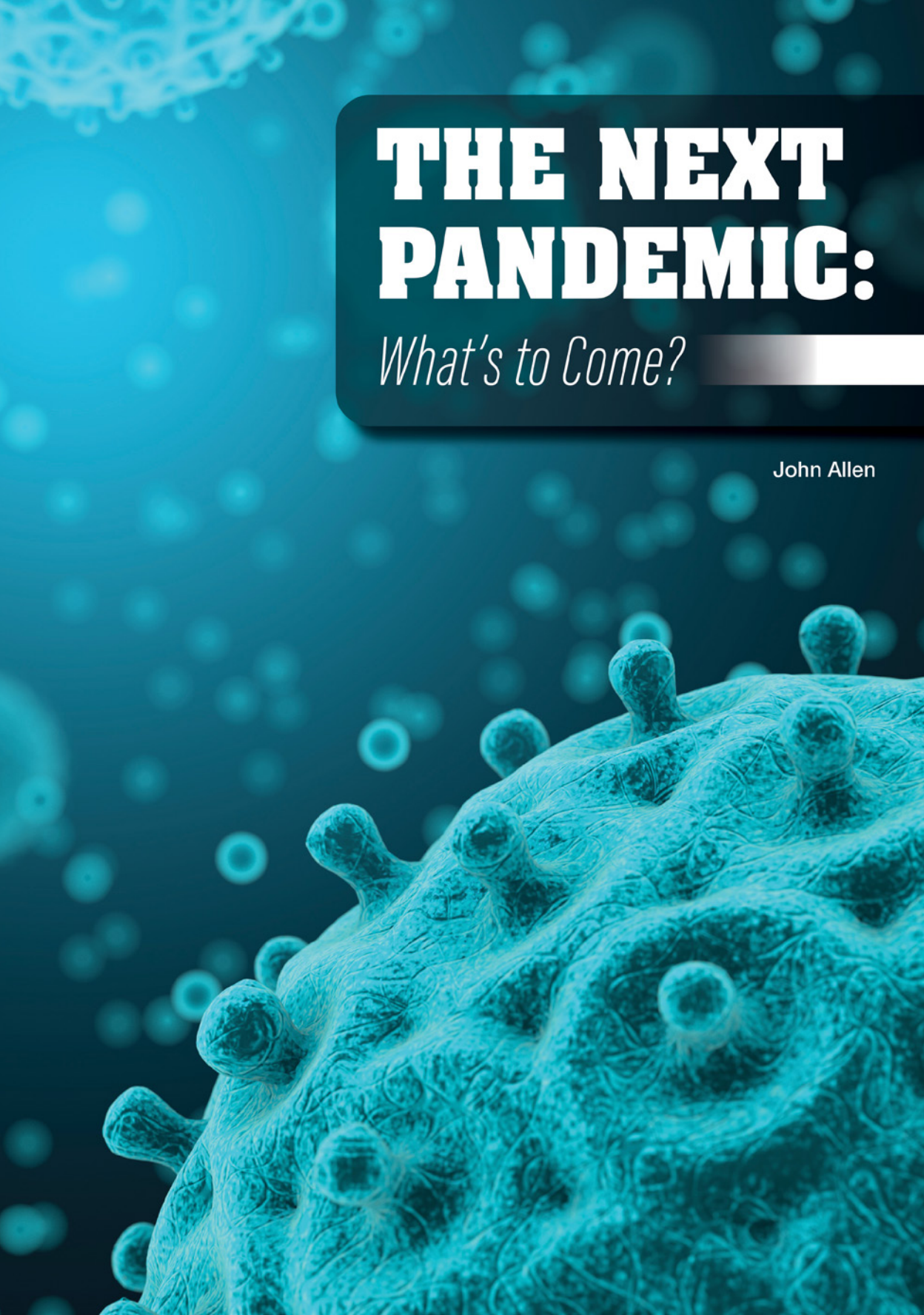
THE NEXT PANDEMIC:

What's to Come?

John Allen



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Early Warning Systems

People pay attention to authorities they respect. For example, the American public trusts the National Weather Service to forecast hazardous weather events. Some believe that a similar system could forecast, and issue warnings about, dangerous outbreaks of disease. According to Caitlin Rivers, an epidemiologist at the Johns Hopkins Center for Health Security, this kind of system could speed America's response to the next pandemic. At a May 6, 2020, appearance before a House committee on health spending, Rivers described the benefits of such a system. An agency made up of scientists, health professionals, and computer experts could monitor signs of infectious disease across the nation. It could recommend border closings or temporary lockdowns before a deadly outbreak could spread. "We don't have anything like that for outbreaks, but this [COVID-19] pandemic underscores why that must change," she said. "We should consider establishing a national center that would perform academic forecasting and analytics."[4]

The Need for a Coordinated System

Most experts agree that the United States needs a coordinated system to track outbreaks of infectious disease and create models predicting how they might spread. The pieces necessary for building a national warning system already exist. The problem is that they are scattered and do not work

together. Georges C. Benjamin, executive director of the American Public Health Association, believes that Rivers's proposal would work. Benjamin notes that an online retailer like Amazon collects massive amounts of data about its customers every day. The data includes where they live, what they eat, what they do for recreation, and what their destinations are when they travel. This data could be used to create more accurate models of how disease outbreaks might move through the population. It could also help forecast other epidemics related to health care. As Benjamin notes, "If we had such a system, we would have had a better early warning on opioid epidemics, we would have had a better early warning on the obesity epidemic, we absolutely would have had a better early warning on this [COVID-19] infectious disease epidemic. All of our data systems are very silo based. They don't talk to one another, and they're not fast."[5]

"All of our data systems are very silo based. They don't talk to one another, and they're not fast."[5]

—Georges C. Benjamin, executive director of the American Public Health Association

Currently, models for infectious disease rely mostly on public health data gathered at the local level and compiled at the National Center for Health Statistics. The modelers work at universities and private foundations, while the data people reside in government offices. Rivers and others believe data collection, modeling, and forecasting for disease outbreaks should all take place under a single umbrella group—a health care version of the National Weather Service. Coordinating these tasks could allow health officials to track disease outbreaks in real time.

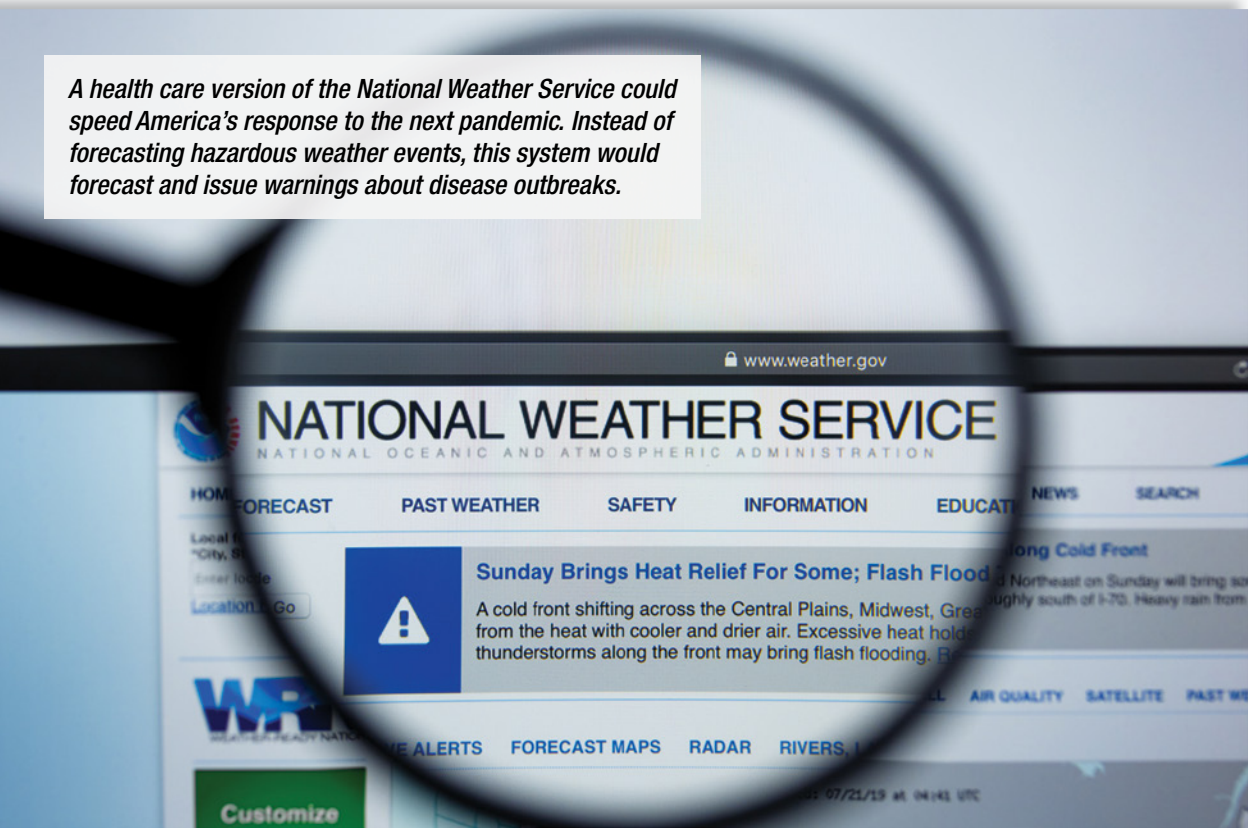
The MOBS Lab

Among the modelers anxious to join this effort is Alessandro Vespignani, a research scientist at Northeastern University in Boston, Massachusetts. Vespignani and his team use 1 million computer processors to create complex simulations of virus outbreaks. Their approach, however, is even more ambitious than that of

most modelers. Their goal is to simulate the movements and behavior of every person on earth, or more than 7 billion individuals.

Vespignani's project is called the Laboratory for the Modeling of Biological and Socio-technical Systems, or the MOBS Lab. It seeks to overcome one of the main problems in predicting the spread of a viral disease. Data about local outbreaks, including cases and deaths, is already out of date by the time it is reported. This makes it almost useless to public health officials trying to implement measures to stop the spread. The MOBS Lab stays ahead of this information curve by predicting trends in how a virus will spread. The predictions are based on minute-by-minute information from social media, medical databases, and apps that track people's travel patterns on the ground and in the air.

The MOBS Lab looks for signals in social media that show how a virus is moving. For example, with COVID-19, its researchers found that increases in coronavirus hospitalizations and deaths in an area could be forecast from increases in Google searches for virus keywords such as "fever" or "cough." The lag time between



A health care version of the National Weather Service could speed America's response to the next pandemic. Instead of forecasting hazardous weather events, this system would forecast and issue warnings about disease outbreaks.

online searches and COVID-19 deaths averaged about twenty-one days. This is remarkably close to the twenty-day gap doctors have seen between onset of serious COVID-19 symptoms and deaths. Vespignani's team makes similar forecasts using tweets about lockdowns, quarantines, and face mask rules. They tend to show where people are planning to travel—and where the virus might bubble up next. MOBS Lab researchers even account for data that might be artificially inflated by fake news or sensational media stories that create a short-term panic. The lab continues to add data from new sources to pinpoint outbreaks with more accuracy. Among the sources are UpToDate, a fact-checking database used by medical professionals, and Kinsa Insights, a database that collects users' body temperatures.

In December 2020 Vespignani and the MOBS Lab began sharing their results with the WHO, the White House, the Centers for Disease Control and Prevention (CDC), and the Bill & Melinda Gates Foundation. The next step for the MOBS Lab is to make its data and forecasts available for public use online. This would help integrate its work with that of local health officials. Using nearly real-time data, officials could make better decisions about tightening or loosening restrictions on the basis of a viral threat. The MOBS system could help forecast trends in infectious disease weeks in advance of current methods. Mauricio Santillana, a professor at Harvard Medical School who partners with the MOBS Lab, believes that bringing health officials on board is crucial. "We've created a way to show public health officials what's going through our minds," Santillana says. "We want them to see what we see."[6]

Using the Internet of Everything

Some experts hope to go beyond simply tracking disease outbreaks. They want to derail epidemics before they get started. The solution, they believe, lies with big data, especially data produced by the so-called Internet of Everything, or IoE. With devices around the world connected to each other and talking all the time, vast amounts of data are produced, categorized, and

stored. In fact, IoE records too much data for ordinary processors to handle. The data comes from smartphones and social media, geospatial tracking devices, satellite imagery, sensors on all sorts of machinery, and many other sources. Sifting this data for clues to potential outbreaks has produced a whole new field of medicine, called computation epidemiology. It employs computers powered by artificial intelligence to sort through mountains of data, looking for patterns that might reveal a possible outbreak of disease on the horizon. In this way, an unusual cluster of coughs or fevers could lead health officials to investigate.

Clues to potential outbreaks can be found in traditional places, such as doctors' diagnoses, lab samples, patient reports, and video checkups. But these sources can take weeks to compile and compare. What is more rapidly available is data pulled from linked devices like smartphones and smart watches. The Fitbit and Whoop trackers worn by runners and other people who exercise can provide hints of impending illness. Health-conscious owners use the devices to monitor heart rate, body temperature, weight loss, and other physical signs. The Apple Watch tracks its owner's sleep patterns and oxygen levels, while also giving users the option to sync their devices with other users. Amazon's digital assistant Alexa can record sneezes and coughs. Patterns of illness can be cross-checked with these results to pinpoint likely outbreaks as soon as they appear.

As the MOBS Lab noted, smartphones also track their owners' movements. They reveal where people have been and where they are going. Social media posts and airline reservations add to the mix. Technology and telecom companies can help data experts map how a pathogen travels and predict future pathways. Armed with this information, health officials can locate areas of high risk and issue real-time warnings to the public.

Scanning for Signs of Illness

Along with self-monitoring smart devices, scientists are turning to data from public monitoring systems. These systems use machine

Privacy Issues in Monitoring for Disease

The next pandemic is sure to bring concerns about privacy as governments increase surveillance to detect outbreaks. During the COVID-19 pandemic, the Chinese Communist Party (CCP) made widespread use of facial-recognition software and public security cameras to collect data on possible infections. The CCP also mandated a smartphone tracking app that used a color-coded system to govern travel. Green meant the user could move relatively freely, while red forced the person into fourteen days of quarantine. The app's 700 million users had to show their color status before boarding a train or entering a supermarket. The app also shared location data with police.

The idea of using such measures to fight a pandemic in the United States alarms those who advocate for privacy rights. Security cameras are already a feature of American daily life. New technologies can fit these devices with sensors to capture more personal information than just images. "Making this information available has [public health] uses, but it also has downsides if it is used in the wrong manner," says computer science professor Madhav Marathe. "We have to decide as a society at what point of time we are willing to give up basic rights."

Quoted in Casey Ross, "After 9/11, We Gave Up Privacy for Security. Will We Make the Same Trade-Off After Covid-19?," *StatNews*, April 8, 2020. www.statnews.com.

vision and artificial intelligence to gather and analyze health data in public settings. Machine vision refers to computerized cameras that scan the environment and inspect images for different purposes. They are placed at high-traffic areas such as airport terminals, sports arenas, and shopping malls. The visual data they collect can provide remarkable clues to possible viral infections.

Binah, an Israeli tech company, has developed software for health-related facial scanning. It employs a technology found on Fitbit devices or smart watches called remote photoplethysmography. It measures vital signs via a series of light flashes on the back of the smart device. The light flashes scan a person's skin for changes in five key vital signs. These include heart rate, respiration rate, oxygen saturation, mental stress level, and heart rate variability. Binah plans to add blood pressure monitoring as well. The software works by measuring slight variations in skin tone

A runner checks distance and heart rate after a run. Linked devices like smartphones and smart watches provide all sorts of physical data that can be used to hint at impending illness and possible outbreaks.

that can scarcely be detected by the naked eye. It focuses on the skin above a person's cheeks, but it can gather the same data from scanning a finger.

To provide scans in public, Binah plans to set up kiosks at the entrances to malls and airports. The scanning process is not instantaneous, but it takes less than a minute. The software also works on a smartphone app for home use. During the COVID-19 pandemic, customers used the Binah app to check for signs of infection before dining or traveling. The company says its scanning software has an accuracy rate of 80 to 99 percent. Binah hopes that one day its software will be standard equipment for employees in offices and stores. The data could then be fed into a central clearinghouse to check for unusual patterns. This would allow for continuous monitoring of infectious disease.

Tracking Symptoms with AI

Experts in viral illness note that one of the first signs of coronavirus in Wuhan, China, was an uptick in patients with symptoms of re-

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FOR FURTHER RESEARCH

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