SANJAY BAID/EPA-EFE/SHUTTERSTOCK

A veterinary doctor in Shahpur, India, tests a chicken for H5N1 influenza in January after migratory birds were reported dead in the area.

HAS COVID TAUGHT US ANYTHING ABOUT PREPAREDNESS?

Researchers warn that plans to prevent the next pandemic do not take into account the failures that have fuelled the current one. **By Amy Maxmen**

As nations struggle to control the COVID-19 pandemic, scientists warn that deadly outbreaks of other viruses are inevitable. History is clear on this: more than six distinct influenza pandemics and epidemics have struck in just over a century. Ebola viruses have spilled over from animals about 25 times in the past five decades. And at least seven coronaviruses, including SARS-CoV-2, have brought illness and death.

Expecting to avoid another spillover is about as realistic as stopping lightning from sparking a forest fire. "Preventing a pandemic may not be possible, so being prepared is the key," says Youngmee Jee, chief executive at the Pasteur Institute in South Korea.

Epidemiologists and researchers who specialize in biosecurity and public health have been outlining preparedness plans for at least 20 years. The core components consist broadly of surveillance to detect pathogens; data collection and modelling to see how they spread; improvements to public-health guidance and communication; and the development of therapies and vaccines.

Governments and private funders have poured millions of dollars into building these capabilities. Researchers have painstakingly tested and evaluated these plans to identify and fill gaps. Still, COVID-19 has demonstrated that the world was even less prepared than most had imagined. And what makes some scientists nervous is that current discussions on how to defend against the next pandemic are stuck on the same strategies as before.

"We can't simply repeat the recipes that failed," says David Fidler, a global-health policy researcher at the Council on Foreign Relations, a think tank in Washington DC. "People are still talking about doing the same things, and not asking, 'Why did this all break down?'"

As new preparedness plans are shaping up around the world, *Nature* spoke to more than a dozen researchers to ask what stands in the way of a better system for identifying

and controlling new outbreaks, and what must change.

Why aren't warning systems better?

"Everything starts with smarter surveillance. If you don't look, you don't see. If you don't see, you will always respond too late," writes infectious-disease researcher Jeremy Farrar, director of the UK biomedical funder Wellcome, in his new book *Spike: The Virus vs the People – the Inside Story*. Unfortunately, too late is the norm. The world's largest Ebola epidemics had been spreading for more than a month before anyone diagnosed the disease. Similarly, scientists agree that people in China had probably been infected by SARS-CoV-2 for several weeks before officials reported a mysterious pneumonia in Wuhan[1].

Insufficient detection worries researchers because outbreaks get exponentially harder to contain once they've expanded beyond a limited area. The world recognized this danger for influenza viruses decades ago. In 1952, one of the first moves by the nascent World Health Organization (WHO) was to set up the Global Influenza Surveillance and Response System. It has since provided an early warning system for flu outbreaks, such as H5N1 avian influenza, and it has alerted researchers to the rise of resistance to certain antiviral drugs[2].

Unknown or unexpected pathogens are harder to monitor, but improvements in genome-sequencing techniques have made open-ended searches possible. For example, in Ede, Nigeria, scientists at the African Center of Excellence for Genomics of Infectious Diseases search for foreign DNA and RNA in blood samples from patients who have high fevers but test negative for the most common maladies in the region. Using this method, they discovered an unrecognized outbreak of yellow fever in 2017. "This is a very good method for finding unknowns," explains Judith Oguzie, an infectious-disease researcher at the centre.

Some researchers say this sort of surveillance should be extended to people who work in forests, on farms handling animals and in virology laboratories – anywhere people might come into close contact with pathogens. Oliver Pybus, a co-director of the pandemic genomics programme at the University of Oxford, UK, adds that new genomic technologies could allow researchers to detect viruses in waste water or air. And once an outbreak is ongoing, these same tools can help them to determine how far it has spread below the radar.

High-tech tracking would provide lots of data, but Mosoka Fallah, the president of Refuge Place International in Monrovia, Liberia, says that basic surveillance needs to improve first. He says funders often support it as a finite project rather than a sustained process, and this defeats the purpose. A case in point: Liberia received more than US$19 million from donors, including the US government and the World Bank, to strengthen its health system and surveillance in the wake of the Ebola outbreak in 2014–16, but many of the funds have run dry. In 2019, the country was facing nationwide shortages in biomedical supplies, and many researchers and health workers weren't being paid.

PIUS UTOMIEKPEI/AFP/GETTY

Scientists analyse coronavirus samples as part of wider pathogen surveillance in Ede, Nigeria.

At a large hospital in Bong County in Liberia, the district surveillance officer, J. Henry Capehart, explained that his team had been unable to monitor endemic infectious diseases, such as measles and Lassa fever, because there were no sample tubes to collect blood. Jefferson K. Sibley, the medical director at the hospital, said that a laboratory technician had recently died of Lassa fever because the hospital didn't have the antiviral drug to treat him. "It's terrible," said Sibley. Some people had stopped seeking care because the clinic had no way to help, meaning that their illnesses were also going undetected.

> **"We can't simply repeat the recipes that failed."**

According to the 2019 Global Health Security Index, Liberia was among more than 70 countries sorely lacking in capacity to detect emerging epidemics, and among some 130 with health systems that would be inadequate in an outbreak. In these places, Fallah says, donors investing in surveillance must also strengthen the health system, or the efforts will continue to be in vain.

How can better data drive smarter decisions?

Epidemiologists learn about emerging diseases by crunching numbers, and the quality of their results depends on access to raw information. On the day after he took office, US President Joe Biden pledged to modernize the country's outdated system for public-health data and create a National Center for Epidemic Forecasting and Outbreak Analytics. The proposal, backed by $500 million through the America Rescue Plan Act of 2021, aligns with earlier suggestions by epidemiologists such as Caitlin Rivers at the Johns Hopkins Center for Health Security in Baltimore, Maryland. She says that the world lost valuable time in January and February 2020, when she and her colleagues were struggling to make sense of scraps of data on COVID-19 from official reports, newspaper articles and social-media posts.

Better data would have helped epidemiologists to determine more quickly and confidently, for example, that SARS-CoV-2 spreads through the air and that it can be transmitted by people without symptoms, says Rivers. That might have prompted scientists to advocate sooner for measures such as widespread testing and face masks. Predictions from mathematical models might have been more accurate, too, adds Jennifer Nuzzo, an epidemiologist at the Johns Hopkins Center for Health Security. "We were doing elegant math on crappy data," she explains.

Biden's forecasting centre will begin by focusing on the United States, where data collection was patchy and sloppy throughout 2020. One problem has been that rules around patient privacy prevented hospitals and health departments from sharing data with researchers who wanted to analyse it. Rivers expects the centre to set standards on how to share data responsibly. Meanwhile, the UK government, in partnership with the WHO and Wellcome, launched the Global Pandemic Radar surveillance network in May

to track disease outbreaks around the world, including the spread of SARS-CoV-2 variants. The Rockefeller Foundation in New York City is developing a pandemic data platform, too. Rick Bright, a former head of the US government's Biological Advanced Research and Development Authority, who is spearheading the Rockefeller project, says its position outside the government is a strength. "A non-governmental, non-political entity would have the ability to seal and protect those data, and to make sure that the world has access to all the same information at the same time," Bright argues.

Although these initiatives should improve the situation, they can't make data emerge from places where lab capacity for diagnostic testing is insufficient, and they could still fail to procure information from sources that don't want to share it. Countries with authoritarian leaders have a history of suppressing news of outbreaks ranging from H1N1 influenza to cholera.

Many criticized China for being less than forthcoming at the beginning of the pandemic, but it hasn't been alone. For example, several counties in the United States refused to share details about outbreaks at companies and jails with the US Centers for Disease Control and Prevention. In India, local journalists exposed the fact that officials were not sharing the case numbers in a timely manner. "Technology is potentially very beneficial, but one has to be cautious about being misty-eyed and thinking it will solve problems if basic capacity and openness is not abundant," says Arvind Subramanian, an economist at Brown University in Providence, Rhode Island. He co-authored an investigation estimating that India had under-reported deaths by 3 million or more from the start of the pandemic to June 2021 (ref. 3).

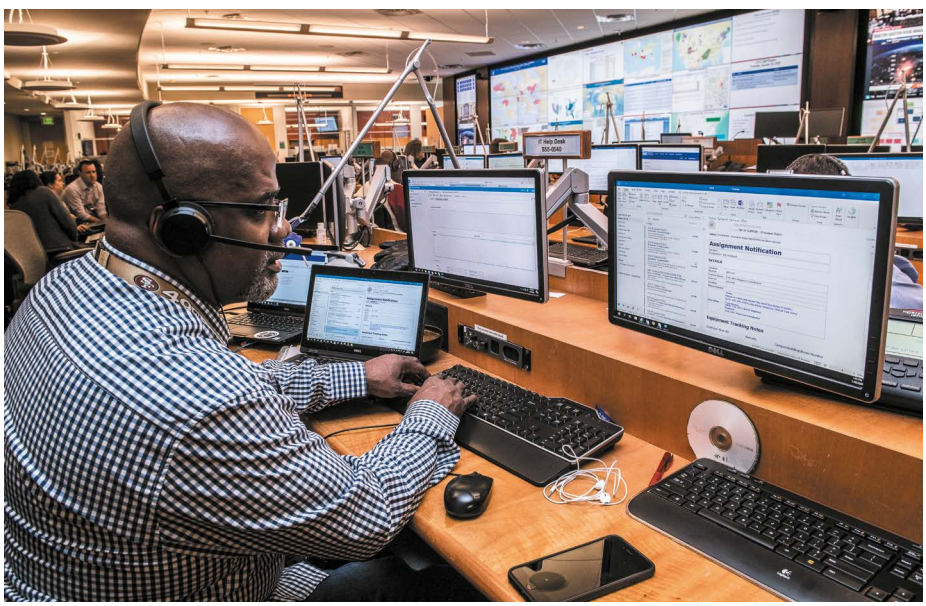
Nuzzo says that to get better raw data, researchers and policymakers need to think about incentives. For instance, most governments around the world report atmospheric conditions because agriculture markets and commerce rely on weather prediction. And community leaders in the United States push people to fill out a census because it can result in resources, she explains.

One incentive could be an agreement that groups sharing data will have access to the technologies that result, says Suerie Moon, a global-health researcher at the Graduate Institute of International and Development Studies in Geneva, Switzerland. She recalls how Indonesia withheld influenza samples in 2006, after it was denied access to flu vaccines that were developed using samples collected in the country. This issue culminated in a 2011 international framework for sharing influenza samples.

"We can't come out of COVID-19 and not have equity be front and centre."

No such deal exists for SARS-CoV-2, and signs of discontent have surfaced. Several researchers in Africa and South America have complained about requests to grant rich countries unrestricted access to their data on emerging variants while they have little to no access to COVID-19 vaccines.

Moon says that sharing epidemiological and genomic data in an outbreak is a political issue that must be negotiated at a high level, similarly to the 2011 influenza framework and other multilateral treaties. Such discussions are ongoing, Moon says, but they have not formally begun to address key issues, including what the WHO is allowed to do if a country is suspected of withholding information.



The US Centers for Disease Control and Prevention aims to guide local health partners.

JAMES GATHANY/CDC/SMITH COLLECTION/GADO/GETTY

Where does communication break down?

Public-health officials in Taiwan and South Korea were concerned about COVID-19 from the start. Recalling the epidemic of severe acute respiratory syndrome (SARS) in 2003, officials recommended face masks and ramped up mask manufacturing just as details on the first cases emerged, says biomedical researcher Chien-Jen Chen, who was vice-president of Taiwan from 2016 to 2020. In both places, government agencies met almost daily to agree on cohesive updates for the public.

Chen tailored messages carefully, emphasizing that recommendations to curb the virus were intended to keep businesses and schools open. "We kept saying, we are doing this because we don't want to lock down," Chen explains. Time helped, too. "People began to feel more trusting as they saw how poorly other countries were doing." As for misinformation, Chen says that a special team was appointed to scout out rumours and dispel them weekly on a dedicated website.

These experiences stand in stark contrast to countries where COVID-19 — and conflicting messages about it — spread out of control. In the United States, health officials didn't recommend face masks until April 2020, but then-president Donald Trump undermined the recommendations by refusing to wear a mask himself. In Brazil, President Jair Bolsonaro contradicted scientists in the country by trivializing COVID-19, calling it "little flu". He also fired two ministers of health who advocated control measures such as social distancing.

In May 2020, the WHO passed a resolution in which countries agreed to combat misinformation at home. A committee of experts listed some key approaches to this in June last year, such as working with data scientists and social-media companies to amplify the reach of credible messages. Facebook had been removing some disinformation from its platform, and renewed attention to the subject prompted the company to go further, adding warnings and links to information from health organizations on posts about COVID-19.

But presenting people with a link hardly helps when there are pre-existing biases against the scientific establishment, health authorities or the government, says Nahid Bhadelia, founding director of Boston University's Center for Emerging Infectious Diseases Policy and Research in Massachusetts, which launched in May. Researchers at this centre will develop evidence-based guidelines and communicate them in congressional briefings and through alliances they

are building with grassroots organizations.

Bhadelia says the centre will fund research on how to help people debunk online misinformation, including articles and videos posing as science that contain false claims and glaring errors. "The pseudo-academization of conspiracy theories is at its nascency — and that is only going to get worse in the next pandemic," she says.

But Peter Hotez, a vaccine advocate and scientist at Baylor College of Medicine in Houston, Texas, warns that scientists on their own aren't equipped to counter the sentiments fuelled by far-right extremists, politicians and media organizations. "I'm on a zillion Zoom calls with scientists to fine-tune our messages, but these are messages in a bottle in the Atlantic Ocean," he says. "Until there is an appetite among government agencies to take down an anti-science empire — to say it endangers the public — it won't be heard."

AFP/GETTY

A doctor in Wuhan, China, checks a patient's lung scans for damage in February 2020.

How can public-health measures be made stronger?

Throughout the pandemic, public-health and infectious-disease researchers have pleaded with leaders to enforce measures to curb COVID-19, often in vain. Bhadelia says a solution to this problem would be granting public-health departments more power during health crises, along with larger and more stable budgets. But, in many places, the opposite is happening.

According to a May report from the US National Association of County & City Health Officials in Washington DC, at least 15 states have passed or are considering laws to limit the legal authority of public-health agencies.

Another issue is that people cannot follow public-health recommendations that compromise their ability to provide food and shelter for themselves and their families. During the pandemic, vast inequality has led to disparities in disease among people who are paid low wages, work or live in crowded environments and don't have adequate labour protections. One study, for example, found an association between income inequality and COVID-19 cases and deaths in US counties[4].

Addressing inequality — or at least incorporating strong measures to correct inequities during a health emergency — should be a crucial component of pandemic preparedness plans, but such solutions are rarely included, says Nuzzo. "People acknowledge this is important, but see it as too hard to fix," she says. "We can't come out of COVID-19 and not have equity be front and centre."

How can vaccines and medicine reach the people who need them?

Drug companies developed vaccines in record time during COVID-19, and researchers say they could move even faster if early-stage work received more funding. Leading the charge is the Coalition for Epidemic Preparedness Innovations (CEPI), which is raising money for a 5-year, $3.5-billion strategy that includes developing vaccines for novel diseases within 100 days. In another proposal, Anthony Fauci, director of the US National Institute of Allergy and Infectious Diseases in Bethesda, Maryland, has suggested creating 'prototype' vaccines against about 20 families of viruses to speed up development in case of emergency.

However, governments have made little progress when it comes to ensuring that new drugs and vaccines are distributed rapidly around the world. This is evident today, where less than 2% of people in low-income countries have been vaccinated so far — more than seven months after regulators authorized the first vaccines.

Priti Krishtel, a health-justice lawyer and co-founder of the non-profit organization I-MAK, based in New York, says that mechanisms to improve the situation could provide models for future pandemics. Governments could agree to temporarily waive intellectual-property rights on vaccines during a pandemic so that other manufacturers could help to increase the supply, for example, or policymakers could create rules ensuring that vaccines developed largely with public money are broadly licensed in an emergency.

However, such agreements require buy-in from multiple countries. The same is true for surveillance, data sharing and other preparedness plans. That's an obstacle, says Stephen Morrison, a vice-president at the Center for Strategic and International Studies, a think tank in Washington DC. He says it's essential to pay attention to how nationalism, US–China tensions and an assault on the WHO paralysed attempts at a global response to COVID-19 in 2020. "We had the biggest global catastrophe since World War Two and yet there was no high-level diplomacy," he says.

To move forwards, he argues that leaders must restore a degree of cooperation between the United States and China on pandemic preparedness, so that plans attract broad support. Fidler agrees, and adds that a stronger alliance between low- and lower-middle-income countries would lend them more bargaining power on the international stage. The political reality is dire, he says. "I think a lot of people in global health are stuck in the past, and they don't want to face the fact that we are in a very different, more difficult, and more dangerous international system now," Fidler adds. "Global health has to operate in this, rather than pretend it doesn't exist."

Despite the complexity, he and others maintain hope. Many world leaders now recognize the devastation that health crises create and are motivated to do something about it. For example, a July report from a G20 panel calls for $75 billion in international financing for pandemic prevention and preparedness — twice as much as current spending levels. "There has been a change in consciousness," Morrison says. "People are watching this horror show and realizing that something has to change."

Amy Maxmen writes for *Nature* from Oakland, California.

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