change can quickly become normal if people accept it. The real abnormality is how uncertain things are. The pandemic has undercut the predictability of normal life, the sheer number of things we always assume we will still be able to do tomorrow. That is why everything feels unmoored, why the economy is collapsing, why everybody is stressed: because we can no longer predict what will be allowed and what will not a week, a month, or three or six or 12 months hence.

Getting to normal, therefore, is not so much about getting back the old normality as it is about getting back the ability to know what is going to happen tomorrow. And it's becoming increasingly clear what's needed to achieve that kind of predictability. What we can't predict, yet, is how long it will take political leaders to do what it takes to get there.

THIS NEW SOCIAL ORDER WILL SEEM UNTHINKABLE TO MOST PEOPLE IN SO-CALLED FREE COUNTRIES.

The background

First, let's look at why simply waiting for a drug or vaccine isn't a practical option.

One feature of the covid-19 pandemic is the speed with which the unthinkable has become the obvious. In mid-March, the British government was still advocating for letting most people go about more or less their normal daily business, while only the sick and the especially vulnerable isolated themselves. It changed tack rapidly after researchers at Imperial College London published a study showing that the policy would lead to as many as 250,000 deaths in the UK.

That study made the case for what almost everyone now agrees is essential: imposing social distancing on as much of the population as possible. This is the only way to "flatten the curve," or slow the spread of the virus enough to prevent hospitals from being overwhelmed, as they have been in Italy, Spain, and New York City. The goal is to keep the pandemic ticking along at a manageable level until either enough people have had covid-19 to create "herd immunity"—the point at which the virus is starting to run out of new people to infect—or there's a vaccine or cure.

Waiting for herd immunity is not an idea most experts take seriously (see page 12). But no matter what the final outcome, some degree of social distancing has to remain in place until we get there. A strict lockdown can slow new infections to a trickle, as it did in China's Hubei province, but as soon as measures are relaxed, the infection rate starts to rise again.

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Why we can't just wait for herd immunity

The widespread perception that it was once official British policy to let the virus spread until the population reached herd immunity is false; the government was just overly optimistic about how easy flattening the curve would be. But the idea has gained so much traction in some circles, fueled by speculation that we might already be much closer to it than we think, that it's worth understanding why it's not a viable policy according to the evidence to date.

First, even assuming people who get sick do become immune, we have no idea how long they'll stay immune. (With some coronaviruses, as well as with ordinary flu, immunity lasts less than a year.) Second, assuming they stay immune, we have no idea how long it would take to reach herd immunity.

The latter uncertainty stems from a few big, though related, unknowns. First, how contagious is the virus? The more contagious it is—measured as R_0, the average number of people that a victim passes the virus on to—the more people need to be immune for the infection rate to start falling. But estimates of R_0 vary (see "What is herd immunity?" page 26). These estimates suggest that anywhere from about half to three-quarters of the population has to catch it.

Second, how many people have actually been infected so far? These estimates vary even more. One study from the team at Imperial College estimated that on March 28, when Italy had just under 100,000 known cases, or less than 0.2% of the population, the virus had actually infected some 10% of Italians, most of whom either had no symptoms or didn't feel sick enough to get tested. That 50-fold difference is far bigger than some other estimates assume.

Third, what proportion of infected people never have symptoms? The official line from the US Centers for Disease Control is that it's 25%, but small studies of some localized outbreaks have suggested it might be nearer 50%. Those would support the theory that the virus is already much more widespread.

But such figures remain highly disputed because we simply aren't testing enough people to know how many infections there really are. And even if there are far more than we think, it's still not clear that we'd reach natural herd immunity sooner than we can develop a vaccine or a cure. Either way, we still have to keep the infection rate down in the meantime to a level that doesn't collapse the hospital system and leave an entire generation of health-care workers severely traumatized.

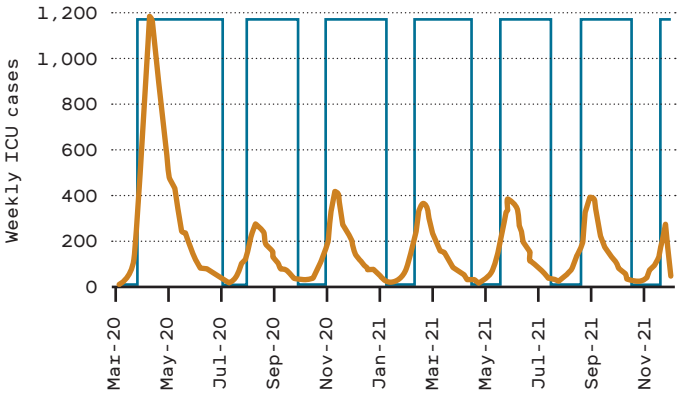
In their report on March 16, the researchers at Imperial College proposed a way of alternating between stricter and looser regimes: impose widespread social distancing measures every time admissions to intensive care units (ICUs) spike, and relax them when admissions fall. Here's how that looks in a graph (right).

The orange line is ICU admissions. Each time they rise above a threshold—say, 100 per week—the country would close all schools and most universities and adopt social distancing. When they drop below 50, those measures would be lifted, but people with symptoms or whose family members have symptoms would still be confined at home.

What counts as "social distancing"? The researchers define it as "All households reduce contact outside household, school, or workplace by 75%." That doesn't mean you should feel free to go out with your friends once a week instead of four times. It means if everyone does everything they can to minimize social contact, then on average, the number of contacts is expected to fall by 75%.

Under this model, the researchers concluded, both social distancing and school closures need to be in force some two-thirds of the time—roughly two months on and one month off—until a vaccine or cure is available. They noted that the results are "qualitatively similar for the US."

The researchers also modeled various less stringent policies, but all of them came up short. What if you only isolate the sick and the elderly, and let other people move around freely? You'd still get a surge of critically ill people at least eight times bigger than the US or UK health-care system can handle. What if you lock everybody down for just one extended period of five months or so? No good—as long as a single person is infected, the pandemic will ultimately break out all over again. Or what if you set



SOURCE: IMPERIAL COLLEGE COVID-19 RESPONSE TEAM

a higher threshold for the number of ICU admissions that triggers tighter social distancing? It would first mean accepting that many more patients would die, but it also turns out that it makes little difference: even in the least restrictive of the Imperial College scenarios, we're shut in more than half the time. That means the economic paralysis lasts until there's a vaccine or cure.

The tools

Those scenarios, however, assumed that being shut in applies equally to everyone. But not everyone is equally at risk, or risky. The key to getting to normal will be to establish systems for discriminating—legally and fairly—between those who can be allowed to move around freely and those who must stay at home.

Assorted proposals now coming out of bodies such as the American Enterprise Institute, the Center for American Progress, and Harvard University's Edmond J. Safra Center for Ethics describe how this might be done. The basic outlines are all similar.

First, keep as many people as possible at home until the rate of infections is well under control. Meanwhile, massively ramp up testing capacity, so that once the country is ready to relax social distancing rules, anybody who asks for a test—and some who don't—can take one and get the result within hours or, ideally, minutes. This has to include testing both for the virus, in order to detect people who are currently sick even if they don't have symptoms, and for antibodies, in order to find people who have had the disease and are now immune.

People who test positive for antibodies might be granted "immunity passports," or certificates to let them move freely; Germany and the UK have already said they plan to issue such documents. People who test negative for the virus would be allowed to move around too, but they would have to get retested regularly and agree to have their cell phone's location tracked. This way they could be alerted if they come into contact with anyone who has been infected.

This sounds Big Brotherish, and it can be: in Israel, such automated monitoring and contact tracing is being done by the domestic intelligence agency, using surveillance tools created for tracking terrorists. But there are less intrusive ways of doing it.

SOME WAYS TO GAUGE PREVALENCE MIGHT BE TO INFER IT FROM GOOGLE SEARCHES, OR EVEN LOOK FOR THE VIRUS IN SAMPLES OF SEWAGE.

The Safra Center, for example, outlines various schemes for "peer-to-peer tracking," in which an app on your phone swaps encrypted tokens via Bluetooth with any other phones that spend some minimum period of time nearby. If you test positive for the virus, you put that information into the app. Using the tokens your phone has collected in the past few days, it sends alerts to those people to self-isolate or go get tested. Your actual location doesn't have to be tracked, only the anonymized identities of the people you've been near. Singapore uses a peer-to-peer tracking app called TraceTogether, which sends the infection alerts to the health ministry, but—in principle, at least—such a system can be set up with no centralized record-keeping at all.

There also needs to be nationwide data-gathering and analysis to better understand how the virus is spreading and spot high-risk areas that might need more testing or medical resources, or another quarantine. This strategy has to include serological surveys—random testing for antibodies to find out how widely the virus has already spread. Some other ways to gauge its prevalence without spying on people directly might be to crowdsource the information using sites like covidnearyou.org, infer it from the volume of Google searches for covid-19 symptoms in different places, or even look for the virus in samples of sewage.

It's also important to make sure people who have tested positive or been exposed are staying in quarantine. This, however, seems hard to do without more direct surveillance. Countries like Singapore and South Korea use various means, such as making people share their location via WhatsApp or download a specialized tracking app. Whether the US or European countries could impose (let alone enforce) that kind of control isn't clear. Without it, we

have to rely on people to be responsible citizens and self-isolate when necessary.

The point is, there are more and less creepy ways of doing all this, and as Genevieve Bell writes in "The benevolent panopticon" on page 16, the crisis could catalyze a broader conversation about how to use people's data for the collective good while protecting the individual.

The hurdles

Regardless of the methods chosen, the goal is the same: after a couple of months of shutdown, to begin selectively easing restrictions on movement for people who can show they're not a disease risk. With good enough testing capacity, data collection, contact tracing, enforcement of or adherence to quarantines, and coordination between the federal, state, and local governments, local outbreaks might be contained before they spread and force another national shutdown.

Gradually, more and more people would be able to return to some semblance of normality. It would still be a far cry from the packed bars and sports arenas of the past, but it would be a less unbearable way to wait for the discovery of a vaccine or cure. More important, the economy could start ticking back to life, as David Rotman writes in "The value of a saved life" on page 70.

This depends on a lot of things going right, though. First, the initial shutdown probably needs to be harsher than it currently is in the US. At the time of writing some US states still had no stay-at-home orders, few cities were enforcing those orders, and there were no restrictions on travel between cities or states. In China, by contrast, cities in Hubei province spent some two months in strictly enforced lockdown, with public transport cut off and inter-city movement restricted.

Second, by some estimates, millions of virus tests a day, promptly performed, may be required to properly keep tabs on the pandemic in the US. By April 8 the country was testing around 150,000 people a day, and many results were taking more than a week to come back.

Third, testing for antibodies is still in its infancy, and most of the tests currently in development still return fairly high rates of both false positives and false negatives, according to the Johns Hopkins Center for Health Security. A plan to order millions of home test kits for the UK ran into trouble after experts found they might work as little as half the time.

Fourth, the US in particular has precious little coordinated national strategy. The chaotic management of the crisis by the Trump administration, the separation of powers between the federal government and the states, and the fragmented nature of privatized health care make it unclear how systems for automated contact tracing, quarantine enforcement, or immune certification will emerge.

That means a reopening of the US in June is optimistic, to say the least, and a reopening by April 30, as President Donald Trump was still hoping for in early April, is a fantasy. But Trump, along with his alter ego, Fox News, has gradually and reluctantly been moving toward a more realistic stance about the pandemic. By the end of March the White House had adopted projections of the death toll in line with those of many experts, even if those projections still assumed stricter social distancing than the federal government is currently calling for. As the pandemic spreads further into the country and starts to pummel the more Republican-leaning states, the president's interests may start to align more closely with those of the country as a whole.

WE'LL EMERGE INTO A WORLD IN WHICH PEOPLE GIVE EACH OTHER WIDE BERTHS AND SUSPICIOUS LOOKS.

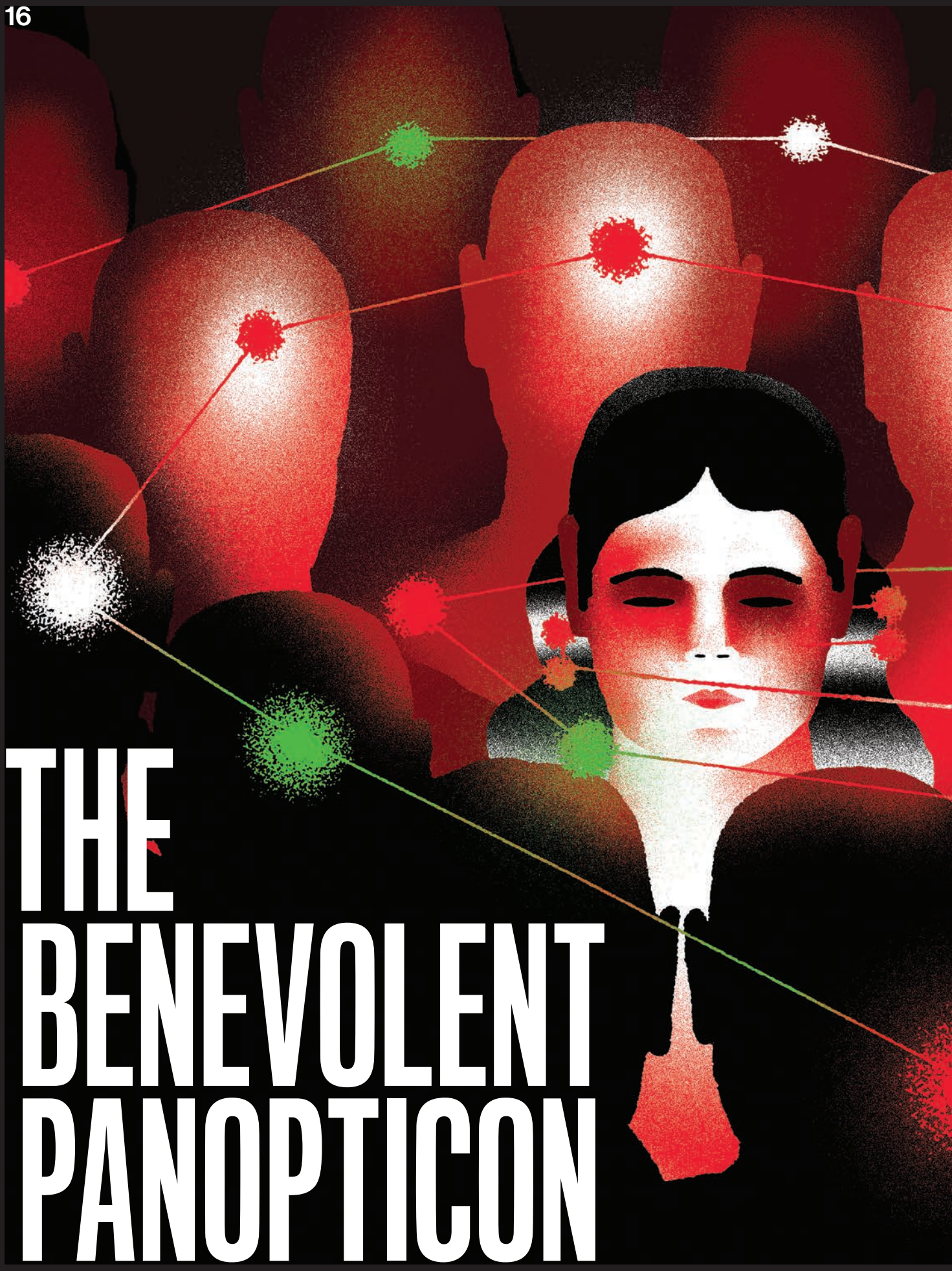
The outcome

This, then, is what passes for optimism in these grim times: the hope that while the days are still warm, and after tens if not hundreds of thousands of lives have been lost that could have been saved with quicker action, some of us will be able to start crawling out into the sunlight. We'll emerge into a world in which people give each other wide berths and suspicious looks, where those public venues still in business allow only the thinnest crowds to congregate, and where a system of legal segregation determines who can enter them. Millions will still be out of work and struggling to get by, and people will watch nervously for signs of a new flare-up near them.

But as you contemplate that future, spare a thought for the billions of people in the world for whom even social distancing and basic hygiene are unaffordable luxuries, let alone testing, treatment, and technologically advanced governments. The pandemic will roar through the slums of the world's poorest countries like fire through sawdust. In their considerably younger populations, it will probably be less deadly than in the rich world. But an unchecked pandemic there may also oblige other countries to keep their borders closed for longer to protect their own populations.

A miracle may still happen. Perhaps a readily available drug will work. Perhaps testing will show that the virus is far more widespread and less deadly than we thought. It's worth hoping for these things, but we can't bank on them. What we can expect is to have an increasingly clear picture, as the days go by, of how this will play out if we take the right steps. That's as normal as things are going to get for a while.

Gideon Lichfield is MIT Technology Review's editor in chief.



THE BENEVOLENT PANOPTICON

Fighting the virus may require handing over extremely personal data. Is this a chance to reinvent the way we collect and share private information so it can help rather than hurt?

By Genevieve Bell

I stop the car when I see him walking slowly down the empty footpath outside our now shuttered building—I know he lives on campus and is far from home. I sent my students away more than a week ago; I think of them as diasporic now, not necessarily remote, but it is still a shock to see him. We talk about his studies, and his fiancée in San Francisco, and how strange this moment in which we find ourselves is—we are at the edges of what language can describe. After one last check-in and the promise to call me if I can help, he says in an awkward voice, "You know I will have to report this."

The Australian National University (ANU), at which I work, is moving quickly in response to covid-19. Our classes have gone online, and we have sent our staff home; we are all navigating a new world of digital intermediation and distance. For the students who remain in the residence halls, locked in a country that has closed its borders and to which airlines no longer fly, it is an ever-changing situation. Keeping them safe is a big priority; there is social distancing, and increased cleaning and temporal staggering of access to services. There are rules and prescriptions and the looming reality of daily temperature checks. And apparently there is a contact log in which I will now feature, and which could be turned over to the local health services at a later point.

Illustration by Daniel Zender

The rigorous use of contact tracing, across digital and physical realms, has been credited with helping limit the spread of covid-19 in a number of places, notably Singapore, Taiwan, and South Korea, as well as Kerala, India (see page 44). As a methodology, it has a long history of use against diseases from SARS and AIDS to typhoid and the 1918-19 influenza pandemic. In its current instantiations—such as the mobile-phone app that South Koreans exposed to the virus must download so they can be monitored during self-quarantine—it has raised new concerns about surveillance and privacy, and about the trade-offs between health, community well-being, and individual rights. Even here at the ANU, we are trying to find a way to balance it all.

Perhaps we are negotiating new social contracts, with our neighbors, our communities, and our governments, that extend to the role technology plays in responding to a health crisis. And as we negotiate these new contracts, questions inevitably arise about our relationships to the data that exists about us, the sheer abundance of information that we generate, and how it could be used to help us or hurt us.

It is a lot to contemplate. Imagine doing contact tracing on yourself. Do you know where you were yesterday, and with whom? What you were doing? How about a week ago? Two weeks ago? How would you track back? Your calendar? Your in-box? Your credit card receipts or digital wallet? Facebook? Google Maps? Your mass transit card? Your shared services profiles? Your dating app? Your chat apps? Your smart watch? Your camera? Your phone? Would you rely on your memory or someone else's? Your digital devices; your data; their data? Could you reconstruct it all?

And if you could, what would it mean and how could it be used, and by whom, for what, and for how long? How would it feel to know you were part of someone else's reconstruction; that you were a trace in their days and weeks? Or to know that a passing moment was now captured, stabilized, stripped of its context, and used to tell a different kind of story—a story not about two people, but about two possible nodes in an epidemic?

And when you knew the arc of the last two weeks, and all its points of intersection and encounter, whom would you feel comfortable telling? Your kids? Your partner? Your parents? Your best friend? Your lover? Your service provider? Your employer? Your teacher? Your doctor? Your neighbors? Your community? Your government? How would you feel if you didn't have a choice in the disclosure? What if you didn't even know disclosure had happened?

As a little girl, I visited Port Arthur with my mother. It was a prison camp, built in Tasmania to house the most recalcitrant prisoners sent to Australia during its early colonial period. In 1853 a new prison was built there, modeled on the Eastern State Penitentiary in Philadelphia and strongly influenced by Jeremy Bentham's ideas of the panopticon, a prison where every inmate can be watched at all times, but never see the watcher—a proto-version of mass surveillance. In Port Arthur, the guards could see each other, and watch the prisoners, through a small keyhole—colloquially known as a judas hole—in each cell door, placed so that no part of the cell was out of its sight. The prisoners could see no one. In the one hour a day they were released from their cells, they were masked and walked in silence in walled, open-air yards. The life of the prisoner was regimented, documented, and constrained; of course, they found ways to resist and subvert the process, but it was a stark existence. The relationships between power, surveillance, and discipline were clear to me even as a child.

Contact tracing has this kind of history too. It was used to identify Mary Mallon, an Irish immigrant cook, as an asymptomatic carrier of typhoid in 1900s New York City. She was repeatedly quarantined and demonized, and survives to this day in the phrase "Typhoid Mary." It was deployed at scale during World War II to manage the spread of venereal disease by American soldiers in the United Kingdom—the overlays of nationalism, prurient interest in sex, and power dynamics in gender relationships are all highly visible. In the 1980s in Australia, it was used to identify at-risk communities at the start of the AIDs epidemic, and gay men bore the brunt of conservative politics, religious backlash, and stigma.

Against this backdrop, we might need to reevaluate how we think about "contact" (which in the latter two examples meant sexual contact that society disapproved of) and "tracing" (associated with criminal investigations and punishment) and ask: can we strip them of their moral and punitive overlays? We have to break some of the social and cultural associations of the past to use these tactics most effectively in the future.

So I guess the question is, can we imagine contact tracing, and other forms of data revelation, that don't feel like a judas hole?

Part of the answer lies in how we think about the basis of contact tracing—data, and its collection. Of course, there are already long-standing worries about the ways large corporations and governments

use and control data. There will surely be questions: Who can use the data, or own it? Can data from sources that were originally supposed to stay separate, such as health services and the police, be combined? Will decisions about who gets access to your data be automated, or will humans review them? Will your diagnoses and antibody statuses be shared with other countries when you travel, or will you be tested at the border? Will at-risk people be targeted, and by whom? And let's not forget that all of this is happening within larger systems and contexts.

Work is already under way in multiple countries on how to better regulate data collection, prevent algorithmic bias, and limit the use of mass surveillance (including facial recognition technology): it will clearly be relevant in answering such questions. So will the regulations and standards currently emerging—mostly from Europe—on privacy, the uses of personal data, and algorithmically enhanced decision-making. And it all needs to happen, as a friend of mine has taken to reminding me, at the speed of the virus—which is to say, very quickly indeed.

However, there is more to unpicking the potential panopticon than merely implementing technical and legal constraints on who controls your data. We might also need to think differently about why the data is being collected, and to what end.

Perhaps we can start by differentiating between three distinct purposes for contact tracing: one centered on public health, another on patients, and the last on citizens. All are necessary; all are different.

Public health is the most obvious focus. This is the sense in which countries like South Korea and Singapore have been doing contact tracing for the coronavirus, as well as the attendant medical interventions—notification, disclosure, registration, isolation, treatment. It is about helping make the best use of finite resources in the name of broader public health: here, contact tracing is how you might contain an outbreak before it gets too big.

DO YOU KNOW WHERE YOU WERE YESTERDAY? WHO YOU WERE WITH? WHAT YOU WERE DOING? HOW ABOUT A WEEK AGO? TWO WEEKS AGO?

The patient-centered purpose requires us to modify our notion of contact tracing to something that resembles a patient journey. Here the focus could be helping someone decide whether and how to seek care, and guiding health-care providers to the appropriate treatment. As one physician put it to me recently, it's about helping patients "triage their worry"—work out when they should be concerned and, equally important, when they should not. Early examples are being trialed in Massachusetts and elsewhere.

A focus on citizens, however, is something quite different. Can we imagine community contact tracing? It could be a way of identifying hot spots without identifying individuals—a repository of anonymized traces and patterns, or decentralized, privacy-preserving proximity tracing. This data might help researchers or government agencies create community-level strategies—perhaps changing the layout of a park to reduce congestion, for instance. It might help us see our world a little differently and make different choices—a collective curve flattening. We could create open-source solutions or locally based tools.

In all three contexts, we need to considerably expand our understanding of the data, platforms, and devices that could be useful. Could mobile-phone data identify places that need help in achieving better social distancing? Could smart thermometers help identify potential hot spots? Is community-level data as useful as personal data for mapping an epidemic and the responses to it? We would also need to shift our sense-making around data: the issue we must grapple with isn't just personal data anymore, or the ideas of privacy we have been contesting for years. It is also intimate and shared data, and data that implicates others. It might be about the patterns, not the individuals at all. How this data is stored and accessed, and by whom, will also vary depending on the tools available for accessing it. There will be many decisions—and, one hopes, many conversations.

The speed of the virus and the response it demands shouldn't seduce us into thinking we need to build solutions that last forever. There's a strong argument that much of what we build for this pandemic should have a sunset clause—in particular when it comes to the private, intimate, and community data we might collect. The decisions we make to opt in to data collection and analysis now might not resemble the decisions we would make at other times. Creating frameworks that allow a change in values and trade-off calculations feels important too.

There will be many answers and many solutions, and none will be easy. We will trial solutions here at the ANU, and I know others will do the same. We will need to work out technical arrangements, update regulations, and even modify some of our long-standing institutions and habits. And perhaps one day, not too long from now, we might be able to meet in public, in a large gathering, and share what we have learned, and what we still need to get right—for treating this pandemic, but also for building just, equitable, and fair societies with no judas holes in sight.

Genevieve Bell is director of the Autonomy, Agency, and Assurance Institute at the Australian National University and a senior fellow at Intel.


COVID-19
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ED JONES/GETTY IMAGES

1

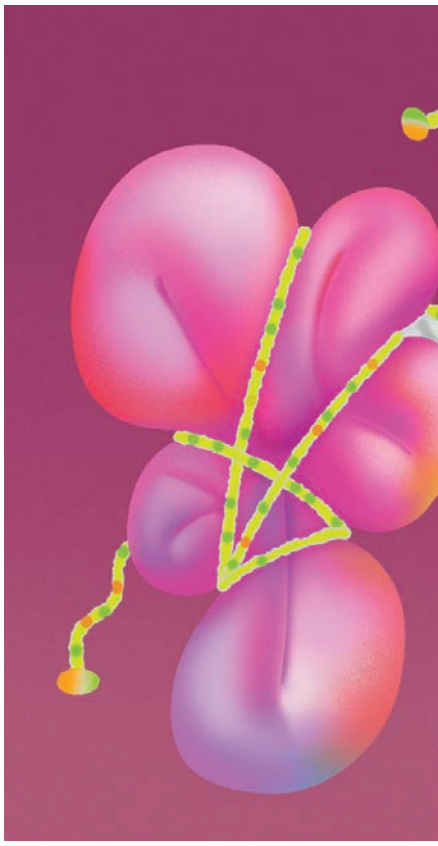
The virus

Production line workers at SD Biosensor, near Cheongju, South Korea, check devices used to diagnose covid-19 just prior to shipment in late March.

HOW DOES THE VIRUS WORK?

What it is, where it comes from, how it hurts us, and how we fight it

By Neel V. Patel



What is it?

A SARS-CoV-2 virion (a single virus particle) is about 80 nanometers in diameter. The pathogen is a member of the coronavirus family, which includes the viruses responsible for SARS and MERS infections. Each virion is a sphere of protein protecting a ball of RNA, the virus's genetic code. It's covered by spiky protrusions, which are in turn enveloped in a layer of fat (the reason soap does a good job of destroying the virus).

Where does it come from?

Covid-19, like SARS, MERS, AIDS, and Ebola, is a zoonotic disease—it jumped from another species to human hosts. This probably happened in late 2019 in Wuhan, China. Scientists believe bats are the likeliest reservoir; SARS-CoV-2's closest relative is a bat virus that shares 96% of its genome. It might have jumped from bats to pangolins, an endangered species sometimes eaten as a delicacy, and then to humans.

How does it get into human cells?

The virus's protein spikes attach to a protein on the surface of cells, called ACE2. Normally, ACE2 plays a role in regulating blood pressure. But when the coronavirus binds to it, it sets off chemical changes that effectively fuse the membranes around the cell and the virus together, allowing the virus's RNA to enter the cell.

The virus then hijacks the host cell's protein-making machinery to translate its RNA into new copies of the virus. In just hours, a single cell can be forced to produce tens of thousands of new virions, which then infect other healthy cells.

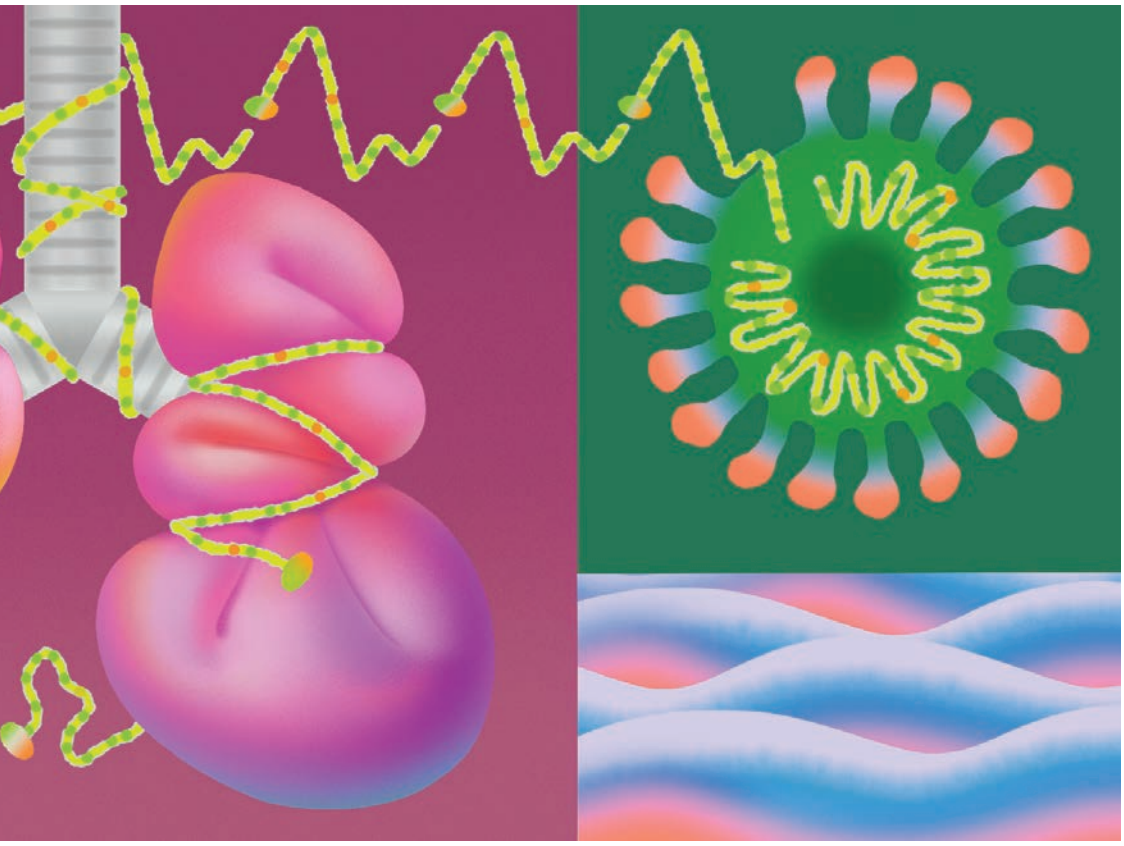
Parts of the virus's RNA also code for proteins that stay in the host cell. At least three are known. One prevents the host cell from sending out signals to the immune system that it's under attack. Another encourages the host cell to release the newly created virions. And another helps the virus resist the host cell's innate immunity.

How does the immune system fight it off?

As with most viral infections, the body's temperature rises in an effort to kill off the virus. Additionally, white blood cells pursue the infection: some ingest and destroy infected cells, others create antibodies that prevent virions from infecting host cells, and still others make chemicals that are toxic to infected cells.

But different people's immune systems respond differently. Like the flu or common cold, covid-19 is easy to get over if it infects only the upper respiratory tract—everything above the vocal cords. It can lead to complications like bronchitis or pneumonia if it takes hold further down. People without a history of respiratory illness often have only mild symptoms, but there are many reports of severe infections in young, healthy people, as well as milder infections in people who were expected to be vulnerable.

SAIMAN CHOW



If the virus can infect the lower airway (as its close cousin, SARS, does more aggressively), it creates havoc in the lungs, making it hard to breathe. Anything that weakens the immune system—even heavy drinking, missed meals, or a lack of sleep—could encourage a more severe infection.

How does it make people sick?

Infection is a race between the virus and the immune system. The outcome of that race depends on where it starts: the milder the initial dose, the more chance the immune system has of overcoming the infection before the virus multiplies out of control. The relationship between symptoms and the number of virions in the body, though, remains unclear.

If an infection sufficiently damages the lungs, they will be unable to deliver oxygen to the rest of the body, and a patient will require a ventilator. The CDC estimates that this happens to between 3% and 17% percent of all covid-19 patients. Secondary infections that take advantage of weakened immune systems are another major cause of death.

Sometimes it is the body's response that is most damaging. Fevers are intended to cook the virus to death, but prolonged fevers also degrade the body's own proteins. In addition, the immune system creates small proteins called cytokines that are meant to hinder the virus's ability to replicate. Overzealous production of these, in what is called a cytokine storm, can result in deadly hyper-inflammation.

How do treatments and vaccines work?

There are about a half-dozen basic types of vaccines, including killed viruses, weakened viruses, and parts of viruses, or viral proteins. All aim to expose the body to components of the virus so specialized blood cells can make antibodies. Then, if a real infection happens, a person's immune system will be primed to halt it.

In the past it has been difficult to manufacture vaccines for new zoonotic diseases quickly. A lot of trial and error is involved. A new approach being taken by Moderna Pharmaceuticals, which has a vaccine about to enter clinical trials, is to copy genetic material from a virus and add it to artificial nanoparticles. This makes it possible to create a vaccine based purely on the genetic sequence rather than the virus itself. The idea has been around for a while, but it is unclear if such RNA vaccines are potent enough to provoke a sufficient response from the immune system. That's what clinical trials will establish, if they first prove that the proposed vaccine isn't toxic.

Other antiviral treatments use various tactics to slow down the virus's spread, though it is not yet clear how effective any of these are. Chloroquine and hydroxychloroquine, typically used to fight malaria, might inhibit the release of the viral RNA into host cells. Favipiravir, a drug from Japan, could keep viruses from replicating their genomes. A combination therapy of lopinavir and ritonavir, a common HIV treatment that has been successful against MERS, prevents cells from creating viral proteins. Some believe the ACE2 protein that the coronavirus latches onto could be targeted using hypertension drugs.

Another promising approach is to take blood serum from people who have recovered from the virus and use it—and the antibodies it contains—as a drug. It could be useful either to confer a sort of temporary immunity to healthcare workers or to combat the virus's spread in infected people. This approach has worked against other viral diseases in the past, but it remains unclear how effective it is against SARS-CoV-2.

With additional reporting from Antonio Regalado.

Neel V. Patel is a senior reporter at MIT Technology Review.

WHAT IS SEROLOGICAL TESTING?

The race to develop tests that will tell us how widespread the virus is.

By Antonio Regalado

The US and other countries are scrambling to test hundreds of thousands of people to see if they are infected by the coronavirus. That test, which employs a technique called PCR, looks directly for the genetic material of the virus in a nasal or throat swab. It can tell people with worrisome symptoms what they need to know: Are they infected right now?

But a swab cannot tell you if you've had the disease in the past—which means we may not understand the full extent of its spread, or whether large numbers of people have already been infected and recovered without showing symptoms.

The answer to this is a different kind of test, one that can look at people's blood to find the telltale traces that show if somebody's immune system has been in contact with the virus. This procedure, known as a serological test, asks a different question—not "Does this person have coronavirus?" but "Has this person's body ever seen the germ at all?"

What is a serological test?

Serological tests work on blood samples rather than nasal swabs. These types of test for coronavirus are being developed by a number of labs around the world. The blood of someone who has been exposed should be full of antibodies against the virus. It's the presence, or absence, of such antibodies that the new tests measure. Among those developing such tests are researchers at the Icahn School of Medicine in New York City, led by Florian Krammer.

How does it work?

To make their version of a test, the Icahn team produced copies of the telltale "spike" protein on the virus's surface. That protein is highly immunogenic, meaning that people's immune systems see it and start making antibodies that can lock onto it. The test involves exposing a sample of blood to bits of the spike protein. If the test lights up, it means that you have the antibodies.

To check their results, the team inspected blood samples collected before covid-19 came out of China this year, as well as blood from three actual coronavirus cases. According to Krammer, the test can pick up the body's response to infection "as early as three days post symptom onset."

What impact could testing have on treatment?

Krammer believes serological testing could have immediate implications for treatment by helping locate survivors, who could then donate their antibody-rich blood to people in ICUs to help boost their immunity.

What's more, doctors, nurses, and other health-care workers could learn if they've already been exposed. Those who have—assuming they are now immune—could safely rush to the front lines and perform the riskiest tasks, like intubating a person with the virus, without worrying about getting infected or bringing the disease home to their families. But tests could have a bigger impact too.

ROBERT DALY | GETTY IMAGES

What else can it tell us?

How widespread is the new coronavirus? How many people get it and don't even know? What is the actual death rate? Those are some of the biggest questions that science doesn't have the answers to yet.

Serological tests, if they are done widely and quickly enough, could give an accurate picture of how many people have ever been infected. And that is the figure disease modelers and governments urgently need to gauge how deep society's shutdown needs to be.

At the time of writing, the coronavirus had killed more than 52,000 people, or about 5% of the confirmed cases: a shocking death rate. But the real fatality rate among everyone infected by the virus is certainly lower, and possibly much lower, than current figures can tell us. The reason epidemiologists can't say for sure is that they don't know how many people are infected but never go to the hospital or even have symptoms. And that's a huge problem for setting policy.

THE REAL FATALITY RATE AMONG EVERYONE INFECTED IS POSSIBLY MUCH LOWER THAN CURRENT FIGURES TELL US.

John Ioannidis of Stanford University argued in the publication Stat that the true death rate could be less than that of the seasonal flu. If so, "draconian countermeasures" are being implemented amid an "evidence fiasco" of "utterly unreliable" data about how many people are infected. Another report, meanwhile, estimated that early in the outbreak only 10% to 20% of the actual infections were being documented. Without more testing, nobody can be truly certain what the next steps should be.

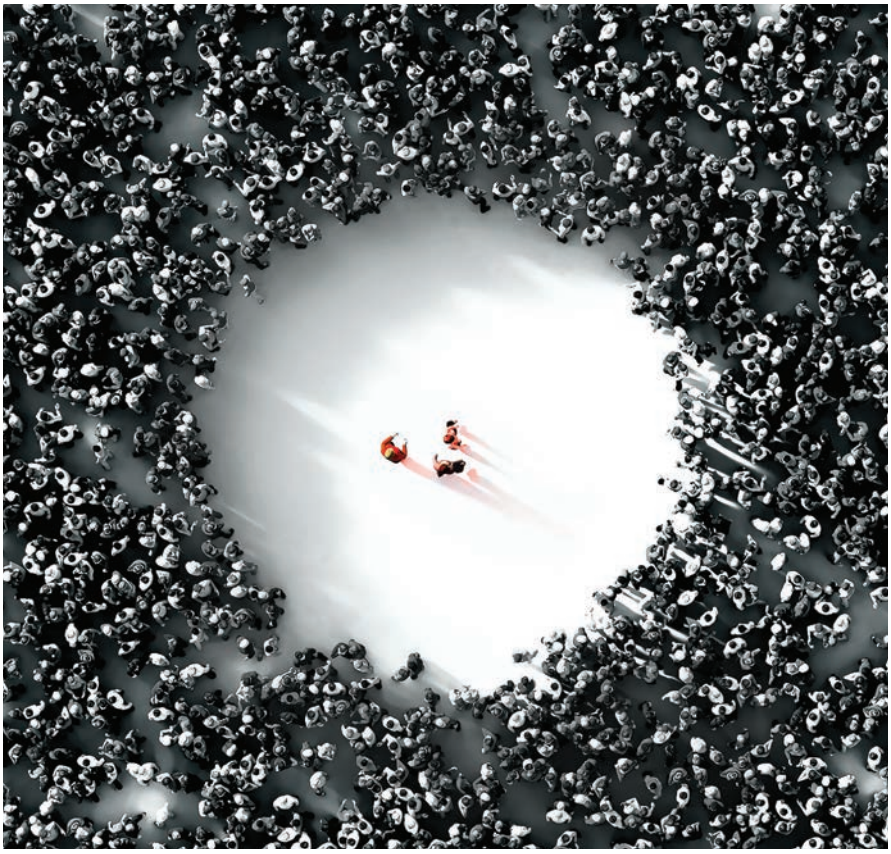
What next?

Other scientific centers, in Singapore and elsewhere, also say they have antibody tests running, as do some US companies selling products to researchers. The US Centers for Disease Control and Prevention says it is developing one; the UK planned to produce millions of at-home testing kits that use finger pricks of blood, but they have run into difficulties with accuracy.

To learn the true extent of infections, the next step for researchers—in New York or elsewhere—is to carry out "serological surveys" in which they'll do the test on blood drawn from large numbers of people in an outbreak area. That may tell them exactly how many cases have gone unnoticed.

But it could be some time before scientists learn the answer. Krammer says the effort to carry out a wider survey is "just starting."

Antonio Regalado is a senior editor at MIT Technology Review.



WHAT IS HERD IMMUNITY?

The controversial approach to bringing the pandemic to an end.

By Antonio Regalado

There are basically three ways to stop covid-19 for good. One involves extraordinary restrictions on movement and assembly, as well as aggressive testing, to interrupt its transmission entirely. The second is a vaccine (see "The race for an antibody drug," page 34). A third is potentially effective but horrible to consider: just wait until enough people catch the disease.

If the virus keeps spreading, eventually so many people will have been infected and become immune—as long they survive—that the outbreak will fizzle out on its own as the germ finds it harder and harder to find a susceptible host. This is known as herd immunity.

When experts suggest that a worst-case scenario would lead to 60% of the world's population being infected, they aren't making a guess. The numbers are informed by the point at which epidemiologists say herd immunity should kick in.

Early in the outbreak, UK prime minister Boris Johnson indicated that his country's official strategy might be to put on a stiff upper lip and let the disease run its course. Mark Rutte, prime minister of the Netherlands, struck a similar note, saying, "We can slow down the spread of the virus while at the same time building group immunity in a controlled way."

But many models suggest that shooting for herd immunity right away would be a disastrous strategy. That's because many of the people infected will become severely ill—and a sudden boom in sick people needing hospitalization or intensive care will overwhelm the health-care system.

GETTY IMAGES

The UK ultimately decided to enforce strict lockdown rules and try to suppress the virus. But even if this slows the pandemic down, it may still take herd immunity to bring it to an end.

What exactly is herd immunity?

When enough of the population is resistant to a germ, its spread stops naturally because not enough people are able to transmit it. Thus, the "herd" is immune, even though many individuals within it still are not.

Although it is ghastly to contemplate the prospect of billions being infected by the coronavirus—which has an estimated fatality rate somewhere around 1%—we've seen evidence for the emergence of herd immunity in other recent outbreaks.

How does herd immunity work?

If each person who is infected passes the virus along to two more people, there's an exponential increase in infections—but once half the population is infected, the outbreak can no longer grow. The precise point at which herd immunity is achieved, however, changes depending on the disease.

Consider Zika, a mosquito-borne illness that caused panic in 2015. By 2017, Brazilian researchers found that 63% of the population in the northeastern beach city of Salvador had already had exposure to Zika; the researchers speculated that herd immunity had broken that outbreak.

Vaccines create herd immunity too, either when given widely or when administered in a "ring" around a new case of a rare infection. That's how diseases like smallpox were eradicated and why polio is close to being erased.

Can people become immune to coronavirus?

With many germs, people who are infected and recover become resistant to getting that disease again, because their immune system is charged with antibodies able to defeat it.

As hundreds of thousands of people recover from the coronavirus, it's likely they are now resistant, although the degree of immunity remains unknown. "I would be surprised, but not totally surprised, if people did not become immune," says Myron Levine, an infectious disease expert at the University of Maryland. Some viruses, like the flu, do find ways to keep changing, which is why immunity against such seasonal germs isn't complete.

When do we reach herd immunity?

The point at which we reach herd immunity is mathematically related to the germ's propensity to spread. This is expressed as its basic reproduction number, or R_0—the average number of people to whom each infected person passes the germ when everybody is susceptible. As more people become immune, and it becomes harder for the virus to find new hosts, the effective reproduction number (denoted as just R) falls. If R_0 is 2, as in our earlier example, half the population has to become immune for R to reach 1, the point at which the outbreak stops growing. If R_0 is higher, so is the proportion needed to reach herd immunity. Measles, one of the most easily transmitted diseases, has an R_0 over 12, and requires about 90% of people to be resistant for unprotected people to get a free ride from the herd. That's why new outbreaks can start when even small numbers of people opt out of the measles vaccine.

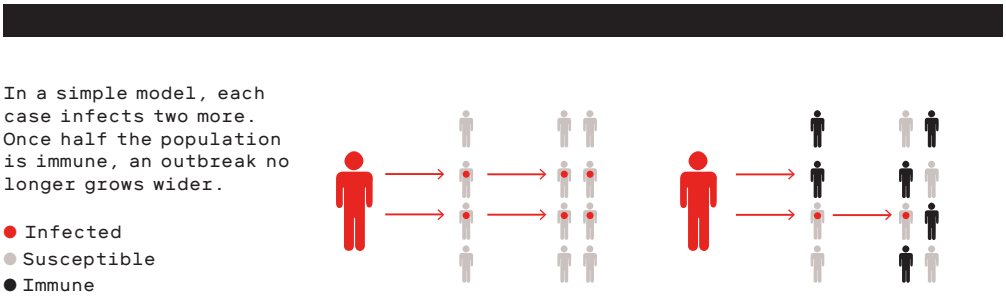
Estimates made in early March suggested an R_0 for the coronavirus between 2 and 2.5. That rate of spread is higher than for ordinary flu, but similar to the rate for emergent influenzas that have occasionally swept the globe before. "That is similar to pandemic flu of 1918, and it implies that the end of this epidemic is going to require nearly 50% of the population to be immune," Harvard University epidemiologist Marc Lipsitch told a gathering of experts.

But in late March researchers at London's Imperial College, using data from 11 European countries, estimated R_0 for coronavirus at 3.87. That would mean nearly three-quarters of the population would have to be immune before the effect kicked in, according to the simplest model.

What are the costs of getting there?

Whether it happens at 50% or 80%, the implication is that billions will be infected and millions killed around the world before herd immunity takes over. Many epidemiological models recommend aggressive "suppression" of the virus: isolating sick people, trying to reduce social contacts by at least 75%, and closing schools.

"Suppressing transmission means that we won't build up herd immunity," says Azra Ghani, an epidemiologist who is one of the leaders of the team modeling the outbreak at Imperial College. The trade-off of success is "that we are driving it down to such a low level that we have to keep those [measures] in place."



Antonio Regalado is a senior editor at MIT Technology Review.

MAGNUM

2

The fight

Artist Antoine d'Agata, working in Paris during the outbreak of covid-19 and subsequent lockdown, uses a thermal camera to investigate the importance of each individual in shared spaces.

Why some countries have fared far better in the battle against covid-19 than others—and what we can learn from them.

By James Crabtree
Illustrations by Franziska Barczyk

HOW TO MANAGE A PANDEMIC

My first taste of coronavirus panic came early one morning in January. An email with the heading IMPORTANT INFORMATION PLEASE READ arrived from our son's elementary school, just minutes before we put him on the bus. The parents of one of his teachers, who had recently returned from China, had been infected—Singapore's cases 8 and 9, as it turned out—and the teacher in question was being quarantined.

Singapore was among the first countries to suffer an outbreak. In the months since, it has been at once reassuring and unnerving to watch its journey from an early hot spot to a kind of haven state, holding out doggedly against an invader that has infiltrated so many others.

Early commentary in the West focused on the failings of China's autocratic system, which hid the severity of Wuhan's outbreak—at what we now know to be catastrophic cost. The more the epidemic has spread, the more it has become clear that Western liberal democracies have badly mishandled it too, ending up with severe outbreaks that could—perhaps—have been avoided.

Yet it makes little sense to view the coronavirus as some kind of perverse vitality test for liberal and authoritarian regimes. Instead we should learn from the countries that responded more effectively—namely, Asia's advanced technocratic democracies, the group once known as the "Asian Tigers." In the West the virus exposed creaking public


New York
BROOKLYN
STATEN ISLAND
Woodbridge Township
Perth Amboy
Upper Bay
Roma
London
Paris
France
Austria
Italy
Rome
Tyrrhenian Sea
Barcelona
Spain
Portugal
San Diego
Los Angeles

services and political division. But Hong Kong, Japan, and South Korea have managed better, while Singapore and Taiwan have kept the disease almost entirely under control, at least for now.

Lessons learned

Partly this shows the benefits of experience. The Asian "technocracies," as geopolitical thinker Parag Khanna dubs them, all suffered SARS outbreaks beginning in 2002, as well as more recent minor scares, such as H1N1 in 2009. These experiences, bruising at the time, helped government planners think through contingencies, developing outbreak management plans and stockpiling essential goods. Taiwan accumulated millions of surgical masks, coveralls, and N95 respirators for medical staff, and kept tens of millions more for the public.

There were new treatment centers too, including Singapore's National Centre for Infectious Diseases (NCID), a 330-bed facility opened just last year, which stands a 10-minute drive from my office. A friend—Singapore's case 113—ended up there for weeks in March, having caught the virus on a trip to Europe and begun to feel symptoms on his flight back home. He was first taken to the center for a test—"The scene was pretty post-apocalyptic, with everyone in plastic suits with big goggles and masks, in rooms filled with plastic partitions"—but was sent home to isolate and await results. He got a call back a few hours later. "They told me, 'Your test is positive,'" he remembered, while still in isolation at the center in late March. "The ambulance will arrive there in 20 minutes. Pack your stuff."

It was also thanks in part to SARS that Asian countries understood the need for rapid action, as Leo Yee Sin, head of the NCID, noted back in early January. At that point, covid-19 was still being referred to as a "mystery pneumonia." Around the region, passengers on flights from affected parts of China were given mandatory temperature checks. As the crisis deepened, those flights were canceled, and then borders were closed entirely. Not every country followed quite the same model of response: Hong Kong and Japan shut their schools early, while Singapore kept its open. But all acted quickly, in coordinated responses led by experts.

Technology mattered too. China deployed extensive and invasive surveillance to bring the virus's spread under control, pushing tech giants to track and monitor hundreds of millions of citizens. New apps proliferated, notably the Alipay Health Code, which assigned users a rating of green, yellow, or red, based on their personal health records with the company. The app, which shared information with Chinese police and other authorities, in effect decided who was quarantined at home and who was not.

Asia's democracies often took more basic routes, monitoring and managing the outbreak with tools no more advanced than phones, maps, and databases. Singapore in particular rolled out an admired contact tracing system, in which centralized teams of civil servants tracked down and contacted those who might have been affected. Their calls could be shocking. One minute you were oblivious at work; the next minute the Ministry of Health was on the phone, politely informing you that a few days before you had been in a taxi with a driver who subsequently fell ill, or sitting next to an infected diner at a restaurant. Anyone getting such a call was sternly instructed to sprint home and self-isolate.

What made this possible was that anyone infected could be grilled for hours. "They sat me down and interrogated me about my travel: every day, minute by minute," my friend told me. "Where did I go? Which taxi did I take? Who was I with? For how long?" The process of tracking and tracing was laborious but produced impressive results. Nearly half of the roughly 250 people infected in Singapore by mid-March first learned that they were at risk when someone from the government called and told them.

Just as efficient was South Korea's testing regime, which in January forced local medical companies to work together to develop new kits and then rolled them out aggressively, allowing planners to keep track of the pandemic's spread. South Korea had tested about 300,000 people by late March, roughly as many as the United States had managed by then, but in a country with a population one-sixth as large.

Clear communication

Transparency was another factor, though perhaps a less expected one in Asia's more autocratic societies. True, media coverage early on was more muted and respectful in countries like Japan and Singapore than in places like the UK, where aggressive reporting highlighted all manner of details that public authorities might have preferred to play down, such as contingency plans to open up a morgue in London's Hyde Park.

Nonetheless, open communication from governments has been a consistent pattern in Asia's more successful responses. Singapore put prominent front-page advertisements in the media, including early campaigns to try to stop citizens with no symptoms from buying up surgical masks and causing shortages for those who needed them. Taiwan and South Korea provided reliable and open data to citizens, along with regular social-media briefings.

As the pandemic worsened, I took a trip to the United States, sure to be the last for quite some time—departing through the forests of temperature checks and body heat scanners that by then lined the corridors of Changi Airport.

For the week I was away, I got calmly factual updates pinged to my phone roughly three times a day from the Singaporean government via WhatsApp, giving details about new infections and what the authorities were doing in response.

This focus on open information was another lesson taken from earlier crises. During the SARS crisis, as well as the 2015 outbreak of Middle East respiratory syndrome (MERS), administrations in countries like South Korea were criticized for hiding information

CORONAVIRUS WAS A TEST, AND THE WORLD'S SUPPOSEDLY MOST ADVANCED NATIONS HAVE ALL TOO VISIBLY FAILED.

and damaging public trust. This time they appear to have concluded that frequent updates from politicians and health experts were a more effective technique against viral misinformation.

This is not to pretend that everything has been perfect. Japan messed up its response to the arrival of the *Diamond Princess* cruise ship in Yokohama, and—like the US—has faced persistent questions since about its own lack of testing equipment.

Hong Kong's government was widely criticized too, in the aftermath of recent street protests that badly eroded public confidence. Hong Kong's citizens, however, have shown extraordinary willingness to self-isolate—which may in part be because they distrust the state's ability to solve the crisis, not because they meekly follow government orders.

Indeed, the examples of Hong Kong and Taiwan, itself a rambunctious democracy, give the lie to the notion that Asian nations have succeeded in this crisis because their citizens are more likely to do as they are told than free-spirited Italians or North Americans.

This idea has uncomfortable echoes of an older, racist debate about so-called "Confucian" cultures, which thinkers like the US political scientist Samuel Huntington described as hierarchical, orderly, and tending to value harmony over competition. As with talk of "Chinese flu" or sudden outbreaks of Sinophobia on American street corners, this line of thinking tells us little about why some countries performed well and others did not.

Preparation is key

Only last October, the Economist Intelligence Unit produced a lengthy report ranking nations by global epidemic preparedness. The US came top, followed by Britain and the Netherlands; Japan and Singapore were 21st and 24th, respectively. However this league table was compiled, it seems to have proved entirely wrong.

Asia has provided many examples of policies that worked—from China's speedy hospital construction to South Korea's aggressive testing to Singapore's contact tracing and open public communication—while in the West, governments that seemed well situated to deliver a swift response have been found wanting.

The thread uniting the countries that did well was that, whether democratic or not, they were strong, technocratically capable states, largely unhampered by partisan divisions. Public health drove politics, rather than the other way around.

The truth of this is likely to be cruelly revealed as the virus spreads elsewhere around Asia, and in particular to places like India and sub-Saharan Africa, where state capacity is notoriously weak.

Many such countries have tried to lock down their populations, as the advanced economies did before them. But even if they can slow the virus's spread, they do not have the benefit of strong health systems, let alone the kind of testing and contact tracing regimes that kept much of Asia safe.

This Asian advantage in competence might not endure into forthcoming phases of the covid-19 crisis, as focus shifts to managing a dramatic economic recession—an area where many Western administrations have recent experience in the wake of the 2008 crash. Governments like those of Britain and the US have already unveiled sizable stimulus packages. But it is undeniable that as they struggled to recover from that financial crisis, Western liberal economies neglected the kind of state capacity in areas like public health and pandemic preparedness that Asian states have quietly been building up. Coronavirus was a test, and the world's supposedly most advanced nations have all too visibly failed.

All this is damaging to the global reputation of the United States in particular. It was only in 2014 that Barack Obama's administration managed to lead a global response to an Ebola outbreak in western Africa. Now, six years later, Donald Trump has barely been able to organize a response in his own country.

China is already using this fact to suggest the superiority of its autocratic model of government.

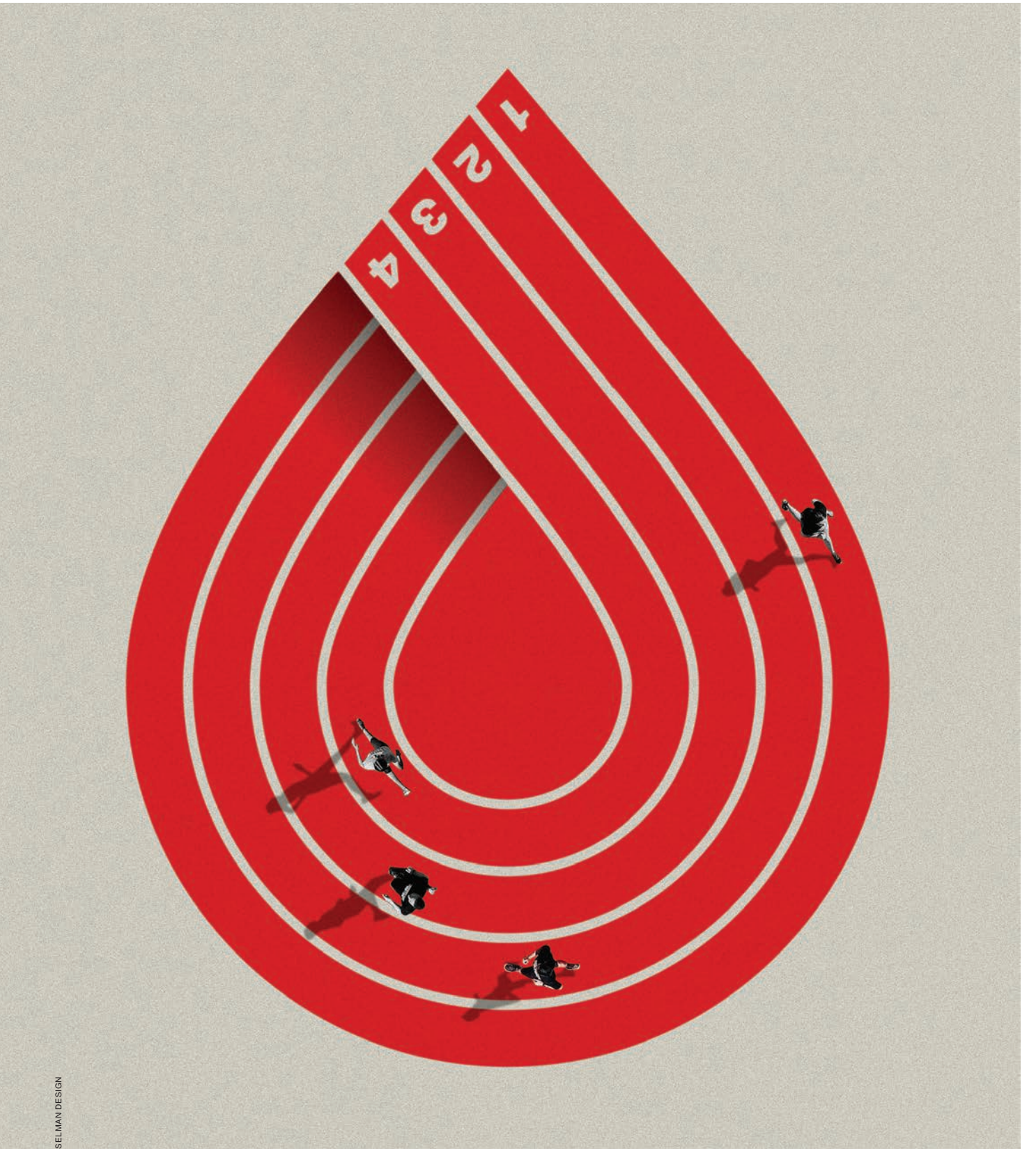
That would be a bad lesson to draw. What matters instead is a new divide between two kinds of countries: those with states that can plan for the long term, act decisively, and invest for the future, and those that cannot.

James Crabtree is an associate professor of practice at the Lee Kuan Yew School of Public Policy at the National University of Singapore. He is author of The Billionaire Raj.

THE RACE FOR AN ANTIBODY DRUG

One of the most promising approaches to making a treatment for covid-19 is to find a powerful antibody in the blood of survivors and produce enough for the rest of us.

By Antonio Regalado



SELMAN DESIGN

The blood sample arrived in Vancouver by courier on February 25. It wasn't much to look at, but to the scientists at the 117-person biotechnology company AbCellera, it was precious. The blood had been drawn from a male survivor of covid-19 in the US. The company was told it was the very first blood sample made available by American authorities. The blood was rich in immune cells oozing prong-shaped antibodies capable of seizing the new coronavirus and blocking it from infecting a cell. These molecules were the man's own immune response to covid-19 and would likely protect him from getting infected again.

The company's scientists quickly prepared the blood for analysis on a microfluidic chip where individual immune cells can be isolated and their antibodies studied. Within three days, CEO Carl Hansen says, the company had inspected 5 million cells and found 500 different excreted antibodies that stuck tightly to the "spike" protein of the virus, probably blocking it. Any one of these antibodies could be a cure for others infected.

In the US, a slow and confused rollout of coronavirus testing helped the new virus get a foothold and cause what is now a raging outbreak. But drug and biotech companies have been searching for a cure since January, when the severity of the epidemic in China became evident. Among the most promising candidates are antibody drugs, a type that already accounts for most of the top-selling medicines in the US.

The goal of the companies looking into antibodies—which include AbCellera, Berkeley Lights, GenScript, Regeneron, and VIR Biotechnology—is to turn one person's solution to covid-19 into a drug that can benefit everyone. Antibodies can lock onto the virus and neutralize it. A dose given to the sickest patients could beat back the infection and lower the death rate. These drugs are not vaccines, but because antibodies last for weeks or months in a person's blood, they could also act like a temporary vaccine—say, to protect health-care workers. If the right antibody can be found, manufactured, and bottled, it could be among the first treatments for covid-19.

That means blood from survivors is in high demand. The Rockefeller University in New York blasted out an email in mid-March saying, "Have you recovered from Coronavirus infection? If so, scientists need your help!" The center offered "compensation and parking" to anyone over 18. The National Institutes of Health (NIH) put out its own call days later.

Some US hospitals are trying to collect blood from survivors so the plasma in it can be directly transfused into patients with severe cases. The use of such "convalescent serum" was tried as early as January as an emergency treatment in China, with promising results. That's not an ideal solution because serum, which has a large mixture of antibodies present in small amounts, is not as potent as a manufactured drug, and blood donations remain in short supply. Direct transfusions are "not scalable" as an answer to covid-19, says Rockefeller University immunologist Michel Nussenzweig. Still, the blood from patients who beat the virus is invaluable in the search for specific, powerful antibodies that can be identified and manufactured in a concentrated form so that "we can give them to other people … to a lot of people," he says.

Despite the promise of antibody drugs, they may not yield a cure soon. Biotech companies say they will have antibody treatments ready for testing within two to four months, and possibly in larger quantities within half a year. That means none of the custom-designed drugs will arrive in time for the first wave of the pandemic, and they may not even be available in large amounts for the next phase, which in the Northern Hemisphere could happen next fall.

Says Nussenzweig, "The time line is similar to vaccines: it will take about year."

Antibodies made in bioreactors at Regeneron could treat covid-19.

REGENERON

VACCINES, PILLS, OR ANTIBODIES

Antibody drugs are just one of the approaches being tried. Since the start of the covid-19 outbreak, drug researchers across the world have raced to find a treatment. Some have thrown open their libraries of chemicals; other have fired up deep-learning programs to predict what drugs could work. Immediately, doctors in China tried existing drugs, from herbal remedies to HIV

medications. By mid-March, there were more than 250 clinical trials under way worldwide, and the World Health Organization (WHO) had launched Solidarity, a global mega-study of four readily available drugs, including one used to treat malaria. More than 60 potential vaccines are also in development.

In the face of widespread disease—and a death rate that, according to the most recent studies, appears to be about 10 times that associated with the flu—all we have now are "non-pharmaceutical" measures. Countries are locking down—closing stores, airports, cafés, everything but essential jobs. The unprecedented campaigns of physical distancing and, in some countries, tracing infected people and their contacts are aimed at reducing the germ's chance to move. But the economic price of these steps is already beyond calculation.

Any medicine able to shorten the duration of symptoms, or that proves effective in saving the lives of dire covid-19 cases, could ease the toughest trade-offs. If a drug shifted the balance of hope for those who end up on ventilators in intensive care units, we could get back to our jobs while protecting the lives of the weak, elderly, and unlucky. With a treatment that cut the death rate significantly, covid-19 might be a problem, but not an economic disaster.

Each major approach—conventional chemical drugs, vaccines, and antibodies—brings advantages and drawbacks. Pills are easy to make and easy to take, but none has yet been proved to work. Vaccines can give protection, but no one can predict when one will be available. (At a minimum it will take 12 to 18 months; 17 years since the world battled an earlier coronavirus, SARS, no licensed vaccine exists.) Antibodies, often given through an IV drip, have the disadvantage that they are complex to manufacture, but the advantage that they copy the body's own solution. Among "de novo" drugs—those being designed specifically for this germ—expect antibodies to be among the first you hear about.

HOW ANTIBODY DRUGS WORK

Inside your blood system, countless immune cells circulate, each one endowed with a unique antibody. Think of the antibodies as sensors able to identify foreign substances, like germs or cancer cells. The immense diversity of antibodies, made possible by the reshuffling of DNA inside newly born immune cells, accounts for why people can stave off many threats never seen before. If one of the B cells made in the bone marrow recognizes a germ, it will start spewing out its antibody in huge quantities. The time it takes to mount a successful immune response is often about a week.

AbCellera's microfluidic technology captures individual B cells from a blood sample and segregates them into micro-chambers, where they can be probed 200,000 at a time. A single experiment can determine which of those cells are making antibodies capable of most strongly attaching to the spike protein of the coronavirus, which it uses to enter human cells. The cells making the best antibodies can be removed from the device to have their DNA, the instructions for making that antibody, read. "You have the potential in your body to encode 100 billion different antibodies," Hansen says. "These cells are special because they recombine their DNA, and that's what our technology is able to sort through, to find the one that can be a therapeutic."

"YOU HAVE THE POTENTIAL IN YOUR BODY TO ENCODE 100 BILLION DIFFERENT ANTIBODIES."

LEARNING FROM EBOLA

How fast can an antibody for the coronavirus be found and start saving lives? The time line to beat, say experts, comes from Ebola, a bleeding disease caused by a virus that flared up in West Africa in December 2013. The disease was fatal about 65% of the time, so when it got into Liberia's urban slums and even reached the US and Europe with airline travelers, the US began pouring millions into potential vaccines and drug treatments.

Regeneron was one of the companies tapped to develop an Ebola treatment. The company has established a system for finding antibodies using mice genetically engineered with partly human immune systems. The mice are exposed to a pathogen "over and over again," according to Christos Kyratsous, the company's vice president for research on infectious disease, so they develop very potent, and entirely human, antibodies without needing blood from a survivor.

Regeneron rushed to create an Ebola antibody drug starting in late 2014, "but by the time we were done, the

epidemic was waning, and we didn't get a chance to use it," says Kyratsous. It was an example of how drugs can come too late in an outbreak or fail to find a market at all. An antibody Regeneron developed for MERS, the coronavirus that can jump from camels to humans and kills 30% of its victims, has never been tried on any patient, Kyratsous says. That disease, first spotted 10 years ago, is still so uncommon it's been impossible to carry out a study.

Interest in the Ebola antibody would have faded too, but then Ebola flared back up in 2018 in the Democratic Republic of Congo (DRC). "So then we had the drug ready to go," says Kyratsous. In what public health experts say could be a model for how to battle covid-19, a trial was carried out involving 673 patients to compare four treatments.

It was less than a year later, Kyratsous says, in August of 2019, that he received a call saying the trial was being halted. It wasn't a failure; rather, it was too much of a success. Regeneron's antibody cocktail and one from the NIH (based on an antibody collected from a survivor of a 1995 outbreak) worked so well that it would be unethical not to give them to every patient. Only 34% of patients treated with the antibodies were dying. Among those who got the drug early, nine of 10 survived.

The drug promised a transformative effect. It made people with frightening Ebola symptoms less likely to hide from health workers. "People think that if you enter a treatment center, you'll leave in a coffin," Jean-Jacques Muyembe-Tamfum, director of the DRC's National Institute of Biomedical Research, said in the British Medical Journal. "From now on, we will no longer say that Ebola is incurable … We have a great message: a treatment center is a place where you can recover and that you leave alive."

"PEOPLE THINK THAT IF YOU ENTER A TREATMENT CENTER, YOU LEAVE IN A COFFIN."

SPEEDING UP THE CHASE

With covid-19, people want to hear that they can go back to work, and see friends and family, without putting elderly relatives at risk. A study of the *Diamond Princess*, a cruise ship that became an accidental coronavirus laboratory, estimated the overall death rate of people with covid-19 infection to be 1.3%. For people over 70, it's five to 10 times as lethal. As Bruce Aylward, a prominent epidemiologist with the WHO, puts it, "This is one of the most serious diseases you will face in your lifetime."

If the Ebola trial—carried out in under a year in a war-torn country—is the current record for coming up with an outbreak treatment, the world hopes to beat that mark now. Regeneron says it plans to pick two antibodies against the coronavirus, and the company's billionaire founder and CEO, Leonard Schleifer, told President Donald Trump on March 2 that he could have supplies ready in the summer. "We anticipate, if all goes well, 200,000 doses per month can come out of our factory in New York, starting in August," he said.

By that point an estimated 60,000 Americans could be dead from covid-19 even with strict social distancing measures in every state, according to projections from the University of Washington's Institute for Health Metrics and Evaluation in April. There is intense pressure to accelerate the drugs' development—to take corners at high speed, if not cut them altogether. But some experts say it's not necessary to skip steps, something that could doom a drug later on. Instead, Ebola showed it's partly a matter of spending 10 times the money to go twice as fast. "You don't throw out the rules, but you shorten all the steps," says Myron Levine, an infectious disease doctor at the University of Maryland, who has trained teams in Africa to run vaccine trials. "An accordion when extended is quite wide, but you push it together and it's short. You don't skip steps; you squeeze the accordion."

As covid-19 has spread outward from China, desperate hopes have surrounded any treatment with even a chance of working. From his Twitter account, Trump touted malaria drugs based on the chemical chloroquine, even though the benefits of these are not proven, and the US took steps to make the pills widely available.

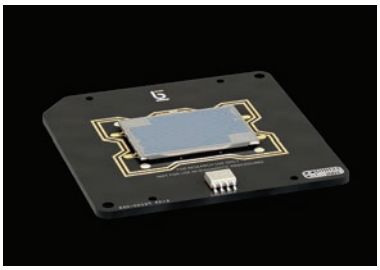
Covid-19 patients have also made pleas for drugs from their ICU beds, sometimes using social media to try to contact companies. One drug they are asking for is remdesivir, an experimental virus blocker made by Gilead Sciences that is also in clinical trials. After handing out hundreds of doses to severely ill patients on a "compassionate" basis, Gilead had to temporarily stop, citing "overwhelming demand."

Yet remdesivir was a flop in the big Ebola study. And that

shows you can't tell what drugs actually work without doing a randomized controlled trial, as Anthony Fauci, the head of the National Institute of Allergy and Infectious Diseases (NIAID), has repeatedly said during White House briefings. That type of trial involves picking some people at random to either get a drug or not get it, and seeing if there turns out to be a difference.

That kind of data should be ready soonest for the available chemical pills, chloroquine and remdesivir, which are already being given to thousands of patients in organized studies. The large number of covid-19 cases means these studies could fill up quickly—and solid proof the drugs work, or don't, could be in hand by summer.

One possible outcome, though, is that these pills will turn out to help only a little, falling well short of a cure. In that case we may need to wait for a vaccine or for purpose-built drugs, like antibodies or custom virus-blocking chemicals of the sort that ended up being able to stop AIDS.



Berkeley Lights' microfluidic chip is used to isolate immune cells.

BERKELEY LIGHTS

MANUFACTURING PROJECT

If the pandemic continues to grow, anyone who discovers a new treatment will be hard pressed to make enough of it. That's especially true for antibodies. During the Ebola trial, each subject got doses as high as 150 milligrams per kilo of body weight—or about 10 grams in all. If a covid-19 antibody is created, millions of people could need it. That means antibodies would need to be manufactured literally by the ton, in a process that involves skimming the molecules from tanks of living cells and drying them into a powder. But the biomanufacturing industry has never been asked to create that much of anything. If there's an antibody Manhattan Project, it would be to build factories big enough for the job.

The largest biomanufacturing facilities in the world cost $1 billion to set up and have as much as 150,000 liters of broths bubbling at once. Carnley Norman, a vice president of manufacturing at KBI Biopharma, which produces antibodies, estimates that one such megafactory might be able to make enough antibody for a million people each year. But what if we needed to treat 10 or 100 million—and what if high doses of several different antibodies were required? At the high end, Norman's calculation then becomes staggering: we'd need more than 300 such plants, more than exist in the world today.

"If the pandemic goes completely unchecked, we are going to have a problem," says Hansen. "If an antibody becomes the only way, we would have to do something very remarkable to treat hundreds of millions. There is a question about whether manufacturing scale-up can keep up with the outbreak."

Quantities of a curative antibody might be severely restricted, leading to difficult decisions about who gets treated, and in what country. Doctors and drug companies—and governments—would have to decide. The sickest patients will need the drugs most, but antibodies work even better if given early on. Giving them prophylactically to health-care workers will be tempting too, especially if supplies are limited. According to Regeneron, just a tenth as much is needed to protect someone for a few weeks as to treat a very sick patient.

But all that's only if we get a drug. And some believe the path to an antibody, like the path to a vaccine, is probably going to be difficult. "We have to worry about the efficacy and the safety, because this virus has unique features," says Liusong Yin, who heads discovery of biological drugs at GenScript, a Chinese research company that has 50 people doing antibody screening. He says if the virus mutates, stopping it will demand more complex antibody cocktails that hit it in three or four places at once. And for severe cases, he worries, antibodies can sometimes make people sicker by contributing to a storm of immune activity.

Given such concerns, some voices are rising to say that science—and, by extension, clever biotechnology firms—should not make excessively optimistic claims. The trouble is that the virus isn't well understood. Basic facts about it remain unstudied, including who is most vulnerable and why. Yet companies are pushing forward, which means biotechnology is being built on a foundation of scientific unknowns. In an editorial, Holden Thorp, editor of the journal Science, compared the undertaking to "fixing a plane that's flying while its blueprints are still being drawn." He knows that the efforts could fail: "I am worried," he wrote, "that science may end up overpromising on what can be delivered in response to coronavirus disease 2019."

But the alternative is that the plane crashes. And few racing to find a cure are ready to accept that fate.

Antonio Regalado is a senior editor at MIT Technology Review.

HELPING HANDS

IT BEGAN AS A PROJECT BEN Vigoda developed to convince his parents. Covid-19 was just beginning to hit the US, and they—like so many other Americans—continued going about their daily lives: they took walks, they went to the grocery store, they hung out with friends.

But Vigoda, the CEO and founder of machine-learning startup Gamalon, knew it was only a matter of time before the situation got a lot worse. A Chinese-speaking coworker had been tracking the outbreak since late December, and by mid-January, Vigoda had instructed all his employees to stock up on groceries; by the end of February, he had told everyone to work from home. Two weeks later, Massachusetts, where he lived, declared a state of emergency.

So in an attempt to get through to his Baby Boomer parents, Vigoda turned to what he knew best: data. Over a series of late nights and weekends, he built a simple model to show the importance of social distancing. "This was part of me getting them to believe me," he says, "because they were just not taking it seriously."

His model allowed them to simulate the impact of their behaviors. If his parents continued their regular social activities, how long would it take for one of their friends to get sick? And how long to spread within their community? How many people would die in the US if everyone did the same? The simulation finally "turned the tide," he says.

In fact, it was so effective that it pushed him to go even further. Unable to find official guidance on how long the pandemic might last, he began pooling together whatever data he could to develop a more sophisticated machine-learning forecast. The projections were meant only for his family, friends, and coworkers, but as he shared his results, he received consistent feedback. "There doesn't seem to be anybody else doing this," he recalls his friends saying. "Maybe you should actually try to get it out."

Vigoda is now working with a small group of data scientists and other researchers to improve their open-source forecast. All of them work during off-hours from regular jobs, in between family obligations. Still, Vigoda sometimes wonders whether all the effort is even worth it. "I'm not an epidemiologist, this is not my profession, and there are probably people doing this full time who are going to put out a model any day," he says. But despite the doubts, he pushes on, with the encouragement of his community.

"During wartime conditions," he says, "everybody pitches in, even if they're not experts."

Vigoda is part of a sudden and fast-growing movement of researchers, engineers, and scientists who have mobilized in the absence of a coordinated government response to fight the US coronavirus outbreak. As the country's caseload has soared, data scientists have scrambled to analyze global data, mechanical engineers have rushed to design makeshift ventilators, and biologists

ILLUSTRATION SOURCE: RACHEL TINE PHOTOGRAPHY

How scientists, researchers, and engineers are organizing volunteer efforts to fight the pandemic.

By Karen Hao

Ben Vigoda says the pandemic has taught him the power of collaboration.

Repurposing drugs might help fight this pandemic

And they could even help with the next one. By Wudan Yan

In mid-February, a California woman with chronic health problems tested positive for coronavirus. She hadn't traveled overseas, nor had she come into contact with anyone who had it.

When Nevan Krogan caught wind of the case, he was immediately concerned. It was the first known case of community spread in the US. "I realized at that point, this is going to be everywhere. This is everywhere," says Krogan.

As a molecular biologist at the University of California, San Francisco, Krogan runs a lab that studies how genes of diseases interact with proteins in the human body. At the time, he only had two full-time staff scientists investigating SARS-CoV-2, the virus that causes covid-19. He quickly went into the lab, gathered everyone, and told them to drop what they were doing and focus on studying the new coronavirus.

In just a few weeks, Krogan and his collaborators managed to do what typically takes years: they purified 26 of the coronavirus's 29 proteins, identified the human proteins that they latched onto, and suggested existing drugs that made good candidates for treating the disease—69 of which were already FDA-approved or in clinical trials. They reasoned that repurposing existing medications might be faster than developing a new drug.

Krogan's team is not alone. The World Health Organization (WHO) is beginning its own global trial, called Solidarity, to investigate which older drugs can treat this new disease. Potential therapies include those currently used to treat HIV, malaria, Ebola, and inflammation.

Creating new drugs is a laborious process. It takes on average about 10 years to bring a new medicine to market, and even a rushed coronavirus vaccine is likely to take 12 to 18 months. Medicines that have already been tested in humans are already known not to be toxic; the only question is whether they work against covid-19 too. That means pharmaceutical companies can immediately put them into clinical trials. That's what Algernon Pharmaceuticals, based in Vancouver, Canada, is doing, says CEO Christopher Moreau. Currently, they are investigating the potential of ifenprodil, a drug used to treat circulatory and neurological conditions. If successful, it could be mass distributed in eight to 10 months.

Some methods might even help us with the next pandemic as well as this one. Distributed Bio, a startup in San Francisco, is modifying an antibody originally designed to treat the 2003 SARS virus. It's hitting a site on the virus that hasn't changed in 18 years, explains CEO Jake Glanville, which could mean it will be effective against future coronaviruses too. "That's really the goal," he says. "Not to just solve the current outbreak. We should look to the future and make sure we're solving the forever war against all versions of corona, forever."

Glanville, Krogan, and others generally agree that a good strategy is to try all the tools and types of drugs available. A breakthrough on any of the drugs in the WHO trial "would be amazing," says Glanville. "That's the fastest route to a drug."

It's extremely difficult to predict what the next pandemic disease will be, so it's unclear whether or not all the effort put into finding a drug for covid-19 will work for the Next Big One. "There are lots of usual suspects," says Angela Rasmussen, a virologist at Columbia University. "Coronaviruses are definitely one of the candidates, but there are probably a lot of viruses we haven't yet discovered as well." If it is another coronavirus that causes the next pandemic, it may be easy to reuse the drugs we find for this disease—or at least shorten the list of potential treatments.

—Wudan Yan is a journalist in Seattle.

have redirected their labs' resources to advance new tests and accelerate the development of vaccines.

Some efforts have coalesced into open-source communities on Facebook and Slack; other people have forged ahead on their own. They are driven by a restless desire to protect their loved ones and stop widespread suffering. They also recognize that they have the sorely needed expertise that could help make a dent in the pandemic's spread. "It's an act of service," says Tonio Buonassisi, a professor at MIT who has been working with a team to develop a rapid covid-19 diagnostic. "I have the skills, and there is this need. This is why I entered this profession: to have an impact on the world."

DEBORAH PLANA, AN MD-PHD student at Harvard, chose her profession to help save lives. But on March 17, the Association of American Medical Colleges issued a guidance that student doctors should be pulled from clinical rotations. The suspension was meant to allow schools more time to adapt and to conserve scarce personal protective equipment (PPE) for essential medical personnel. But the decision weighed heavily on Plana.

"I know so many people at the front lines that are very likely going to get sick, and I'm just a couple of years away from [being] in that spot. In a weird way, I'm protected from it, yet so emotionally close to people who are not," she says. "It's really frustrating to be told not to participate."

Plana was not alone. She joined dozens of other Harvard

medical students on the Covid-19 Student Response Team to use their medical knowledge in non-clinical ways. Recognizing how little time clinicians have to stay on top of medical literature, the team split up the most pressing questions and began researching answers. Within four days, they had produced a publicly available educational curriculum on the disease, hundreds of pages long and vetted by medical faculty. The materials have since been shared widely around the world and are being translated into other languages.

The intense push invigorated Plana, but she also worries that in the long term the effort will burn her out. "In theory, I'm still a full-time PhD student that's supposed to be working toward manuscripts and grants," she says. "We're being told from our PI [principal investigator], 'This is the time to be productive! Newton discovered gravity during the plague!' It really contrasts with the urgency that I feel to be useful in any capacity."

> "TODAY WAS THE FIRST DAY I WAS ABLE TO REALLY CRY ABOUT IT. I THINK THAT'S PROGRESS. I'M ... ACCEPTING THAT THIS IS WHAT'S HAPPENING."

It's the same feeling that led Ian Baker, a senior software engineer at Dropbox, to join a group trying to tackle the PPE shortage. When he was first forced to start working from home in San Francisco, anxiety about the crisis overwhelmed him and made it impossible for him to focus on his job. "I mean, it's not like my job is meaningless," he says. "However, it's been very difficult for me to continue moving my long-term projects forward when the world is burning around me."

Then he heard from a friend who had formed a Facebook community designing and sourcing emergency medical supplies. He joined without hesitation. "Once I had an area in which it felt like I was exercising agency, where I was doing something helpful instead of being trapped in my house and helpless to do anything, I was suddenly able to do my job again," Baker says. "I started getting my life back on track."

Now every day, in the hours between his job and sleep, Baker works on the PPE Link initiative, which gathers PPE donations and distributes them to hospitals and medical facilities. He leads a small group of engineers building a platform that will make it easier to match donations with need. On weekends, too, he continues writing code and coordinating work through Slack and regular remote meetings. Like Plana, he fears burnout, but he fears slowing down even more. "The faster I can get this code out the door, the fewer people have to die," he says.

The exertion is also his salvation, a way to cope with the relentless news and the crushing sadness that comes with it. "Today was the first day I was able to really cry about it," he says. "I think that's progress. I haven't just been paralyzed on some deep emotional level. I'm starting to move beyond being totally incredulous to accepting that this is what's happening."

BUT WHILE SOME VOLUNTEERS have expertise that's clearly needed, many others with less relevant skills are also eager to join the fray. The trouble is, the crowdsourced, amateur nature of such efforts can also be risky. One particularly high-profile example came when Aaron Ginn, a Silicon Valley marketer who had helped found a conservative technology think tank, wrote an extensive Medium article based on his analysis of existing coronavirus data to refute claims about the pace of its growth. After it went viral, receiving millions of views, its conclusions drew outrage from experts. Medium ultimately took it down as a piece of dangerous medical disinformation.

Miscalculations like Ginn's are common. Many people with analytical skills but without proper knowledge of infectious disease or epidemiology have attempted to find patterns and make sense of the data. Gregg Gonsalves, an epidemiologist at Yale, calls it "an epidemic of armchair epidemiology." In an environment of heightened misinformation, the threat posed by such uninformed analysis is vastly amplified.

Vigoda, at least, is sensitive to this issue. He was initially reluctant to release his forecasting model because he lacked credibility. But he never received responses when he contacted official forecasting teams offering to help. His model now predicts trajectories similar to their own forecasts, and he hopes the open-source nature of his projections will encourage them to release their code for public scrutiny as well.

But Vigoda doesn't want to stop there. He's part of a professional community of data scientists that he estimates to be 100,000 strong worldwide, who could be tapped to pitch in. He also sees potential to repurpose some of his company's proprietary techniques for extracting and summarizing information in documents. After the White House announced an open call for machine-learning experts to help the medical community mine covid-19 research, he organized a hackathon to encourage participation.

The pandemic has shown him what's possible in a way that wouldn't have happened before. "It's taking me out of my shell," he says. "I think we were working in too closed and too isolated a way before."

He's never seen this kind of cross-disciplinary teamwork, where he can collaborate with "other scientists who I never met, where I just meet them over social media," he says. "Now I'm realizing there's so many more ways to work collaboratively and to leverage more distributed expertise."

Karen Hao is a senior reporter at MIT Technology Review.

THE TRACE RACE

By Sonia Faleiro

Even with a national government asleep at the wheel, one Indian state showed the world the right way to tackle coronavirus.

A government health worker in Kerala checks a boy's temperature.

STR/XINHUA/ GETTY IMAGES

THE SUN HAD ALREADY SET ON March 7 when Nooh Pullichalil Bava received the call. "I have bad news," his boss warned. On February 29, a family of three had arrived in the Indian state of Kerala from Italy, where they lived. The trio skipped a voluntary screening for covid-19 at the airport and took a taxi 125 miles (200 kilometers) to their home in the town of Ranni. When they started developing symptoms soon afterward, they didn't alert the hospital. Now, a whole week after taking off from Venice, all three—a middle-aged man and woman and their adult son—had tested positive for the virus, and so had two of their elderly relatives.

PB Nooh, as he is known, is the civil servant in charge of the district of Pathanamthitta, where Ranni is located; his boss is the state health secretary. He'd been expecting a call like this for days. Kerala has a long history of migration and a constant flow of international travelers, and the new coronavirus was spreading everywhere. The first Indian to test positive for covid-19 was a medical student

PB Nooh, a civil servant in Kerala, saw quickly that the only way to control transmission was to break the chain.

who had arrived in Kerala from Wuhan, China, at the end of January. At 11:30 that same night, Nooh joined his boss and a team of government doctors on a video call to map out a strategy.

For some, this wasn't their first time fighting a deadly epidemic. In 2018, the state had dealt with an outbreak of Nipah, a brain-damaging virus that, like the coronavirus, had originated in bats and transferred to humans. And, as with covid-19, there was no vaccine and no cure. Seventeen people had died, but the World Health Organization (WHO) called Kerala's handling of the outbreak a "success story" since—despite technical shortfalls—the state's health system had contained a potential disaster.

This time, though, they would need to go further and move faster.

By 3 a.m. the team had settled on a WHO-recommended plan of contact tracing, isolation, and surveillance. It had been used to limit the spread of Nipah, and on the medical student in January. The plan relied on consulting patients, mapping their movements to see who they'd interacted with, and isolating anyone in the chain with symptoms.

There was, however, one obstacle. The family "weren't forthcoming," says Nooh. They were in isolation at the district hospital but didn't want to declare the full extent of their movements. It was as though they were embarrassed.

At this point, 31 people had tested positive for covid-19 across the country. It was a small number, but the virus was fast-moving—on average, one person was thought to infect two to three others.

This spelled bad news for India. Many of its 1.4 billion residents live in large families and don't have running water, making it difficult to sanitize things and maintain social distancing. Even countries with advanced health-care systems were being overwhelmed, and India had just 0.5 hospital beds for every 1,000 people—a long way behind Italy, with 3.2 beds per 1,000, and China, with 4.3. In addition, there were only 30,000 to 40,000 ventilators nationwide, while testing kits, personal protective equipment for health-care workers, and oxygen flow masks were also in short supply. It was clear to Nooh and his colleagues: the only way to control transmission was to break the chain.

NOOH, WHO IS 40, WITH A THICK head of hair that he combs dutifully to one side, is a soft-spoken man who lives with his wife, a medical student, close to his office. In 2018, when a flood swept through the district and left more than two dozen people dead and 20,000 houses damaged, he had led relief efforts, and got no more than two or three hours of sleep at night. Admirers started a Facebook fan page called Nooh Bro's Ark.

The experience taught him not just how to manage people in a crisis, but also how to read them. He gauged, correctly, that this family from Ranni would be intractable. So rather than rely on them, he turned to old-style detective work and technology to piece together where they'd been and who they'd come in contact with.

He brought in 50 police officers, paramedics, and volunteers, and split them into teams. Then he sent them out to retrace the family's movements over that crucial week. They'd given his district officers scraps—an address here, a name there—but Nooh's task force expanded it dramatically, using GPS data mined from the family's mobile phones and surveillance footage taken from the airport, streets, and stores.

In a matter of hours they had learned a lot more about the family's movements than they'd been told—and what they found alarmed them. In the seven days since arriving in Kerala, the family had gone from one densely crowded place to another. They'd visited a bank, a post office, a bakery, a jewelry store, and some hotels.

INDIASPEND/SHREEHARI PALIATH

They even went to the police for help with paperwork.

THAT EVENING, KERALA'S HEALTH minister, KK Shailaja, arrived from the state capital. A former science teacher, she'd already gained a reputation for her prompt and efficient handling of the unfolding crisis: the media had nicknamed her the "Coronavirus Slayer."

While the rest of India, along with countries such as the UK and the US, wouldn't take stringent steps to limit movement for another two months, Shailaja had ordered Kerala's four international airports to start screening passengers in January. All those with symptoms were taken to a government facility, where they were tested and isolated; their samples were flown to the National Institute of Virology 700 miles away. By February, she had a 24-member state response team coordinating with the police and public officials across Kerala.

This was unusual—but Kerala often goes a different route from the rest of India. The small coastal state at the country's southern tip is steeped in communist ideas and governed by a coalition of communist and left-wing parties.

In recent years, as some states have followed the populist lead of India's Hindu nationalist prime minister, Narendra Modi, Kerala has maintained its focus on social welfare. Its health-care system is ranked the best in India, with world-class nurses who are head-hunted for hospitals in Europe and America; the state's life expectancy figures are among the highest in the country.

IN THE SEVEN DAYS SINCE ARRIVING IN KERALA, THE FAMILY HAD GONE FROM ONE DENSELY CROWDED PLACE TO ANOTHER.

The minister's arrival in the district reassured Nooh. He wasn't on his own; the machinery of the entire state was at his disposal. "The seriousness of the government was amazing," he says. Each team on his task force was increased from six people to 15.

By March 9, around 48 hours after the family tested positive, Nooh's teams had a map and a flow chart listing each place they had been, when, and for how long. The information was circulated on social media, and people were asked to dial a hotline if it was possible that they had interacted with the family. Nooh's office was flooded with calls: the family had met with almost 300 people since arriving in town.

Now the teams had to track down these people, gauge their symptoms, and either send them to the district hospital for testing or order them to self-isolate at home. The number of people self-isolating quickly rose to more than 1,200. Still, Nooh knew that people who agreed to self-isolate wouldn't necessarily do it. So he set up a call center in his office, bringing in more than 60 medical students and staff from the district's health department, whose job was to call everyone isolating, every day.

The callers ran patients through a questionnaire meant to assess their physical and mental health, but also to catch lies. If anyone was caught sneaking out, "we had the police, the revenue department, and village councils ready to act," Nooh says. But the carrot was as important as the stick: his office also delivered groceries to those in need. The district was placed on high alert. Nooh wore a mask, scattered bottles of hand sanitizer around the office, and reverted "to the old model of *namaste*" rather than shaking hands. This was now ground zero for the covid-19 crisis in India.

ON MARCH 11, THE WHO DECLARED the covid-19 outbreak a pandemic. The next day, India reported its first death. Even so, Modi—perhaps concerned by the impact on the already lackluster economy—refused to issue public advisories and didn't address the media. His biggest concern seemed to be a plan to redesign the heart of the Indian capital, including parliament, at a cost equal to $2.6 billion.

In Kerala, a different style of leadership was on display. With 15 cases now confirmed across the state, Pinarayi Vijayan, the chief minister, ordered a lockdown, shutting schools, banning large gatherings, and advising against visiting places of worship. He held daily media briefings, got internet service providers to boost capacity to meet the demands of those now working from home, stepped up production of hand sanitizer and face masks, had food delivered to schoolchildren reliant on free meals, and set up a mental health help line. His actions assuaged the public's fears and built trust.

"There was so much confidence in the state government," says Latha George Pottenkulam, a clothing designer in the port city of Kochi, "that there was no resistance to modifying one's behavior by staying in."

Kerala's health minister, KK Shailaja, a former science teacher, quickly gained a reputation for her handling of the unfolding crisis: the media nicknamed her the "Coronavirus Slayer."

WIKIMEDIA/SANU N

There were other reasons why Kerala was better equipped to deal with the crisis than most places. It is small and densely populated, but relatively well-off. It has a 94% literacy rate, the highest in India, and a vibrant local media. Elsewhere in the country, people were taking WhatsApp rumors at face value—for example, spreading messages claiming that exposure to sunlight could protect against the virus. But in Kerala, most people realized the seriousness of the situation.

Manju Sara Rajan, the editor of an online design magazine in the district of Kottayam, told me she felt safer living in Kerala than anywhere else in India. "We have been considering the possibilities for far longer," she said. Everyone around her knew the number to call if they developed symptoms, and they weren't acting heedlessly by rushing to the hospital at the first sign of a dry cough.

By March 23, the number of confirmed cases in Nooh's district had risen from five to nine, but the containment efforts were judged successful.

That didn't mean Kerala was coming through unscathed. It is one of India's smallest states but has almost the same population as California: the district of Pathanamthitta has more than a million residents alone. Services were under severe pressure, and local doctors were stretched.

Nazlin A. Salam, a 36-year-old GP at the district general hospital, found herself working 12-hour days. She christened her turquoise blue Nissan Micra the "Covid Car"—nobody else in her family would go near it—and sanitized it every night. After returning from work she would bathe before approaching her children, and refused to kiss them in case she unwittingly transmitted the virus.

Her patients were stable, she said, but there were only three ventilators at the covid-19 isolation ward and another two for general use, in a hospital with a potential intake of 400 people. To keep numbers down, the district administration would have to continue contact tracing and testing. By March 28 it had more than 134,000 people under surveillance, with 620 in government care and the rest isolating at home. Every day, Nooh arrived at his office at 8:30 a.m. and didn't leave until 9:30 p.m. Even when he was in bed, calls and messages about the situation streamed in.

For most of March, India's prime minister still hadn't announced a plan to combat the pandemic. He *had* asked Indians, in a nationally televised speech, to come out on their balconies one Sunday to clap for health workers. Another day, he asked them to stay home for a few hours—a "people's curfew"—but his messaging was so muddled that large crowds, which included police officers, took to the streets to blow conches, bang utensils, and ring bells as though they were celebrating a festival.

Then, on March 24, without warning, Modi declared that India would go into a 21-day lockdown—and it would start in less than four hours. Keralites were prepared for this national closure, since they had already been living in an informal lockdown for weeks. But they also had support: Vijayan, the state's chief minister, was the first in the country to announce a relief package. He declared a community kitchen scheme to feed the public, and free provisions including rice, oil, and spices. He even moved up the date of state pension payments.

The rest of India wasn't quite as lucky. With the shutdown just hours away, people rushed out to buy food and supplies: in many areas they quickly dried up.

At the same time, hundreds of thousands of migrant workers who were now out of jobs tried to find their way home, but with state borders sealed and trucks and buses suspended, they had no option but to walk hundreds of miles to their families. By March 29 at least 22 of them had died on the way.

Meanwhile police officers, determined to be seen doing

their job, chased down anyone who was outside, even trucks carrying essential supplies, couriers from Amazon Pantry, and of course the desperate migrant workers. In West Bengal, they beat a man buying milk. He died. The government later confirmed that the lockdown didn't cover shops selling food, but many people chose to stay indoors to avoid crossing paths with law enforcement.

The supply crisis escalated so quickly that one reporter nosing around the prime minister's home constituency in Uttar Pradesh found hungry children chewing on grass. Equipment shortages left some desperate doctors wearing raincoats and motorcycle helmets instead of coveralls and protective masks. Although the government announced a $22.5 billion stimulus package, it was tiny relative to the needs of India's population. It wasn't even clear how and when it would get food into people's hands. And yet, Indians had no choice but to stay indoors.

The country had "missed the boat on testing," said Ramanan Laxminarayan, director of the Centre for Disease Dynamics, Economics, and Policy, in a TV interview. "Containment is not an option anymore." The lockdown would slow the spread of the virus, but, he said, there could be 300 million to 500 million cases by July: "Eventually everyone in India will get covid."

What was needed now was to proactively test anyone over the age of 65 who was showing symptoms, and for the public sector to start making ventilators "on a war footing."

THE LOCKDOWN DIDN'T COVER SHOPS SELLING FOOD, BUT MANY PEOPLE CHOSE TO STAY INDOORS TO AVOID CROSSING PATHS WITH LAW ENFORCEMENT.

A few days earlier, the prime minister had proposed an emergency covid-19 fund for the eight member nations of SAARC, the South Asian Association for Regional Cooperation. In grandiose fashion, he declared that India would contribute $10 million. "We can respond best by coming together, not growing apart—collaboration, not confusion; preparation, not panic," he said, during a video conference with regional leaders.

Then, after flashing money at SAARC, he tweeted to solicit donations from the public for a fund he had set up to fight covid-19, but with little transparency about the fund's legal framework and where the money might actually go.

As the virus spread across villages, towns, and cities and then lit into India's—and Asia's—largest slum, Dharavi, in Mumbai, the government continued to ignore calls for more testing and equipment. Then it announced that it would start broadcasting reruns of the *Ramayana*, a 1980s TV show based on the Hindu epic of the same name whose central message is the triumph of good over evil.

The Modi government's failure to act left it to individual states to protect people as best they could. Only states like Kerala, with the experience and aptitude to take on a crisis of international proportions, felt able to do so.

AS OF MARCH 31, THE INDIAN GOVernment had announced 1,637 cases of covid-19. In Kerala, 215 people had tested positive. And if Laxminarayan is correct, this was only the beginning.

Nooh was still contact tracing, testing, and isolating, his team chasing down every potential patient. There were now more than 162,000 people in self-isolation in his district, as well as more than 60 community kitchens, eight relief camps to house and feed migrant workers unable to return to their home states, and a two-member documentation team taking notes in the event that the situation repeats itself.

One Saturday in March, Nooh took a long drive to Konni, a town on the edge of a forest that is famous for elephants. One part of the forest is inhabited by an indigenous community of 37 families, separated from the town by a river. There was no bridge, and Nooh had heard that relief supplies hadn't gotten there. At the water's edge, he rolled up his sharp blue trousers and hoisted a jute sack full of provisions over his shoulder. It weighed about 35 pounds (16 kilograms). This wasn't his job, but he wanted to send a message. "In an unprecedented situation, everyone must contribute," he said.

Twenty-three days earlier, Nooh had been faced with the "biggest ever challenge" of his career. Now, despite being severely overworked, he saw an opportunity. "As a society, we've never faced such a situation," he said. "Let's see what we can do."

Sonia Faleiro is the author of Beautiful Thing: Inside the Secret World of Bombay's Dance Bars (2010). Her new book The Good Girls will be published in January 2021.

THE LESSONS OF EBOLA

TR: Q+A

Smarter leadership makes a big difference, says Christopher Kirchhoff, who worked on US Ebola response.

By Konstantin Kakaes

Q: What steps did the US government take after the 2014 Ebola outbreak?
A: An emergency spending bill that was passed by Congress in December 2014 included $1 billion that the administration used to address some crucial weaknesses. Many nations around the world didn't have testing capabilities to be able to notice when a novel or really lethal pathogen emerges. Using that money, we partnered with more than 60 countries to introduce much more widespread testing capability to detect pathogens when they first emerge. Then we conducted a country-by-country assessment of how strong their emergency response and public health system is and worked with each country to strengthen their preparedness and response capabilities.

We also established a network of Ebola treatment centers: 35 hospitals across the United States, plus a number of labs that were designated by the federal government. If somebody were to come down with Ebola or another highly lethal pathogen, they wouldn't be more than two hours away from a hospital that was designed to treat them.

Another thing that was really important was the creation, toward the end of the Obama administration, of a new office in the White House called the Global Health Security Directorate.

This new office within the National Security Council had two functions. The first was to coordinate the response in the event of a future crisis. The second purpose was that it would be responsible for seeing through substantial structural changes in many departments and agencies. These were the kinds of reforms that wouldn't happen on their own, without organized follow-through from the White House.

Q: Can you go into a little bit more detail on what those structural changes were?
A: On the domestic side, the very small number of Ebola cases that we had in the US showed major gaps in how federal, state, and local authorities responded together. Because the US has a federal system where most public health authorities are actually at the local levels, but most capability is at the federal level, we had to have tighter coordination in the future to respond.

On the international side, we discovered whole new doctrines for how to respond to an outbreak abroad by using different capacities in government. Never before had the military been used to support civilian health responders in the way it was in West Africa.

Q: Do you think the existence of an office like that would have made a substantial difference to the prevalence of the novel coronavirus in the US today?
A: Yes. The office was dissolved in May 2018. But Ebola taught us that there's an incredible penalty for inaction, because epidemics grow exponentially: every day you delay responding, you end up facing a steeper exponential curve that makes the situation quickly transition from what would have been manageable to something that's unmanageable. This is where we are today. You have to imagine that the presence of an office well staffed with professionals in emerging infectious diseases would have been able to help the US government be more nimble in those crucial early days, when more capabilities could have been brought online and could have been ready to help us get ahead of the curve.

Q: What do you think might have happened had the Obama administration not sent nearly 3,000 military personnel to West Africa?
A: I think you would have seen the epidemic continue the way that it was growing in August 2014, when it was doubling in size every three weeks. Although the three countries where the outbreak was concentrated don't themselves have high rates of international travel, there are land routes to other African nations. One scenario that people worried about tremendously

DAVID VINTINER

Christopher Kirchhoff was a member of the White House Ebola Task Force. He is a senior fellow at Schmidt Futures.

was Nigeria—not only having the mega-city of Lagos, but in the north of Nigeria having insecure conditions with an Islamic insurgency that might well have prevented international health responders from accessing those who needed care, which could have resulted in Ebola becoming endemic in Africa.

Q: Has the role the current administration has given to scientific research limited the effectiveness of the US government response?
A: I think it's unavoidable to talk about the fact that the CDC [Centers for Disease Control] budget has been significantly decreased, that administration budgets have continually advocated for dramatic cuts to research and development. Programs oriented to delivering therapeutics and vaccines have been affected in this process. And in an emergency like this, you want to have more of them.

Q: What role did the private sector play in 2014, and what can be done today?
A: There were tremendous contributions during the Ebola outbreak from both the private sector and the philanthropic sector. Paul Allen pledged $100 million to fight Ebola, and his foundation developed an ability to safely transport people infected with Ebola on airplanes so they could be medically evacuated. This was a capability that the US military didn't even have. We're seeing the same thing today, where the Gates Foundation stepped up in Seattle and rolled out test kits before the government was able to.

At Schmidt Futures, the philanthropy I work for, we're doing a lot of thinking about the role technology can play. One of the efforts we've already funded is using online education tools to train people to use ventilators. It turns out that we have very few ventilators, but we have even fewer people able to operate them.

Another example: there's a great race among technologists in Western countries to be able to do location-based, smartphone-enabled contact tracing in a privacy-protected way. There are several different architectural approaches to this. It could be an enormously powerful tool—particularly toward the latter stages of an outbreak, when you revert from a situation with widespread community transmission to just a few carriers who nevertheless still infect others. Just like in Ebola, contact tracing is the only way, at the tail end of an outbreak, to ensure that an outbreak is stopped in its tracks. This gives technologists an important window to experiment with different capabilities that could be enormously important if they were to come online two to four to six months from now.

Q: How optimistic are you that we will learn lessons from what's going on now that will enable us to be much more effective in fighting epidemics in the future?
A: What we are living through now will be hard to forget. So I think there will be an intense focus on how to prevent an outcome like this in the future, but there will be no substitute for leadership to see through the very significant changes that are necessary if we want to grow our capacity on all fronts for outbreaks.

I think there's an enormous opportunity for Congress to lead on making investments that not only will help us respond today, but will help us grow the capacity of our response systems in the future. Investments in helping hospitals all across the United States be able to surge capacity in the event of an emergency; investments in our ability to rapidly produce diagnostic testing; investments in our public health infrastructure at the state and local level; investments around the world, particularly in nations that are not themselves well equipped to confront the outbreak of novel diseases. And that work can begin now.

This interview has been condensed and edited for clarity.

Konstantin Kakaes is an editor at MIT Technology Review.

PUNIT PARANJPE/GETTY IMAGES

3

The impact

Mumbai residents light candles and turn on mobile-phone lights to show solidarity during a nine-minute vigil called by Indian prime minister Narendra Modi in early April.

THE CLIMATE IS ALSO A CASUALTY

Global cooperation on climate change was already faltering. Things just got much worse.

By James Temple

On the early afternoon of December 15, the gavel fell at the UN COP25 conference in Madrid. The weeks of negotiations over crucial pieces of the Paris climate agreement reached four years earlier had ended in failure. Despite spending nearly two days longer than scheduled, thousands of delegates departed the convention halls deadlocked on the basic rules required to move forward.

There's plenty of blame to go around. But by most accounts, Australia, Brazil, and the United States—each now run by nationalist leaders who rose to power in part on promises to defy global demands for greater climate action—took special pains to thwart progress.

Brazil immediately backed out of hosting the convention after the election of Jair Bolsonaro, and its delegates spent their time in Madrid arguing for the need to open up the Amazon for farming and mining. The US, on track to exit the accords altogether under President Donald Trump, stonewalled efforts to establish a process for providing funding and support to poor nations hit by climate disasters.

In the end, nearly every major decision at COP25 was punted to the next conference, originally scheduled for this November in Glasgow. "The can-do spirit that birthed the Paris agreement feels like a distant memory today," Helen Mountford, vice president for climate and economics at the World Resources Institute, said at the close of the talks.

Two weeks later, researchers in China identified a deadly new coronavirus strain that had infected dozens of people, marking the start of the global pandemic. Borders slammed shut. Global trade stalled and markets crashed. Countries traded accusations and insults. In a matter of weeks, any lingering momentum behind efforts to jointly confront climate change essentially vanished.

As the worldwide death toll accelerated, countries locked down cities, banned international travel, and all but shut down their economies in a desperate effort to slow the outbreak. Under the demands of social distancing, the teenage activist Greta Thunberg shifted her swelling climate movement online—where it effectively dropped out of public sight. The UN ultimately canceled this year's COP, killing any last hopes that nations would, as originally intended, adopt more ambitious emissions targets on the fifth anniversary of the deal.

The Paris accords had lifted hopes that after decades of dithering, the world might finally pull together to confront climate change. Nearly every nation signed on, each agreeing to take specific steps to rein in emissions. But what if, in retrospect, Paris was not the start of an era of cooperation, but its high point?

THE NATIONALIST NARRATIVE

As the covid-19 outbreak rages across the world, it's easy to forget about the climate crisis. The priorities right now are, and should be, slowing the pandemic, saving lives, and then restarting economies left

MIGUEL PORLAN

in shambles. But by that point few countries are likely to be able or especially eager to sacrifice near-term growth to help slow global warming.

In the short term, global emissions are falling, as they did during steep economic declines in the past. But carbon dioxide can stay in the atmosphere for centuries, meaning the total concentration will continue to rise even if we're producing less of it. And emissions will bounce back as soon as economies do. They're already nearly within normal ranges in China again.

So the threat of rapidly accelerating climate change will remain. And we'll be living in a much poorer world, with fewer job opportunities, less money to invest in cleaner systems, and deeper fears about our health, our financial futures, and other lurking dangers.

These are ripe conditions to further inflame nationalist instincts, making our global challenges even harder to solve. Indeed, the breakdowns in international (and even intra-national) cooperation as countries race to understand and tackle the covid-19 outbreak offer a stark warning for our climate future.

By its very nature, climate change is a global problem: every country needs to nearly eliminate emissions. But they don't all have the same incentive to do so. Regions like Europe that pumped out huge shares of historic emissions have less to lose by curbing them than nations like India that need faster economic growth to reduce poverty. Those rich countries also

aren't likely to face nearly the same level of climate disasters as poor ones. Colder nations, like Russia and Canada, could even benefit economically from warming.

"It's not surprising that the most ardent nationalist populists—in Brazil, the US, EU skeptics in Britain—are also the most skeptical of Paris," says David Victor, co-director of the Laboratory on International Law and Regulation at the University of California, San Diego. "But that whole agenda is deeply problematic for climate because ultimately what you need is a set of institutions and some measure of cooperation that helps diffuse good ideas and products around the global economy."

AMERICA FIRST

Donald Trump, a self-described nationalist who denounces "globalism," inflicted the single biggest wound to the Paris agreement by declaring, on the very first day he could, that the US would withdraw from it. During his Rose Garden speech on June 1, 2017, he laid out a case against the deal that had little to do with the actual terms—which were self-determined and nonbinding—and everything to do with stoking simmering resentment of foreign nations, international institutions, and distant elites who would dare tell the US what to do.

He's lambasted international treaties and trade deals along similarly zero-sum, narrowly nationalist lines, launching a bitter, costly, and divisive trade war with China.

"The Paris agreement handicaps the United States economy in order to win praise from the very foreign capitals and global activists that have long sought to gain wealth at our country's expense," Trump said that day. "They don't put America first. I do, and I always will."

For Trump, the pandemic is one more opportunity to fan fears of outsiders and push his nativist policies. He's repeatedly referred to the coronavirus as the "Chinese virus" in a transparent attempt to pin blame overseas and deflect criticism of his own failures in handling the public health crisis.

Using powers granted to the surgeon general, the White House said it would immediately send back asylum seekers and others who illegally cross the borders, in defiance of earlier court orders to grant them due process. Later, the administration sought to compel manufacturer 3M to stop sending respirator masks to its customers in Canada and Latin America, in a move the company warned would prompt retaliatory restrictions on critical medical supplies flowing into the US.

None of this portends well for the future of international cooperation on climate change.

THE COLLAPSE OF TRUST

Before the outbreak, the world's largest carbon emitter, China, had made major strides to increase its solar, wind, and nuclear generation, meet the rising demand for automobiles with more electric vehicles, and build up huge domestic industries to pump out solar panels, batteries, and EVs. It still appears to be on track to achieve its central (if not particularly ambitious) Paris pledge: reaching peak emissions no later than 2030.

But there have been worrying signs more recently of a slowdown in its efforts. China's investments in renewables fell 8% last year to the lowest level since 2013, according to BloombergNEF, even as the world total slightly increased. Moreover, it's kicked off a new building boom in coal plants: nearly 150 gigawatts' worth are under construction or likely to be revived, roughly the capacity of the EU's entire fleet, according to a report late last year by Global Energy Monitor.

China may pump money into some clean energy sectors through economic stimulus efforts in the coming months, but there are few reasons to suspect it will back off its reliance on cheap coal or accelerate its timetable for cutting climate pollution in the foreseeable future.

Indeed, even before the pandemic, there were signs China was souring on climate cooperation. During COP25, it and other emerging economies made clear they have no intention of tightening their emissions targets at the next conference, whenever that now happens, asserting that rich countries first need to make good on their commitments to provide funding and support to developing nations.

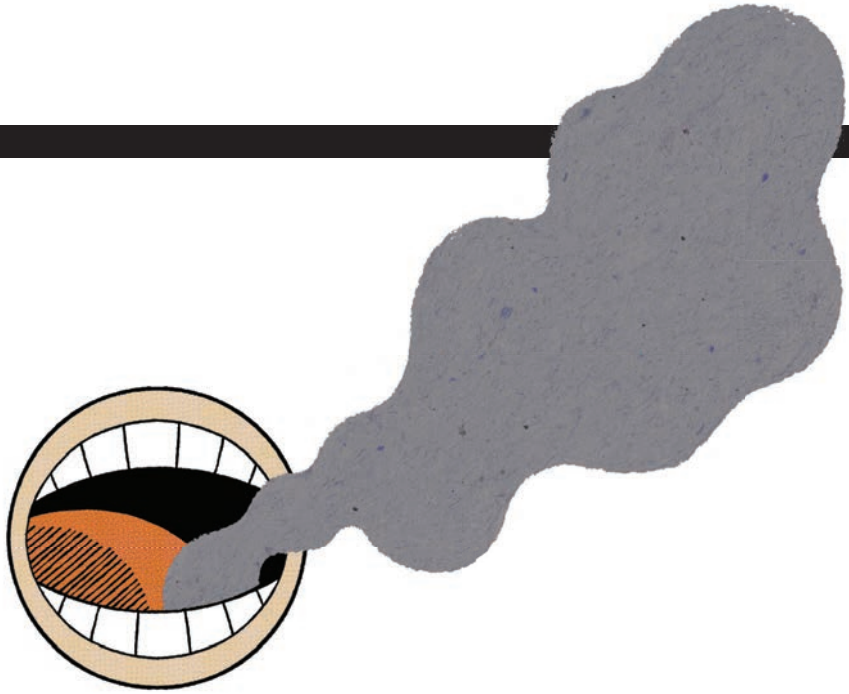
A major factor in these shifts is that rising nationalist sentiments elsewhere, and related trade hostilities, were already changing how China sees its choices, says Jonas Nahm, who studies China's energy policy at the Johns Hopkins School of Advanced International Studies. Increasingly unable to rely on predictable supplies and prices for imported fuels and parts, it seems to be turning to the energy source it can rely on—abundant domestic coal.

"I think the rise of nationalism, in the US and elsewhere, has created a degree of economic uncertainty that has strengthened the hardliners and forced them to rethink the degree to which they can rely on green energy to power their future," Nahm says.

One other casualty of the pandemic has been our faith in a global supply chain. As countries shut down production and distribution, first in China and then around the world, essential goods are in short supply. It has become evident how trade relationships and concentrated manufacturing centers leave us vulnerable.

That too presents a challenge for climate change. China produces about a third of the world's wind turbines, two-thirds of its solar panels, and roughly 70% of its lithium-ion batteries, as Nahm highlighted in an article in Science late last year. Even with massive government support, it took decades of growth at "a breakneck pace" for Chinese businesses to create the technologies, supply chains, and manufacturing capacity to achieve that.

"It is unrealistic to expect that another nation will be able to rival China's capabilities ... in the time frame needed to limit climate change to below 2 °C," Nahm and coauthor John Helveston of George Washington University wrote. That means countries, businesses, and researchers around



WHAT IF, IN RETROSPECT, THE PARIS AGREEMENT WAS NOT THE START OF AN ERA OF COOPERATION, BUT ITS HIGH POINT?

the world need to figure out how to forge closer relationships and collaborate more productively with China—"the United States in particular," they said.

CLIMATE FASCISM

As the historian Nils Gilman argued in February in a persuasive essay, "The Coming Avocado Politics," there are good reasons to worry that rising anxieties over environmental emergencies will justify a more hard-line set of solutions on the right, an "ecologically justified neo-fascism" that includes militarizing borders, hoarding resources, and bolstering national protections against climate change.

This attitude could also justify "neo-imperialist" responses "where we actively seek to repress the development and ambitions of the rest of the world," Gilman says. Specifically, the US or other nations could turn to extreme methods, from eliminating development financing to deploying military force, to prevent the carbon bombs that would go off if billions of poor people start consuming goods, services, and energy at the same levels as Americans.

The tragic trial run of the coronavirus outbreak certainly bolsters fears that sentiments could rapidly turn in this direction. In addition to Trump's efforts to inflame foreign resentments, there have been widespread reports in recent weeks of hate crimes and harassment against those of Asian descent around the world, including brutal beatings on public streets, verbal attacks on public transit, and racist memes online.

As the virus spreads and the economic downturn deepens, people will, rightfully, focus primarily on the immediate dangers: risks to their health and that of friends and family; the likelihood of losing work; and the plunge in their retirement savings and home values. Enhancing global cooperation and combating distant climate dangers just aren't going to take priority for some time.

The question, of course, is what happens as the pandemic recedes. In theory, this presents a new opportunity to get climate progress back on track. Stimulus packages designed to kick-start economic growth could include funding and policies to accelerate clean energy and climate adaptation projects, for example. The world will certainly be better equipped to face both pandemics and climate catastrophes if nations choose to more readily share resources, expertise, and information.

"That interconnectedness is quite apparent when it comes to getting masks and medicine," says Jane Flegal, program officer with the William and Flora Hewlett Foundation's Environment Program. "And it's also apparent when you talk about the importance of making clean energy cheap and the role of technology transfer in the climate context."

But in the end, whether people are left feeling that we need to tighten international ties or erect higher walls may depend a lot on how ugly things get in the coming weeks and months, and the political narratives that take hold as we try to make sense of how it all happened.

James Temple is a senior editor at MIT Technology Review.

MIGUEL PORLAN

VAXX THE VOTE

America might survive coronavirus. But will the election?

By Patrick Howell O'Neill

SIMOUL ALVA

MOST AMERICANS ARE UNDER ORDERS TO STAY AT HOME,

but Jeff Ellington is preparing for the busiest year he's ever had. Runbeck Election Services in Arizona, which produces vote-by-mail ballots, has stocked its 90,000-square-foot (8,300-square-meter) facility in Phoenix with 200,000 half-ton rolls of paper—and there's much more on order.

Ellington, Runbeck's chief operating officer, is preparing for an election unlike any the United States has seen before. He says the company usually works with 21 states to produce and mail ballots so that people can vote from home. Today, staff are fielding calls from almost every state in the country, taking phone meetings and video chats anywhere they can safely self-isolate, whether that's in their kitchens, their yards, or their cars. But in the next few weeks they're going to have to get back to work.

The machinery of electoral politics has been thrown into turmoil by covid-19. While primaries have already been held in some states, others have been delayed or transformed. All the typical activities of a campaign—canvassing for votes, trying to drive the political conversation, grabbing the public's attention—seem impossible in a time of strange and deadly crisis. Right now, we don't even know if it will be safe to vote at polling places when November rolls around. The only thing that does seem to be clear is that 2020's election is going to be a challenge of unprecedented proportions.

UNSAFE OPTIONS

The biggest problem—and the one occupying Ellington and his staff, as well as politicians, campaign managers, and many voters—is also the most obvious one: How will voting actually happen?

There are three possible solutions. The first is to continue traditional in-person voting at polling stations on Election Day.

Crowded polling places have, for better or worse, become emblematic of American democracy. But if the virus's spread continues into the fall—and infectious-disease modelers say it very likely will—then these gatherings could be willfully dangerous to public health, and not just that of the voters themselves. Reports from Florida to California, where primary voting went ahead despite the growing pandemic, show election officials and poll workers—who are generally older and more vulnerable—falling sick.

"I was sadly on a call yesterday with election officials in California," says Tammy Patrick, an elections expert at the Democracy Fund. "One of them has the coronavirus, and they know for a fact that they contracted it during the primary season. So it literally is a question of life and death. Conducting an entirely in-person election would put voters at risk, poll workers at risk—election officials and candidates too."

A second option is to spread in-person voting out over days or weeks to reduce crowding. This is not impossible—39 states and Washington, DC, already allow early voting—but it is still a health risk.

The third and safest answer, most experts agree, is voting by mail. It's a tried and trusted system already embraced by 20% of US voters. But on such short notice, making it happen everywhere is a lot more complex than it sounds.

Some states, like Oregon and Colorado, already do almost all their voting this way. Arizona, California, Hawaii, Montana, Utah, and Washington are majority vote-by-mail, with support from all sides. Some are trying to make the switch: Georgia and Michigan have announced that they will be sending absentee ballots to every single voter. But others, such as Louisiana and West Virginia, make postal voting especially difficult.

In any case, even state governments don't have full control of what happens during the vote. Instead of one election authority, or even 50, there are more than 5,000 separate local jurisdictions that run the country's elections. Preparing them all for rapid change will be overwhelming. But there isn't really an alternative.

"We have to determine how we are going to make sure that our democracy continues to function," says Amber McReynolds, a former Colorado election official and now the head of the National Vote at Home Institute. "This is an emergency. Vote-by-mail is one of the only solutions we have right now to make sure all Americans can vote effectively, safely, and securely."

GOING POSTAL

If the decision to switch to vote-by-mail is made, a second problem arises: the gargantuan task of getting tens of millions of extra voting papers into people's hands. Ellington says Runbeck, one of just a handful of national election services companies, has the capacity and materials to produce just over 4 million extra ballots, and there are around 250 million eligible voters in America. Following government recommendations, 95% of Runbeck's staff were working from home in March, but the company is now in the process of bringing many of them back on site to deal with what's about to happen.

The work is complicated. While mail-in voting slips may look much like ordinary mass mailings, they are also individualized and differ widely from county to county and state to state. Envelopes have to be custom printed with the correct addresses, county logos, tracking data, and information that gets ballots back to

their local counties for tabulation. Proofreading, gathering resources, educating voters, and dealing with counting processes, new election laws, complex hardware needs, and sluggish bureaucracy are just a few of the hurdles officials face.

And on a raw, physical level, the sheer quantity of paper required to produce these precisely printed ballots and envelopes is mind-boggling. The 100,000 tons of paper already at Runbeck's facility is not exactly what you'll find at your local Staples or OfficeMax.

"Our rolls are about 1,000 pounds [450 kilograms]," Ellington explains. "We run it through a printing press, and out the other end come about 20,000 ballots every hour. We have the capacity of producing a little over 1 million ballots per day out of our facility."

Right now, American companies like International Paper face a rapidly changing environment because of the virus. On the one hand, work they thought they'd be doing has fallen through as the country shuts down; on the other, there will be an influx of orders as states and counties decide to make the switch. When exactly Runbeck gets its bumper order for more paper depends on where it fits on the priority list, says Ellington.

And, critically, there are strict time limits, he explains. "In the situation we're in now, decisions need to be made in April because of the volume we're talking about," he says. "The equipment is not simple. The staffing and training are extensive. If we have a massive push to vote-by-mail, the planning has to start now, and people need to start thinking differently."

"IF WE HAVE A MASSIVE PUSH TO VOTE-BY-MAIL, THE PLANNING HAS TO START NOW."

And then there's the problem that voting by mail, even if experts recognize it as the best, safest option in a pandemic, is deeply unpopular in some quarters.

REPUBLICAN REJECTIONS

In March, as the number of coronavirus cases in the US started to spike, President Donald Trump took to his favorite TV haunts to fight against the idea of mail voting. In an interview with Fox & Friends, he criticized Democrats as they pushed to include vote-by-mail support in the $2 trillion stimulus bill.

"The things they had in there were crazy," Trump said. "They had levels of voting that if you ever agreed to it, you'd never have a Republican elected in this country again."

No matter that the president and first lady had recently registered to cast their own absentee ballots from their new home state of Florida; Republicans have repeatedly opposed expansion of voting rights for absentee and mail-in ballots, claiming that it increases fraud.

That doesn't reflect reality, however. Oregon has seen over 100 million mail-in ballots since switching to vote-by-mail in 1998, and no one has ever found significant numbers of fraudulent votes. In 2016, out of over 2 million voters, only 10 Oregonians were convicted of vote fraud. (In fact, mail votes incorporate a number of security measures, including bar-code tracking of ballots and accurate voter registration databases. Most of the time, signatures are used to verify identity.)

However, Trump has built part of his political success on lying about mass voter fraud, and the Republican Party has mounted efforts to make voting harder, not easier, such as purging voter rolls and adding further identity requirements. Vote-by-mail is a victim of that partisan attack, even if evidence shows it can increase turnout across the board.

In the end, the stimulus bill passed in March did include $400 million to help states with their election problems. It's a big number, but less than a quarter of the amount voting experts say is needed to run this election safely during the pandemic. "I think it shows a really lamentable lack of properly prioritizing the importance of elections that are the bedrock of our democracy," says Eddie Perez of the Open Source Election Technology Institute.

"THERE IS NO SUNNY SPIN IF YOU ARE RUNNING AGAINST AN INCUMBENT. IT'S DEVASTATING."

Still, things could change. When Congress returns later in April, a more robust vote-by-mail bill championed by Democratic senators Ron Wyden and Amy Klobuchar is expected to become a priority. It would give even more cash—the exact amount is still being decided—to those who actually run elections, designating it to speed up the difficult transition to vote-by-mail.

The bill, known as the Natural Disaster and Emergency Ballot Act, would also ensure that people who cannot vote by mail have more time to vote in person by requiring at least 20 days of early voting to prevent long lines and crowds. It would give states money to hire and train new poll workers to avoid endangering the older folks who usually fill that role.

Wyden and Klobuchar may or may not secure the funding they want or the votes in Congress they require. But more money is definitely required to manage the shift properly. McReynolds's National Vote at Home Institute tallied up the cost in Michigan, including the price of facilities, infrastructure, ballot mailing, voter education, professional services, and employee salaries. Final bill: $37.5 million for that single state, and only if they start the work today.

GROUND GAME GONE

Even if the voting process is expanded, authorities act quickly, and they get all the funds they need, there's a whole other universe of issues to solve. For example, if so much of the country is under shelter-in-place orders, how will the campaign be fought?

Already we're seeing election season shift as the crisis changes the way we interact and communicate. Rallies have moved from arenas to live streams. For the Democratic presidential primary debates, TV studio audiences were told to stay home. And fundraising has plummeted as markets have gone through some of the steepest drops and most dizzying ascents in US history. When millions of Americans file for unemployment simultaneously, no one is thinking much about donating to their favorite candidates.

Jaime Lennon, a spokesperson for Dutch Ruppersberger, a congressman from Maryland, says business as usual is not an option. "He's so busy right now," she says. "We are hitting near records in terms of phone calls and emails from constituents that need help, whether it be unemployment, or small-business owners needing help navigating the new aid package, or just folks with medical questions, like questions about the availability of testing… It seems like all election operations are on pause at the moment."

Even if there were time to campaign, what would that look like when supporters can't go knocking on doors to drum up votes and the economic crisis is draining the bank accounts of grassroots donors?

"There is no sunny spin if you are running against an incumbent. It's devastating," says Brianna Wu, a software engineer and candidate for Congress in Massachusetts. Unable to knock on doors, Wu may struggle even to get the signatures needed to end up on the ballot, a task her campaign was previously well ahead on.

There are plenty of ways to target voters without ever having to meet anyone in person, like phone banking, television ads, and social media. But Wu, who ran and lost in 2018, says it's not enough.

"We've certainly been fortunate in having a very strong digital game, but one of the lessons I learned in the 2018 race is you cannot win an election by just hanging out online," she says. "I got about half the votes I needed to win by focusing on digital. And that was great for a first-time candidate, but my hardest lesson is you cannot win without a strong field operation. And I find myself asking, how the hell are we going to do that?"

Many candidates—including Wu—had been focused on

SIMOUL ALVA

building the kind of ground game that famously catapulted Alexandria Ocasio-Cortez to victory in New York City: knock on doors, talk with people, win votes. Now Wu's campaign is calling up individual houses and asking to send over petitions, pens, and envelopes to get signatures and move their fight forward. Meanwhile, conversations about fundraising are next to impossible.

"My theory is this crisis will benefit the status quo," Wu says. "It will come down to name recognition if people vote at all."

THE FOG OF ONLINE WAR

The social-media platforms that were exploited as conduits for disinformation in the 2016 election will have more impact than ever in the 2020 campaign: there simply is no better way to reach voters under lockdown. Though the platforms now have new rules and algorithms to limit disinformation, a rapid shift to making the campaigns even more digital creates new opportunities for misleading voters.

China, where the pandemic began, first tried to cover up the disease: now it has armies of propagandists spreading conspiracy theories about covid-19's origins. European Union officials, meanwhile, say Russia is undertaking a "significant disinformation campaign" against Western Europe, intent on sowing chaos and uncertainty during a crisis.

The biggest disinformation threat the US faces, however, may be domestic. In 2016, Trump tried to undermine trust in election results by saying that if he didn't win, it would be because the system was rigged. And during the coronavirus crisis, while his rivals for the presidency have been muted, he has used his daily press briefings to repeatedly downplay the severity of the pandemic, rewrite the historical record about his response to the situation, and distort or lie about things like the effectiveness of drugs and the availability of ventilators.

"You want a leader to give people hope, but you need a leader to be honest," says Angus King, a senator from Maine who cochaired the Cyberspace Solarium Commission, a project meant to define the US's national strategy online. "What did Churchill say at the beginning of World War II? 'I have nothing to offer but blood, toil, tears, and sweat.' He told the British it was going to be hard, with no sugarcoating. President Trump said it'll be like a miracle and it will just go away, and that this malaria drug is a gift from God. Turns out it isn't. That's harmful."

NO STOPPING

In the fall of 2018, one of the strongest storms ever recorded in the western Pacific Ocean slammed into the Northern Mariana Islands, a commonwealth of the US. The storm had intensified over the span of three days into a category 5 super-typhoon, with winds reaching 175 miles (280 kilometers) per hour. Typhoon Yutu made landfall on October 24, killing dozens of people, destroying hundreds of millions of dollars' worth of buildings, and disrupting life in ways no one there had ever seen before.

The Northern Mariana Islands pushed Election Day back a week in order to begin recovering from the storm first. Remarkably, this had never happened before in US history: elections have taken place on schedule through not just the influenza pandemic of 1918 but two world wars and even the Civil War.

That means the likelihood of the national election being pushed back or even canceled is virtually nil. Election experts and constitutional lawyers widely agree that such a change would require a constitutional amendment, and little about the current political climate suggests that Congress could pass one.

A bigger concern is that without the option to vote by mail, the pandemic will discourage people from voting altogether. The 1918 flu outbreak may have been responsible for low turnout in that year's midterm election (though turnout fell for the next two midterms as well). More recently, France held its nationwide municipal elections on March 15—just one day after a national lockdown was announced in response to the coronavirus. Turnout was low, and the next round of elections was pushed back by three months as a result. Low turnout in November will inevitably invite claims that the results lack legitimacy.

"Generally speaking, it's not a good idea to roll out major changes in election rules in the midst of a major election," says Richard Hasen, a political science professor at the University of California, Irvine, and author of a recent book on threats to American democracy. "But we're facing an unprecedented health emergency. And so we're not going to have a perfect election. The question is how we can make it as good as possible and disenfranchise as few people as possible."

The answer—for voters and for democratic institutions alike—is clear: if America wants to hold an election that produces a "normal" result without sacrificing people's health, it has a blueprint to work from. It needs to start now, even if the solution isn't perfect. And it's going to require one hell of a lot of paper.

Patrick Howell O'Neill is a senior editor at MIT Technology Review.

THEY WERE WAITING FOR THE BIG ONE. THEN CORONAVIRUS ARRIVED.

Can being ready for one kind of disaster prepare you for another?

LINDA KOZLOWSKI'S NEIGHBOR wanted to know if she needed anything from Walmart. It wasn't a quick trip into town; the drive from the Oregon coast to Portland took two hours. But because of her age, Kozlowski, a 77-year-old retiree, might be at risk from covid-19. Perhaps there would be hard-to-find goods, like hand sanitizer. She thought for a moment and asked for bread, pasta, and toilet paper.

Helping senior citizens is a neighborly thing to do, especially in the middle of a pandemic. But in Manzanita, where Kozlowski lives, joint grocery runs are part of a detailed disaster preparedness plan that Kozlowski herself introduced to the town 13 years ago. Back then, it wasn't a disease they were concerned about, but a storm that helped locals realize exactly how vulnerable they were to power outages, floods, and landslides.

The Oregon coast is a harsh, unforgiving place where mundane outings can quickly turn deadly. This past January, Jeremy Stiles and his two young children, Lola and William, were swept out to sea

By Britta Lokting

COURTESY PHOTOS


WESTERN
OREGON
Emergency
Volunteer
Corps


POLICE

by a sneaker wave while hiking north of Manzanita. Lola died at the hospital. William's body was never found. (Jeremy recovered from hypothermia.)

Until recently, though, the main thing most residents were preparing for was a combined earthquake and tsunami they nicknamed The Big One. The Cascadia Subduction Zone fault line stretches from Vancouver Island in Canada to Cape Mendocino, California. The last Cascadia earthquake occurred in 1700, and scientists have predicted that one will occur every 300 to 600 years. When it hits, the region will be devastated.

So Kozlowski had helped the neighborhood get prepared. She'd followed advice, called a meeting, and identified who had first aid skills, who had generators, who had a chainsaw. She'd organized a spot for everyone to rendezvous if things went bad. Sure, she'd created the disaster plan in case there was a tsunami. But it meant that when the coronavirus pandemic hit, Kozlowski and her neighbors already knew exactly how to lean on one another.

Manzanita has "blown away every other community as far as preparedness." Many other towns along the Oregon coast have followed its lead.

GETTY IMAGES

THE MAJORITY OF AMERICANS are not ready for disaster. A 2016 survey conducted by Columbia University's National Center for Disaster Preparedness found that 65% of households reported having no or inadequate plans to survive a catastrophe. Forty-one percent of households said they weren't confident their communities knew what to do if disaster struck unexpectedly.

And yet, in the face of coronavirus, preparation has become urgent in a whole new range of ways to a whole new range of people. Lockdowns and shelter-in-place orders have paralyzed communities, shut down businesses, and led to panic buying. If the nation was generally unprepared for disaster, it was even less ready for this particular flavor of emergency.

"Are we prepared as a country? I don't think so," says Irwin Redlener, the director of the Columbia center. "The fact is, the studies we have done that have to do with individual preparedness have been extremely depressing."

Which makes the preppers of the Oregon coast—and Kozlowski, their grassroots leader—a bit of an anomaly. She believes being prepared for one disaster, like a tsunami, means being prepared for other disasters, like coronavirus.

Patrick Corcoran, a hazard outreach specialist at Oregon State University, says it's impossible to ready yourself for an unprecedented event. "Can you really prepare for what's to come if you haven't experienced it?" he asks. "We toggle between denial and bargaining with the devil."

But what else are you meant to do you when disaster strikes and your government fails to step in and help? Testing for coronavirus in America has been a mess, medical workers are pleading for masks, and hospitals are desperate for ventilators. The confused federal response has led to an unprecedented swell of local, personal action: neighbors buying food for their infirm neighbors, fashion designers stepping in and sewing protective gear, teams of volunteers putting together grab-and-go meals for kids.

Steven Eberlein, a professional resilience specialist who has given preparedness presentations up and down the Oregon coast, says that people should do what they can to prepare—but that some issues are just too huge for individuals to tackle alone. "Federal, state, and local governments can't respond to everyone in a quick manner," he says. "When you look at what's happening with the pandemic, one of the big problems is our supply lines are clogged."

A LITTLE OVER TWO YEARS AGO, I was home in Portland for the holidays when my dad mentioned his cousin, Ellen, and her husband, Pete. They were preppers who lived on the coast, he said, getting ready for some big

tsunami. I wasn't sure what that meant, so I called them up, and Pete invited me down to their house to show me. I took my dad along.

For 90 minutes, we drove through canyons of evergreen forests. After passing through the city of Tillamook, famous for its cheese, we turned onto a narrow, flood-prone road that hugged the bay. As I followed the road's curve toward Cape Meares—the coastal village where Pete and Ellen live—I became highly aware that if my hand slipped on the wheel, we would plunge into the water.

Pete and Ellen built their house in 1990 as a vacation home and retired there full time in 2003. It's built on a slope and has stilts to support the deck. Six years ago, Pete did a seismic reinforcement of the foundation. When we walked up the steep steps and entered the cozy cabin, Ellen was in the kitchen making tuna melt sandwiches. (She and Pete can a year's worth of tuna every August.) It was a shockingly clear day, and from the picture window in their dining area, you could see the beach and the Pacific Ocean stretching away for miles.

While Ellen made the food, Pete, who is 79, gave us a tour of the house. Cape Meares is divided into six neighborhoods and has about 60 full-time residents; Pete is the captain of their area. His job is to keep new residents up to date on preparedness plans and to coordinate with the emergency manager in Tillamook County. He's a walking encyclopedia about The Big One, and he told us that when it happens, they have only 20 minutes to get to higher ground. He's mapped out every possible exit route he and Ellen might have to take.

To ready themselves for The Big One, Pete and Ellen keep four cords of wood in case the electricity gets cut off, a butane cooker, a propane cooker, 100 gallons of drinking water, a Berkey water filter that Pete likes to note is used by Doctors Without Borders, and enough food to last them six months. They have nailed the bookcases to the wall and have three packs ready to go, whose contents include water purification tablets, duct tape, a tin cup, fire starters, dental floss for cordage, space blankets, a small folding straw, a pocket knife, aluminum foil, rubber gloves, cotton gloves, storm-proof matches, and jelly beans. In the bedroom, Ellen keeps her glasses in a cubby above the bed because she realized that in an earthquake they could fall off the nightstand and shatter, and she wouldn't be able to see. Prepping "really is a way of life," she told me.

It was Pete who first told me about Linda Kozlowski: Cape Meares, which is 30 miles south of Manzanita, has largely followed her lead, as have many other towns along the coast.

> "THERE WAS SPOT RESPONSE, BUT NOT A COMMUNITY-ORGANIZED RESPONSE, BECAUSE WE JUST DIDN'T HAVE ANYTHING. WE WERE JUST REALLY LUCKY."

KOZLOWSKI LOOKS LIKE THE kind of person who gets things done. A small, compact woman, she has a wispy blond pixie cut, sharp eyes, and plump cheeks that make her look 20 years younger than she is. She often wears her blue Emergency Volunteer Corps sweatshirt with a lanyard dangling from her neck. The role seems to suit her: before retiring, she spent her career as a professional headhunter, and it's easy to see why it was a good fit. But it wasn't always like this.

She moved to Manzanita full time in 2004, arriving from Portland like many others in the area, and almost immediately decided to run for city council. When she won, and the mayor doled out responsibilities, she wound up—somehow—in charge of emergency preparedness. She knew little, if anything, about the topic. And for three years, she really didn't do much with it.

Then on December 1, 2007, a windstorm known as the Great Coastal Gale slammed the Pacific Northwest coastline from British Columbia all the way down to Oregon. It lasted three days, with gusts reaching 137 miles per hour. Residents along the Oregon coast lost power for five days, and landslides on Highway 101, the coastal road, blocked the roads with no way out. Trees were downed, motel and road signs ripped off. There were some helping hands, but not many. One neighbor had a generator and graciously passed it around. In Manzanita, the person who acted as both fire and police chief fielded calls by himself for 36 hours straight. Even so, senior citizens were running out of oxygen tanks. Fuel for heat was getting dangerously low. "There was spot response, but not a community-organized response, because we just didn't have anything," Kozlowski says. "We were just really lucky."

Kozlowski had never experienced that kind of isolation before, and it terrified her. Afterwards, she realized she needed to step it up. After starting off with the basics

The residents of Manzanita are no strangers to natural disasters. In 2016, a tornado lasting only two minutes damaged 128 homes and downed a third of its trees.

COURTESY PHOTO

of organizing, she discovered the government's Community Emergency Response Team (CERT) program, which helps with first aid and search-and-rescue. She organized residents to get trained. Then came the portable, handheld emergency radio operators and those familiar with ham radio. Today, every Thursday at 6 p.m., they call in to a centralized channel called the Net (the operation center is the firehouse), say who they are, and listen to what's called an "educational moment," about something like how to get to an assembly site. Last year there were 2,701 total check-ins.

In 2008, Kozlowski expanded from Manzanita to two other local towns, covering some 2,000 people, and formed the volunteer corps. Most of its money comes from local fundraising and from the fire department. Her budget is small—even if it has risen from $4,000 to $12,000—but the corps offers classes in emergency radio, WaSH (water, sanitation, and hygiene), and managing chronic illness in austere conditions. The closest hospital is 40 minutes away, so the corps also has a medical reserve made up of local doctors, nurses, vets, and physical therapists. Kozlowski says this training has all helped them deal with coronavirus. "We've been talking about 'How do you wash your hands?' for a long time," she says. "Because after a disaster, the last thing you want to do is get diarrhea."

Kozlowski's efforts were soon mimicked around the coast. Sharon Kloepfer, a CERT volunteer in Gearhart, another coastal town, told me Manzanita has "blown away every other community as far as preparedness." In Rockaway Beach, a strip of land south of Manzanita, David Elkins is trying to copy Kozlowski after taking her volunteer corps classes. He was told the city didn't have any money to hire an emergency manager, so he rallied 25 residents who are now trained in first aid, lost-person search, and small-fire suppression.

Unlike the stereotype of a prepper, Kozlowski takes an approach that is less everyone-for-themselves and much more we're-all-in-this-together. "How we recover in this next step is sticking together," she says.

WHEN AMERICA REPORTED its first coronavirus case on January 20 in Snohomish County, Washington, disaster responders in many states—including Oregon's volunteers—were put on alert. By the time the first victim died in Seattle on February 29, they had gone into overdrive, telling people to shelter in place and stock up on two weeks' worth of food, and relaying information from the Centers for Disease Control back to residents.

But even the most battle-ready prepper admits that this is a very different kind of disaster from the one they, and most of America, had in mind. There are no power cuts, no extreme weather or loss of running water—just empty streets and a lack of medical ventilators. This has made it extremely difficult to apply the come-together strategy of Kozlowski's program. "It's really hard to work as a community because we're quarantined," says Jim Kusz, a retired fire and rescue captain who teaches preparedness at Oregon Coast Community College.

And of course Kozlowski's program can't possibly apply to every disaster: after all, a pandemic—or, say, a terrorist attack—is a very different beast from a tsunami.

"A city might be prepared for a major coastal storm for which very little will apply to being prepared for a pandemic," says Columbia's Redlener. Though Kozlowski says her plans have proved vital during the coronavirus situation, not everything readied for The Big One is useful. Tsunami prep, for example, takes into consideration exit routes and water filtration. But those are unlikely to come into play during a pandemic, where access to masks and food has become much more important.

This might not make a difference to how an individual prepares, but at a larger level it can be a big problem. "Preparedness" is a vague term, says Redlener, and it can create confusion, cover up incompetence, and even lead to underfunding of important services. "We want New York City or the Oregon coast or the Gulf of Mexico to be 'prepared' and we really don't know how to define that," he says.

Kozlowski was certainly not prepared for covid; her plans were targeted at a very specific and very different "bogeyman." And I wondered at times whether her toolkit could help with covid-19. So much seems unknown about the virus, and the situation is so ever-changing, that being prepared for everything is almost impossible.

Still, there's likely to be a shift in how Americans think about preparedness immediately following this pandemic—an awareness of how a worldwide disaster could happen again and affect the whole country, not only those in identified high-risk areas. The US will need to acclimate, just as people living in high deserts already own masks for wildfires or residents of Los Angeles don't hang paintings above their beds for fear of earthquakes. And yet the adaptation will most likely be short-lived. "We like normal. We like comfort. We like stability," says Eberlein. "Part of the reason that we roll our eyes at our grandparents talking about the Great Depression and the scarcity is it makes us uncomfortable. We don't like the possibility of disruption."

"PART OF THE REASON WE ROLL OUR EYES AT OUR GRANDPARENTS TALKING ABOUT THE GREAT DEPRESSION AND THE SCARCITY IS ... WE DON'T LIKE THE POSSIBILITY OF DISRUPTION.

I know what he means. When I first visited Pete and Ellen, and my dad and I stood in their garage gaping at the shelves piled with canned goods, it all seemed a little alarmist. It was such a beautiful, clear day that it was hard to imagine a tsunami. Plus, I'm the complete opposite of Pete. I let my gas tank dwindle to empty before I refill. I only buy the bare necessities at the grocery store. A few years ago, I saw an infographic in New York magazine about what would happen if a 10-kiloton nuclear bomb were dropped in Times Square. My neighborhood, the East Village, would be spared, but radioactive ash would fall for 72 hours, confining me to my apartment. I realized then that I would starve if that happened. My mentality has changed, of course, with coronavirus. When my mom asked how many rolls of toilet paper I had and I said 12, she was pleasantly relieved. "You usually have, like, one little square left," she told me.

In March, after coronavirus began spreading in America, I checked in with Ellen and Pete. On the phone, Pete said their way of life hadn't changed except they were now having groceries delivered and they couldn't watch their grandkids' basketball games, but those had been canceled anyway. They were still gearing up for the spring Chinook salmon season, just like any other year, so they could have a fresh supply of fish to freeze, smoke, and can. "We've just become perpetual preppers," he said.

WHEN I CALLED KOZLOWSKI TO see how she was dealing with the pandemic, she said she felt secure. She was frustrated, though, by the swell of beachgoers who had descended upon Manzanita and were ignoring the calls for social distancing. Residents along the coast had been raging on social media—and to me—about the tourists. At the time, there hadn't been a single confirmed coronavirus case in Tillamook County, and residents wanted to keep it that way: a quarter of the county's population is over 65, after all, and cases in the US were jumping by the thousands every day. On March 21, Manzanita shut down the town to visitors and ordered out-of-towners to vacate. On March 26, the first person in Tillamook County tested positive for covid-19.

The shutdown was a promising action by city officials, but there is always more to be done—including tweaking your own personal disaster plan. Kozlowski is currently working on a "human waste strategy" for her and her husband. For now, they're using a large garbage can piled with leaves. It's not ideal. "If worst comes to worst we'd probably dig a hole in the backyard," she told me.

But because she's already equipped to handle disruption, she seemed more confident than many Americans about this incredibly unpredictable situation. "I feel really good about the work we've done to prepare our community as much as we could for this pandemic," she said. It doesn't mean her future is certain, though: "This is going to be a major disruption, and even the best plans in the world—it's just hard work to come back."

Britta Lokting is a writer and journalist based in New York City.

THE VALUE OF A SAVED LIFE

How do we choose between stopping covid and reviving the economy? Fortunately, it doesn't have to be a choice: we can do both.

By David Rotman

FRANCESCO CICCOLELLA

In the first employment report after social distancing measures had taken hold in many US states, the Department of Labor announced that 3.3 million people had filed jobless claims. A week later, in the first week in April, an additional 6.6 million claims came in—almost unfathomable compared with the previous record of 695,000, which was set in 1982.

As bad as those numbers are, though, they greatly understate the crisis, since they don't take into account many part-time, self-employed, and gig workers who are also losing their livelihoods. Financial experts predict that US GDP will drop as much as 30% to 50% by summer.

In late March, President Donald Trump warned against letting "the cure be worse than the problem itself" and talked of getting the country back to business by Easter, then just two weeks away. Casey Mulligan, a University of Chicago economist and former member of the president's Council of Economic Advisers, warned that "an optimistic projection" for the cost of closing nonessential businesses until July was almost $10,000 per American household. He told the New York Times that shutting down economic activity to slow the virus would be more damaging than doing nothing at all.

Eventually the White House released models suggesting that letting the virus spread unchecked could kill as many as 2.2 million Americans, in line with the projections of other epidemiologists. Trump backed off his calls for an early reopening, extending guidelines on social distancing through the end of April. But his essential argument remained: that in the coronavirus pandemic, there is an agonizing trade-off between saving the economy and saving lives.

Evidence from research, however, shows that this is a false dichotomy. The best way to limit the economic damage will be to save as many lives as possible.

A novel recession

Part of the difficulty with setting policy now is that

the situation is unprecedented in living memory. "It's impossible to know how the world is changing," says David Autor, a labor economist at MIT. "It isn't like anything we've seen in a hundred years." In any past recession or depression, the economic solution has always been to stimulate demand for labor—to get workers back on the job. But in this case, we're purposely shutting down economic activity and telling people to stay at home. "It's not just the depth of the recession," Autor says. "It's qualitatively different."

One of the biggest fears is that those least able to withstand the downturn will be hit hardest—low-wage service workers in restaurants and hotels, and the growing number of people in the gig economy. For the last two decades, service workers have become an increasingly large part of the labor force as many of the midlevel office and manufacturing jobs previously open to people without college degrees have dried up, says Autor. It's people in these service jobs, already low paid and often with few health and other benefits, who will struggle the most.

"On a good day they are vulnerable, and on a bad day they are even more vulnerable," Autor says. "And this is a very bad day."

Provisions included in the $2 trillion legislative package passed by Congress in late March were meant to give affected workers and businesses the means to weather the shutdown and, once the outbreak is under control, help restart the economy. Each adult earning less than $75,000 will be given $1,200, and for the first time, gig workers and self-employed people will qualify for unemployment benefits. Hundreds of billions of dollars will also go to helping businesses stay afloat.

But it almost certainly won't be enough, especially in the hardest-hit areas of the country. Cities like Las Vegas and Orlando, "places with gargantuan leisure hospitality economies," will be badly affected, says Mark Muro, coauthor of a report from the Brookings Institution analyzing the numbers. But any region with a large service economy is vulnerable. Muro points out that many of these places never recovered from the 2008 financial crisis.

The people losing these low-wage service jobs were already experiencing skyrocketing mortality rates from what economists have begun calling "deaths of despair," caused by alcoholism, drug abuse, and suicide. The coming crash could make things much worse.

The value of a life

Yet shutting down businesses is the only real choice, given that an unchecked pandemic would itself be hugely destructive to economic activity. If tens of millions of people become sick and millions die, the economy suffers, and not just because the workforce is being depleted. Widespread fear is bad for business: consumers won't flock back to restaurants, book air travel, or spend on activities that might put them at risk of getting sick. In a recent survey of leading economists by Chicago's Booth School, 88% believed that "a comprehensive policy response" will need to involve tolerating "a very large contraction in economic activity" to get the outbreak under control. Some 80% thought that "abandoning severe lockdowns" too early will lead to even greater economic damage.

Meanwhile, any measures to slow deaths from the virus will have huge downstream economic benefits. Michael Greenstone, an economist at the University of Chicago, finds that even moderate social distancing will save 1.7 million lives between March 1 and October 1, according to disease-spread models done at Imperial College London. Avoiding those deaths translates into a benefit of around $8 trillion to the economy, or about one-third of the US GDP, he estimates, on the basis of a widely accepted economic measure, the "value of a statistical life." And if the outbreak is less severe than predicted by the Imperial College work, Greenstone predicts, social distancing could still save some $3.6 trillion.

"Our choice is not whether we intervene or whether we go back to the normal economy," says Emil Verner, an economist at MIT's Sloan School who has recently looked at the flu pandemic of 1918 for insights into today's outbreak. "Our choice is whether we intervene—and the economy will be really bad now and will be better in the future—versus doing nothing and the pandemic goes out of control and really destroys the economy."

Overall, Verner and his coauthors found that the 1918 pandemic reduced national manufacturing output in the US by 18%; but cities that implemented restrictions earlier and for longer had much better economic outcomes in the year after the outbreak.

Verner points to the fates of two cities in particular: Cleveland and Philadelphia. Cleveland acted aggressively, closing schools and banning gatherings early in the outbreak and keeping the restrictions in place for far longer. Philadelphia was slower to react and maintained restrictions for about half as long. Not only did far fewer people die in Cleveland (600 per 100,000, compared with 900 per 100,000 in Philadelphia), but its economy fared better and was much stronger in the year after the outbreak. By 1919 job growth was 5% there, while in Philadelphia it was around 2%.

Today's economy is much different—it's geared more toward

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services, and far less toward manufacturing than it was 100 years ago. Nevertheless, the cities' stories are suggestive. Verner says that even a conservative interpretation of the data suggests there is "no evidence that interventions are worse for the economy." And most likely they had a significant benefit. "A pandemic is so destructive," he says. "Ultimately any policy to mitigate it is going to be good for the economy."

The cure, then, isn't worse than the disease. But for every day that normal economic activity is shut down, a huge number of Americans won't be earning an income. Many already live paycheck to paycheck. Many may in fact succumb to diseases of despair. Families will fall apart under the stress. Hard-hit cities will feel abandoned. The urgency to open the economy will only grow.

However, a number of influential economists and health-care experts are saying there's a way to get America quickly back in business while preserving public safety.

Reviving the economy

These days Paul Romer sounds exasperated. "We're caught up in the trauma: kill the economy or kill more people," he says. There is so much "learned helplessness, so much hand-wringing." The New York University economist and Nobel laureate believes he has a relatively simple strategy that will "both contain the virus and let the economy revive."

The key, says Romer, is repeatedly testing everyone without symptoms to identify who is infected. (People with symptoms should just be assumed to have covid-19 and treated accordingly.) All those who test positive should isolate themselves; those who test negative can return to work, traveling, and socializing, but they should be tested every two weeks or so. If you're negative, you might have a card saying so that allows you to get on an airplane or freely enter a restaurant.

Testing could be voluntary. Romer acknowledges some might resist it or resist isolating themselves if positive, but "most people want to do the right thing," he says, and that should be enough to snuff out the spread of the virus.

Romer points to new, faster diagnostic tests, including ones from Silicon Valley's Cepheid and from the drug giant Roche. Each of Roche's best machines can handle 4,200 tests a day; build five thousand of those machines, and you can test 20 million people a day. "It's well within our capacity," he says. "We just need to bend some metal and make some machines." If you can identify and isolate those infected with the virus, you can let the rest of the population go back to business.

Indeed, in an early April survey by Chicago's Booth School, 93% of the economists agreed that "a massive increase in testing" is required for "an economic restart."

In a piece called "National Coronavirus Response: A roadmap to reopening," former FDA director Scott Gottlieb also argued for ramping up testing and then isolating those infected rather shutting in the entire population. Likewise, Ezekiel Emanuel, chair of the University of Pennsylvania's department of medical ethics and health policy, called for increasing testing in a New York Times piece called "We Can Safely Restart the Economy in June. Here's How." Harvard medical experts, meanwhile, have outlined similar ideas in "A Detailed Plan for Getting Americans Back to Work."

The proposals differ in details, but all revolve around widespread testing of various sorts to know who is vulnerable and who isn't before we risk going back to business.

"WE'RE CAUGHT UP IN THE TRAUMA: KILL THE ECONOMY OR KILL MORE PEOPLE."

There is, however, little evidence that massive and frequent testing will be implemented anytime soon. Despite the appearance of new tests, screening is still largely unavailable for anyone but the most severely ill or those at the medical front lines. Test kits and equipment to perform them are still in short supply. Many hospitals and doctors complain they can't get needed tests; and Roche's CEO said at the end of March that it will be "weeks, if not months" before there is widespread coronavirus testing in the US.

It's the type of inertia that clearly frustrates Romer. He calls the $2 trillion legislation passed by Congress "palliative care" for the economy. If you took $100 billion and put it into testing, he says, we would "be far better off."

One day we will have to reopen the economy. Perhaps we'll be able to hold out until the pandemic is showing signs of receding, or perhaps the economic suffering will prove intolerable both to those in charge and to those living in hard-hit regions. When that day comes, if we do not have widespread testing, we will be sending people back to work without knowing if they're at risk of getting the virus or spreading it to others. "We're thinking about this the wrong way," Romer says. The idea that one day you will be able to restart the economy without massive testing to see if the outbreak is under control is just "magical thinking."

It could be a gradual process—those who are found to be free of infection or immune might be allowed back first. But without testing we won't know how to manage this transition. In that case we will in fact be left with the Trumpian choice: between salvaging the economy and risking countless deaths.

David Rotman is editor at large at MIT Technology Review.

TOGETHER ALONE

What the sea taught me about a life of isolation.

By Rose George

Ten years ago, I ran away to sea. My stepfather, who had aggressive dementia, had been sent to a secure unit. I had a book to write. So once I felt sure enough about my mother's safety, I departed for 9,288 nautical miles on a container ship, the *Maersk Kendal*. Its journey from Europe to Asia would take five weeks, and I would be the only passenger. This was no cruise ship: there would be no organized entertainment, fancy restaurants, or on-board cinema. And back in 2010, there was no Wi-Fi, no TV, and only dial-up emails sent once a day through the captain's account, plus an expensive satellite phone that I used once to check that my mother was okay. What, my friends said, would I do? How would I fill all that time?

Today, I am marooned in my house because of coronavirus. This is only the second time I have had my freedom truly restricted. Perhaps the first experience has trained me for the second?

My friends thought endless days at sea meant inevitable loneliness and isolation; I thought it meant escape. I'd lugged books with me and I had work to do. Besides, I had company. There would be 21 crew members on board the ship too, although I couldn't know how they would accept me, nor whether I would feel safe. The first day was a bad portent: left alone for hours, I wandered the ship and wondered where everyone was (they were busy, it turns out, as they always are in port). The chilly welcome was made worse by dinner, where no one spoke. My attempts at conversation sank like a dying whale, and I returned to my cabin in a state of unease. If it was going to be like this, I wasn't sure I'd last a week. Throughout history, plenty of sailors have gone mad at sea. Even now, 2,000 seafarers a year die or are killed; the number of those that are suicides is unclear. Compared with some, this was a good ship, with a small library (mostly trash fiction), a small gym with room for a treadmill, bike, and rowing machine, and two lounges with a Wii-outfitted TV and karaoke. But what it lacked was socializing. There was no bar and no alcohol allowed. A basketball hoop on the poop deck was unused; so was a rusty oil drum barbecue, placed uninvitingly under the constant groaning of the refrigerated containers. The tiny swimming pool had been empty for years. After dinner, the crew retreated to their cabins. The lounges stayed mostly empty: only once did I hear some karaoke song by Journey that traveled up the stairwell. The captain reminisced about the old days, when they rigged up a sheet and watched films together on the deck. No more: now the crew had laptops and loneliness.

Humans who don't need contact are rare. We thrive on company: loneliness and social isolation produce higher rates of morbidity and mortality. Recent research suggests that social isolation raises the chance of an earlier death by nearly 30%, and living alone increases it by 32%. A ship used

COURTESY OF THE AUTHOR

The Filipino crew called their job "prison with a salary."

to be an unusual place: perhaps only spaceships and submarines were similar, in that they must serve as home, work, and leisure space. But now we all are stuck in a space that must be everything, with infrequent relief; space that, no matter how big, is narrowing with each passing day.

On board, I chafed at first. I missed the internet, the immediacy of its answers and the connection. When we called into a port, I rushed ashore not just to fetch necessities, but also simply to be somewhere else, to be on land that didn't move. By the third week, I had been institutionalized: I cared more about nautical charts than my emails. Eventually I made friends. The chilly captain I'd met on arrival was replaced by a charming, chatty one with whom I'm still friends. Sometimes we stood on the bridge wings, outside the wheelhouse, just to look at the sea. There was nothing there but water, and that was fine.

THE CAPTAIN REMINISCED ABOUT THE OLD DAYS, WHEN THEY WATCHED FILMS TOGETHER ON THE DECK. NO MORE: NOW THE CREW HAD LAPTOPS AND LONELINESS.

I welcomed this restricted life. There was a purity to the removal of choice that felt relaxing. But it was finite. I didn't have the grueling hard labor of the crew, nor the tiring watches of the officers, nor their multi-month contracts to serve at sea. Because of the nature of modern ships, where crews are constantly changed, it is easy to experience isolation in company. Seafarers' social relations, academics have written, "are experienced as a series of discontinuous encounters." The Filipino crew called their job "dollar for homesickness" or "prison with a salary."

Isolation, whether social or physical, makes the body pay. It raises cortisol levels and leads to chronic inflammation, which is linked to heart trouble and cancer. The ship changed my body, but it was the relentless thrumming of the engine at night that shook my mind asunder. I woke every morning after dreams of such violence I had to shake them free like sand.

The hardest period was a week of pirate lockdown when we were passing through the Indian Ocean. I could no longer walk on deck to the fo'c'sle and lean over and watch the bulbous bow slicing through water. All windows had blackout blinds at night. Suddenly I missed fresh air and the freedom to open a door and go outside, even if outside was a metal deck.

For now, stuck at home in a pandemic, I still have outside. Here in Britain we are permitted outdoor exercise once a day, and tending to vegetable gardens is also allowed. I have every technological communication tool at my disposal and am far better connected than I was at sea. But there is one deprivation that hits me hard, and I recognize it.

After several weeks at sea, I missed land. Not the land of quays and ugly port concrete, but the hills and wild country of Yorkshire. A wildness different from the ocean. To run through moorland heather; to pelt down sliding scree. To be somewhere that didn't sound like a ship engine, relentless.

Many years after learning to run on the treadmill at the gym, I became a hill runner. Until last week, I'd spent almost every weekend of the last few years racing in beautiful wild country. That is now forbidden for those of us who do not live at the foot of moors or mountains, and people who drive to the countryside to walk are now policed by sinister drones and shamed on social media.

Still my serenity is so far intact, but I know that won't last. When it burns out, I will remember my lesson from pirate week, when my fresh air was removed and time stretched so slowly: This will end. We will reach the safe zone on the other side—at the end of pirate waters on the south coast of Oman, or in several months' time—and I will disembark and open the door and head for the hills.

Rose George is a British author and journalist. She is the author of books including Nine Pints, Ninety Percent of Everything, and The Big Necessity.

THE STRESS TEST

By Tanya Basu

There's a boom in mental health apps and teletherapy. But are they good enough?

In early March, Angela went to her therapist's office for her regular appointment. The following appointment, however, took place at home over a secure video chat.

"It's the first time I had heard of teletherapy," she says. She's anxious, and increasingly so these days. It "hasn't kicked in or fully set in yet," she adds, that this is her—our—new reality.

The coronavirus outbreak has forced millions of us to isolate ourselves, sometimes even within the same house, from those we interact with every day: coworkers, friends, family. Combine that with a looming unknown future, and it's understandable that anxiety is high.

No wonder, then, that the use of mental health apps—from meditation and wellness aids like Headspace and Sanvello to teletherapy platforms like Talkspace—has spiked.

Headspace's chief science officer, Megan Jones Bell, says there's been a 19-fold increase in downloads of stress-relieving meditations, with a 14-fold jump in those intended to relieve anxiety. The company has launched a free set of meditations called "Weathering the Storm," made specifically for dealing with the crisis.

Sanvello has responded similarly, releasing its premium content for free. Monika Roots, the company's chief medical officer, says the app's mood tracker started seeing "mentions" of the words "covid-19" or "coronavirus" on January 22, the day President Trump told CNBC the virus was "totally under control." By February 16, coronavirus mentions were up 157% from the week before. "By the last week of February, they were up 509%," Roots says. "And by the week of March 9,

JULIA DUFOSSÉ

mentions were up 605% from the week previous."

Meanwhile, Amy Cirbus, a New York–based therapist who offers services through Talkspace, says her user volume is up 65% since mid-February, which she attributes to coronavirus fears. "People are concerned about how this will affect them and their families as well as dealing with a new norm and social isolation," she says.

At the same time, changes in regulations are making it easier for people to get mental health care online. On March 17, the US Department of Health and Human Services relaxed constraints that had previously made it nearly impossible to meet digitally with a doctor because of privacy concerns under HIPAA, the US law protecting the confidentiality of health data. That could be a game changer, even once the current pandemic has subsided.

"I think this will fundamentally change how people see telehealth broadly," says Reena Pande, the chief medical officer of AbleTo, a teletherapy platform that counts over 700 clinicians across the US. She says that in the past week, requests to connect with a professional have increased 25%.

But while mental health apps make advice and care easier to access, are they as good as traditional in-person counseling? "These apps help augment care or extend it," says John Torous, the director of digital psychiatry at the Harvard-affiliated Beth Israel Deaconess Medical Center. "When they're used as standalone tools or as single interventions, there's good evidence from meta-analyses that they might not be as effective, or not enough as treatment alone."

A 2012 study in the Journal of the American Medical Association found that patients who got cognitive behavioral therapy over the phone and those who met with a therapist face to face both saw improvements in depression, but with some differences. While more of the telephone group stuck with therapy, a higher proportion of them had slipped back into depression six months later. The face-to-face group had a slightly lower rate of sticking to therapy but their outcomes were broadly more positive.

Another issue is that it's difficult for consumers to have confidence that an app will be effective. Many mental health apps market themselves by citing scientific studies. "These studies are often of lower quality, like comparing apples to oranges," Torous says. That's not to say that the apps are harmful, but the marketing might overpromise. A 2019 study in the Journal of Medical Internet Research found that fewer than 2% of app makers' claims were evidence-based, and that more than 50% of claims about easing anxiety or depression could not be substantiated. "A lot of them say they're based on cognitive behavioral therapy," he says. "But we don't know how they're translating that. It's like saying, 'If you love the books, the movie is going to be great!'"

> "I THINK THIS COULD BE THE MOMENT IN THE HISTORY OF PSYCHIATRY WHERE WE'LL SEE PEOPLE INCREASE THEIR ACCESS TO MENTAL HEALTH CARE."

Nevertheless, the relaxation of HIPAA rules around privacy means apps are uniquely poised to make a dent in mental health care. It should make teletherapy more attractive not only for consumers but for providers, potentially widening access.

And there is some evidence that apps with a human being at the other end can be pretty effective. The 2019 study found that when an app involved therapy or some other interaction with another person, people used them more and got more benefit than if they simply listened to a recording or tracked their mood, says Torous.

Angela felt awkward about her appointment. Her neighbors were around, and her husband has been working from home with her, which made it difficult to be completely open. "I didn't feel the safety I typically feel in their office," she said. "It wasn't a bad [Wi-Fi] connection; it was just difficult to get the connection you get in person."

It's still unclear what the future of mental health care will be in a world where self-isolation might last for long periods and the only way we can connect with others is via a digital device. Smartphones aren't just a potential gateway to mental health care; they could also radically transform what it means to go to the doctor's office.

What is clear is that the relaxation of HIPAA constraints could lead someone who might not otherwise have been comfortable seeking mental health care to do so for the first time, online. At such a stressful time, that might be enough.

"I think this could be the moment in the history of psychiatry where we'll see people increase their access to mental health care," Torous says.

Tanya Basu is a senior reporter at MIT Technology Review.

ON "USELESS" DISASTERS VS. "USEFUL" ONES

TR: Q+A

From car crashes to terrorist attacks, catastrophes have often changed how we live, says historian Mar Hicks.

By Karen Hao

Q: What has the role of disasters been in shaping society throughout history?
A: Disasters tend to make structural failures and long-running structural inequalities glaringly obvious. They force them to a crisis point. And ideally these terrible events then force people to reckon with ongoing problems that have been ignored by those in power.

Q: You distinguish between useful and useless disasters. What causes disasters to turn out one way or the other?
A: A useful disaster in some way produces regulatory or legislative change. But it should never come off as glib when we're talking about a disaster somehow being useful. We always have to be attentive to the fact that in almost all cases people died and lives were ruined.

One of the first disasters we look at in the course is an episode of cholera in London in the mid-19th century. That particular episode was really useful for getting London to install more sewers so that people's drinking water was not mixing with their waste.

One of the dark sides is that a useful disaster is something you pretty much always and only see when the richer and more privileged people in a society get hit. You see a lot of "useless" disasters when the people who are affected are disproportionately poor or minoritized. Their problems are seen as not the problems of those in power or of all citizens, and they can be pushed to one side.

Q: Do you think the current pandemic risks becoming a useless disaster?
A: I would hate to make a firm pronouncement on that right now, because things are still unfolding. But if you look at things historically and you look at how changes usually come into place, we definitely are at risk of not having those mechanisms.

Q: Could you give an example of how different systems—social, political, technological—worked together to create change after a disaster?
A: The coronavirus disaster is not a discrete event but a combination of systemic, infrastructural failures over a period of years. The outcomes we're currently coping with may appear sudden but have been designed into our healthcare, political, economic, and social systems.

The example of the auto industry in the early to mid-20th century drives home the need to think about how disasters are both sudden and gradual.

A new technology came into play. Then as roadway infrastructure built up, it started killing and maiming lots of people. People were hitting dashboards that had sharp edges, or they were getting impaled on steering columns, all because auto manufacturers refused to spend the extra time and money to put a collapsible steering column in place or make seat belts standard.

So there was this huge push in the middle of the 20th century, in large part led by consumer safety advocates like Ralph Nader, to try to get the federal government to pay attention. People knew what was wrong for a long time: doctors had been retrofitting their own automobiles with seat belts for decades. But it had to be forced to a head before there was the political will to say auto manufacturers had to be regulated and that cars had to have certain safety equipment.

At the same time, the laws weren't enough. There also had to be an agency to ensure auto manufacturers would follow these laws. That's how the National Highway Traffic Safety Administration came into being. The price of heading off disaster is this constant process of trying to mitigate harms and plan systems that don't scale in harmful ways.

You can also look at the history of pollution and the setting up of the EPA. Or the Triangle Factory Fire in 1911 and how that brought into place a lot of labor laws. Oftentimes these disasters cause change, but only with struggle. People really put their lives on the line and then constantly have to make sure that those changes don't get rolled back.

COURTESY PHOTO

Mar Hicks teaches a course at the Illinois Institute of Technology on the history of disasters.

Q: As you've been experiencing this pandemic personally, how have you used history to make sense of the challenges we're currently facing?
A: In general, with our current situation, it seems like we have a good handle on the root causes of what's going on, but we're having a lot of trouble mobilizing support for potential fixes. One thing that's really difficult about public health disasters is that even in democracies, public health measures have to be coercive to a great extent. Vaccines, sanitary sewer systems—you can't opt out of these systems as a citizen, because then it doesn't work.

So that raises a lot of dicey issues regarding authoritarianism. Especially in a moment of crisis, there tends to be government overreach. On the other hand, without top-down public health measures, you can't mitigate and stop the spread of a virus.

Q: People are definitely concerned that the covid response will be used as an excuse to erode privacy protections. What lessons are there about how to prevent this type of exploitation?
A: If we flash back to September 11, it was a moment ready-made for governments to put into place things that abrogate people's civil rights and then never roll them back. In other words, you have lost rights not for the duration of the crisis but for the foreseeable future, and potentially forever.

Unfortunately, one of the biggest lessons that we can learn from previous disasters is to have a robust disaster response. We can't let a disaster get to the point where you have to play catch-up in ways that require really strict authoritarian measures or that seem to make surveillance and abrogation of people's right to privacy necessary. Once it's under way, it's very difficult to arrest the slide into more and more measures that take away privacy in the service of a greater good.

Q: Have we already passed that point?
A: I don't think anything is a foregone conclusion, and I think that state and local governments in particular are trying to be very sensitive to this issue. But I do think that on the federal level we have a real crisis of leadership. A lot of bad decisions were made to get us into this situation.

Q: It seems like we've never really seen a disaster that affected so much of the world at once. That means that we don't have one particular governing body to take responsibility for producing new kinds of regulations. How does that change the challenge of recovery?
A: It's definitely challenging, but there are precedents for what's happening now. There have been pandemics that cross borders. You can also look at pretty much every situation where there's been a war that touches many different countries, or in more recent memory, economic disasters like the 2008 mortgage-backed-securities crisis.

One of the reasons this disaster might seem different is that certain countries, including the United States, were just so unprepared for it, so it's gotten really bad really quickly. But the covid-19 crisis is actually kind of similar to other disasters where we've needed national and international cooperation to try to do things like cut down on carbon emissions and we haven't had an adequate response.

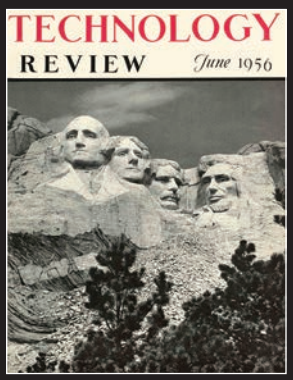
Q: Is it inevitable that we'll always ignore warnings until disaster strikes?
A: The thing is that a lot of times, warnings are not ignored. But when infrastructure works, we don't see it. When there's actually a good federal disaster response, it heads off the disaster altogether. So do we need these disasters to effect systemic change? I don't think we do. But sometimes those in power can't be forced to act without a disaster that they can't ignore.

This interview has been condensed and edited for clarity.

Karen Hao is a senior reporter at MIT Technology Review.

Pandemics through the decades

A viral disease has a way of reminding us that technology can't help us if it's not paired with human cooperation.

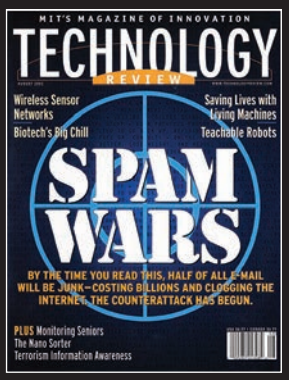


June 1956

From "The First Great Epidemic of History": Since the beginning of recorded history the people of this world have been molested by a long series of awesome epidemics, several of which have brought mankind dangerously close to extinction. The worst of them all is generally thought to have been the so-called Black Death, which ravaged the known world during most of the second half of the Fourteenth Century. Even more extensive in scope than the Black Death was an epidemic, or pandemic, which occurred nearly 600 years later. This was the influenza outbreak of the Twentieth Century, which began in Europe in May or June of 1918 and in three waves traveled literally throughout the world. It is probable, in fact, that the total carnage from this recent epidemic exceeded that of the Black Death.

October 1995

From "Controlling Infectious Diseases": These are global problems transcending political and national boundaries. An infection may come to light anywhere in the world and span continents within days or weeks. Recognizing as much, several expert groups have concluded that a surveillance system to spot emerging infections—an "early warning system"—is an essential first line of defense. But so far we aren't even close to having such a system … As of now, humanity remains vulnerable to a staggering array of infections. We have no unified system for global surveillance, let alone one for response. Some of us have been paralyzed by complacency—thinking, wrongly, that the threat of infectious diseases is past. Others have been equally paralyzed by defeatism, perhaps feeling that it is too difficult to build the systems needed to protect us. But even imperfect systems are better than none at all.



July/August 2003

From "Thinking Like a Virus": Why did it take less than two weeks to find the mutant coronavirus responsible for Severe Acute Respiratory Syndrome, or SARS, while it took the better part of three years to find HIV? There are many reasons—including better technology and a less elusive viral target—but don't discount the unprecedented level of worldwide communication among SARS researchers.

The success of a global research network in identifying the pathogen is an example of the huge payoff that can result when researchers put aside visions of patents and glory for their individual laboratories and let their work behave more like, well, a virus. After all, the hallmark of an opportunistic virus like the one that causes SARS is its ability to spread quickly. Those mounting a response need to disseminate their information and innovation just as rapidly.

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