COVID-19: LEARNING FROM PAST DISEASE OUTBREAKS

BEING PREPARED: ARE WE READY FOR THE NEXT DISEASE?

SWIFT RESPONSE: AFRICA LEADS ON EARLY CONTAINMENT

HEALTHCARE

IMPACT 2020

AN FII INSTITUTE PUBLICATION

WINNING THE BATTLE AGAINST DISEASE TOGETHER

FII INSTITUTE
Future Investment Initiative Institute | Impact on Humanity

FACTS AND FIGURES

DATA ON DISEASE
HOW ARE WE TACKLING THE THREAT?

(AS OF MAY 19 2020)

COVID-19 APPS TRENDING

26

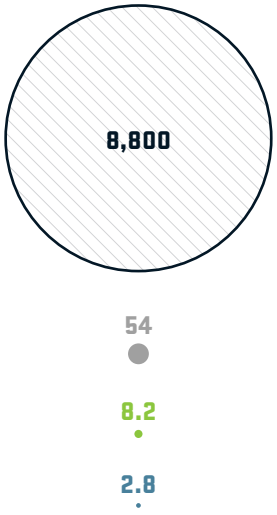
From Malaysia to North Macedonia, developers worldwide are working on apps to help track and trace Covid-19, according to MIT.

THE COST OF DISEASE

Disease impacts not only health but also the economy.

● COVID-19 ● SARS
● MERS ● EBOLA

ESTIMATES IN BILLION US $

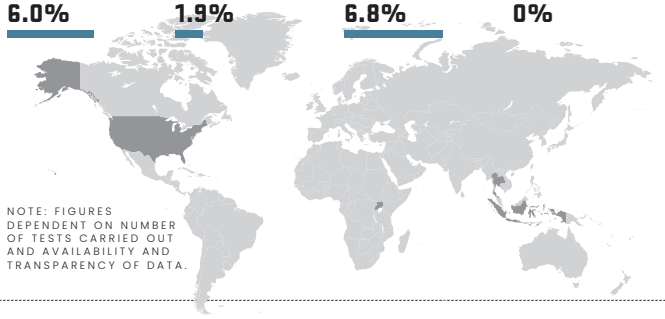


PLANNING AND REALITY

In 2019, the Global Health Security Index (GHSI) measured how well countries were prepared for a pandemic. These countries were considered the best prepared in each income bracket. How have they fared so far in the Covid-19 outbreak?

● GHSI SCORE ● COVID-19 CASES PER MILLION POPULATION ● FATALITY RATIO

HIGH INCOME	UPPER MIDDLE INCOME	LOWER MIDDLE INCOME	LOW INCOME
UNITED STATES	THAILAND	INDONESIA	UGANDA
83.5	73.2	56.6	44.3
4,688	43	68	6
6.0%	1.9%	6.8%	0%



NOTE: FIGURES DEPENDENT ON NUMBER OF TESTS CARRIED OUT AND AVAILABILITY AND TRANSPARENCY OF DATA.

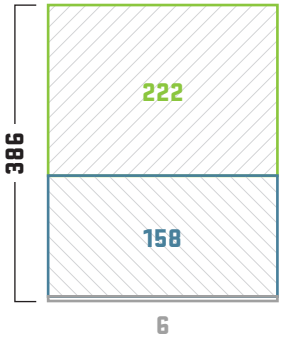
PROGRESS IN THE PIPELINE

The WHO tracks the development of health products for all diseases. This is the current number of products in active development for some of the most dangerous infectious diseases.

DISEASE	PRODUCTS
COVID-19	222
ZIKA	55
EBOLA	50
MARBURG	14
MERS	13
LASSA FEVER	12
SARS	6
NIPAH AND HENIPAVIRAL	5
CRIMEAN-CONGO HAEMORRHAGIC FEVER	1

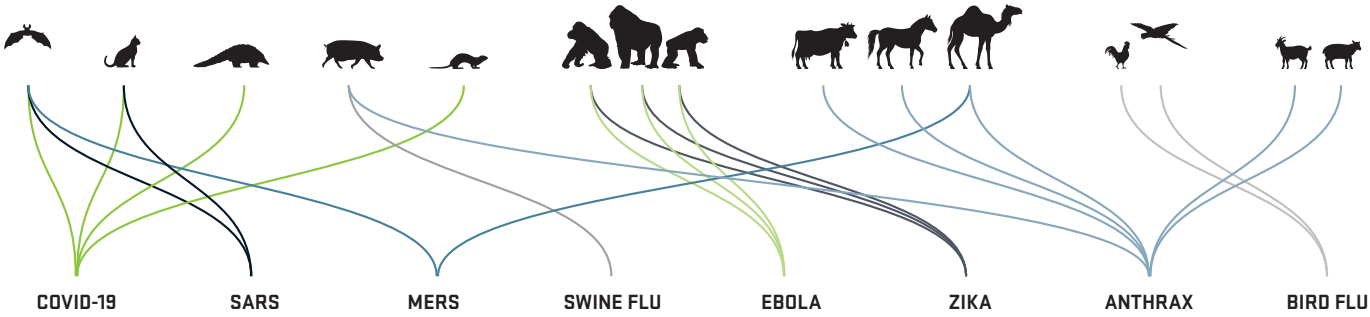
Products in development for these diseases by type.

● ALL ● MEDICINES
● VACCINES ● DIAGNOSTICS



THE HUMAN-ANIMAL INTERFACE

Over 70% of emerging infectious diseases originate from wildlife, sometimes via another animal. As humans encroach on natural habitats, the risk of these diseases being transmitted to humans increases.



SOURCES: MIT TECHNOLOGY REVIEW COVID TRACING TRACKER; METABIOTA; ASIAN DEVELOPMENT BANK; GLOBAL HEALTH SECURITY INDEX; JOHN HOPKINS UNIVERSITY; WORLDOMETERS; WORLD HEALTH ORGANIZATION. ALL DATA AS OF MAY 19 2020

EDITORIAL

FII INSTITUTE Future Investment Initiative Institute | Impact on Humanity

A NEW FORCE IN THE BATTLE AGAINST DISEASE

WELCOME TO IMPACT, a new report series, brought to you by the FII Institute. I write to you as we face one of the greatest global challenges in recent history. Covid-19 is unprecedented in its scale, impact, and speed. At the same time, we may have a unique opportunity to shift our thinking on key health concerns, drive an exceptional level of global collaboration, and support the development of ground-breaking technologies.

Our mission is "Curating and enabling ideas to impact humanity sustainably". This report represents the first in the pursuit of this mission. We have brought together leading experts to discover what we have learned from past epidemics and which promising technologies can be leveraged to contain future outbreaks.

The need to find sustainable, innovative solutions to threats to our public health has never been more urgent. This crisis has shown that our strength lies in cooperation and the sharing of knowledge – a message that is deeply embedded in our vision and mission.

More than just sharing knowledge and impactful ideas, our core ambition is to create tangible impact across four areas: Healthcare, Sustainability, Robotics and AI. We aim to form long-lasting partnerships to jointly work towards a brighter future. I invite you to join us to solve society's most pressing challenges to, ultimately, create a positive impact on humanity.

Richard Attias
CEO, FII INSTITUTE

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Distancing

With Covid-19, we became used to the streets of many major cities being emptied of people as countries applied differing degrees of societal lockdown. In the absence of a vaccine, social distancing is one of the key weapons in our defensive armoury against infectious disease.

TACKLING COVID-19

Countries are differing in their approach to one of the greatest threats to human health. What can we learn from these different approaches as we come together in global cooperation to build resilience against the hidden enemy of disease?

PHOTOS: ALEX HAY/TRUNKARCHIVE; ETHAN MILLER/GETTY IMAGE

Disinfection

Disinfection has always been an important tool in preventing the spread of infectious disease. If robots could take on this job, particularly in clinical settings, it would reduce the risk of exposing human workers to infection and safeguard lives.

Measuring

The more we know, the better we are able to combat disease. With big data and AI, we have the power to predict and prepare as never before, providing we learn how to turn the mass of data into actionable insights.

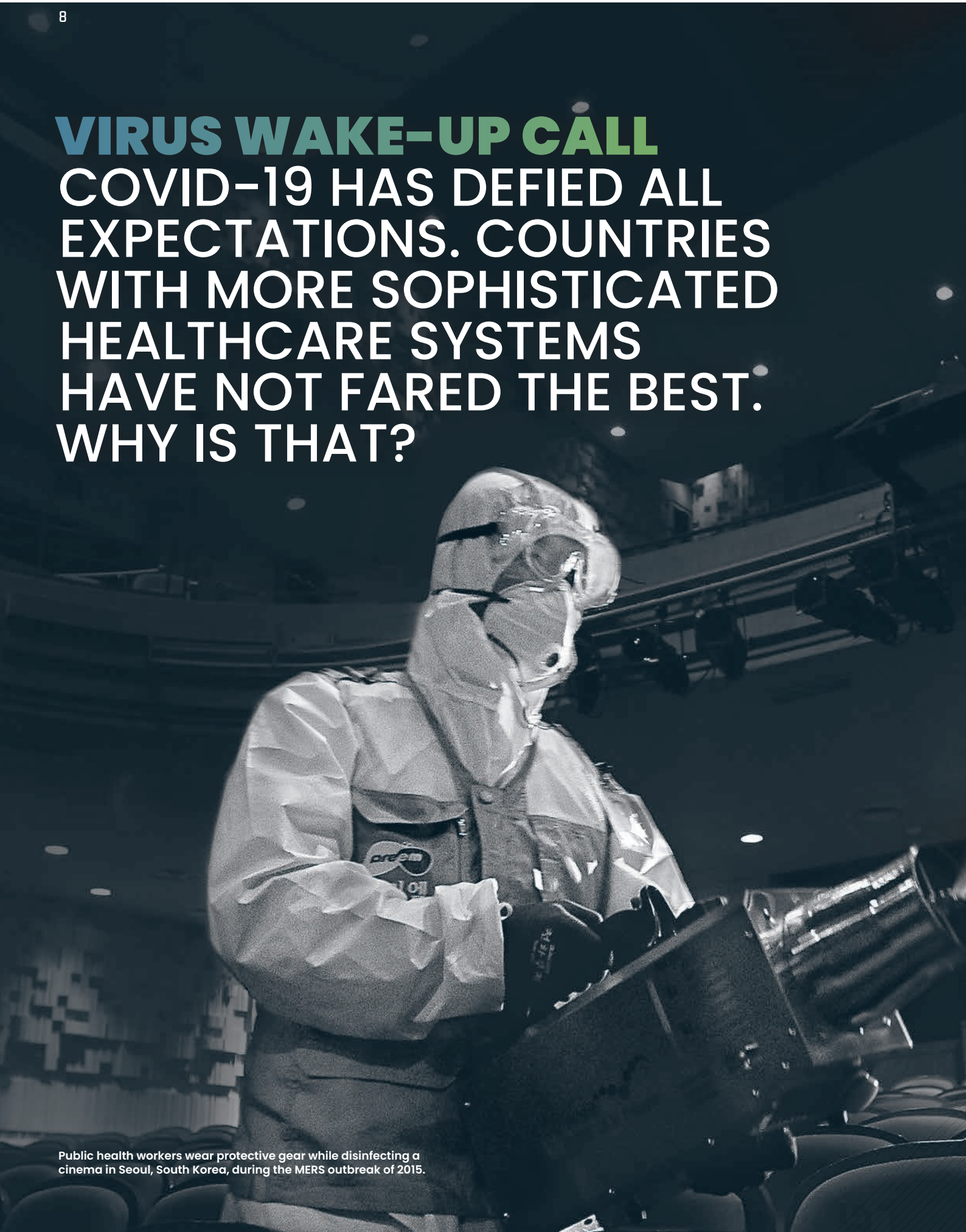
PHOTOS: BAY ISMOYO/GETTY IMAGES, RUI OLIVEIRA

Testing

The countries with the most successful records on disease containment have applied the three Ts – test, track and trace – at the earliest opportunity. Learning to do this at speed will bolster global defences against future disease.

VIRUS WAKE-UP CALL

COVID-19 HAS DEFIED ALL EXPECTATIONS. COUNTRIES WITH MORE SOPHISTICATED HEALTHCARE SYSTEMS HAVE NOT FARED THE BEST. WHY IS THAT?



Public health workers wear protective gear while disinfecting a cinema in Seoul, South Korea, during the MERS outbreak of 2015.

PHOTO: CHUNG SUNG-JUN/GETTY IMAGES

IN SEPTEMBER 2019 the Global Preparedness Monitoring Board published its first annual report, looking at how prepared we were for a global health emergency. Just a few months after publication, the worst-case scenario in the report was starting to unfold in Wuhan, a major commercial and transport hub of 11 million in central China.

Convened in 2018 by the World Bank Group and the World Health Organization (WHO), the Board was tasked with identifying gaps in global preparedness for a future pandemic. Its co-chair, former WHO head Dr. Gro Harlem Brundtland, warned that the world was unprepared for the "very real threat of a rapidly moving highly lethal pandemic of a respiratory pathogen killing 50 to 80 million people." Her prophetic warning went mostly unnoticed by the world's media.

She had good reason to be worried. Between 2010 and 2019, the WHO had been tracking almost 1,500 epidemics worldwide. Diseases such as Severe Acute Respiratory Syndrome (SARS), Asian Influenza, Middle East Respiratory Syndrome (MERS), Ebola and Zika had already revealed themselves to be formidable adversaries, some with the potential to kill hundreds of thousands of people if they were to spread at speed through our globalized economies. Each time an outbreak occurs, key lessons are learned. But to the clear frustration of Dr. Brundtland they are not being acted upon. "For too long we have allowed a cycle of panic and neglect when it comes to pandemics: we ramp up efforts when there is a serious threat, then quickly forget about them when the threat subsides. It is well past time to act," she warned.

SARS SHOWS THE WAY

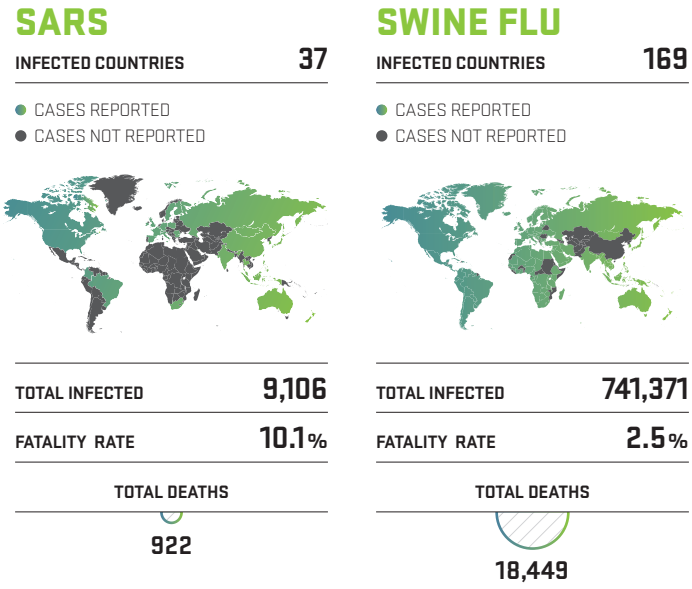
In January 2020, as events unfolded in Wuhan, there were uncomfortable echoes of the SARS outbreak in 2003 that ultimately claimed around 800 lives and impacted 29 countries. Similar to Covid-19, SARS-Cov is thought to have begun as an animal virus. Later analysis revealed that the first infection of humans in Guangdong province of southern ↘

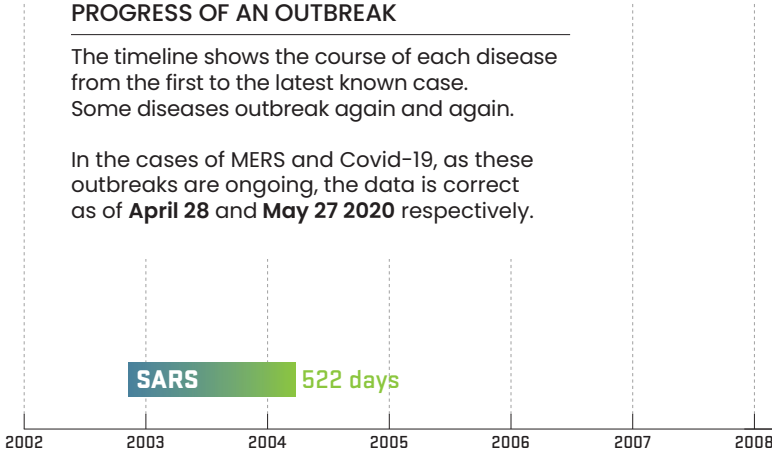
MAPPING DISEASE OUTBREAKS

THE IMPACT OF MAJOR EPIDEMICS THIS CENTURY

With the Covid-19 pandemic, the whole world has now woken up to the devastating effects of infectious disease. Although Covid-19 is in many ways unprecedented, previous major epidemics gave plenty of indication of the risks we faced. But warnings went largely unheeded.

SOURCES: METABIOTA, WORLD HEALTH ORGANIZATION, LOCAL MINISTRIES OF HEALTH, JOHN HOPKINS UNIVERSITY, WORLDOMETERS





↘ China began in November 2002. It was not until February 2003 that the WHO was alerted to unusual numbers of pneumonia cases. The WHO issued its first global alert on March 12 2003. Cases outside China started to appear from March 3 in Vietnam, Hong Kong, Canada, Singapore and Taiwan.

The SARS outbreak taught us the importance of disease surveillance, international cooperation, transparency and the need for national and international public health authorities to take rapid and decisive steps towards containment.

It is no coincidence that those areas worst impacted by SARS in 2003 – Taiwan, Singapore, Vietnam and Hong Kong – were the fastest and most effective at tackling the first wave of Covid-19 in 2020. SARS was the first coronavirus to reveal its potential to travel around the world while failing to respond to the classic antiviral therapies. Affected countries were forced to fall back on traditional public health interventions: early case detection, case isolation, tracing and quarantine of contacts, strict infection control, social distancing and the dissemination of accurate public information.

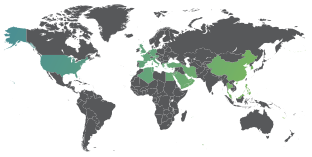
SETTING THE STANDARD

Taiwan is just 80 miles off the coast of China, with more than one million of its 23 million citizens either residing or working on the mainland. With 2.71 million Chinese visiting Taiwan in 2019, Taiwan had the potential to be one of the world's worst impacted regions. However, thanks to its state of constant alert to the spread of epidemics, Taiwan has managed to keep the number of people infected to about 400 with only six deaths. Its actions, born out of its experience with SARS, are seen as a template for the rest of the world.

MERS

INFECTED COUNTRIES 28

- CASES REPORTED
- CASES NOT REPORTED



TOTAL INFECTED 2,557

FATALITY RATE 34%

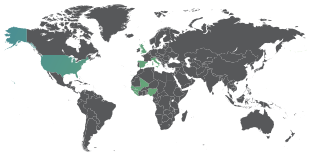
TOTAL DEATHS

871

EBOLA

INFECTED COUNTRIES 10

- CASES REPORTED
- CASES NOT REPORTED



TOTAL INFECTED 28,628

FATALITY RATE 39.5%

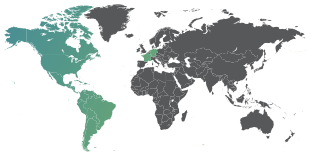
TOTAL DEATHS

11,312

ZIKA

INFECTED COUNTRIES 55

- CASES REPORTED
- CASES NOT REPORTED



TOTAL INFECTED 749,694

FATALITY RATE <0.1%

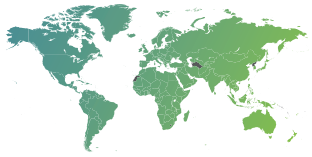
TOTAL DEATHS

45

COVID-19

INFECTED COUNTRIES 213

- CASES REPORTED
- CASES NOT REPORTED

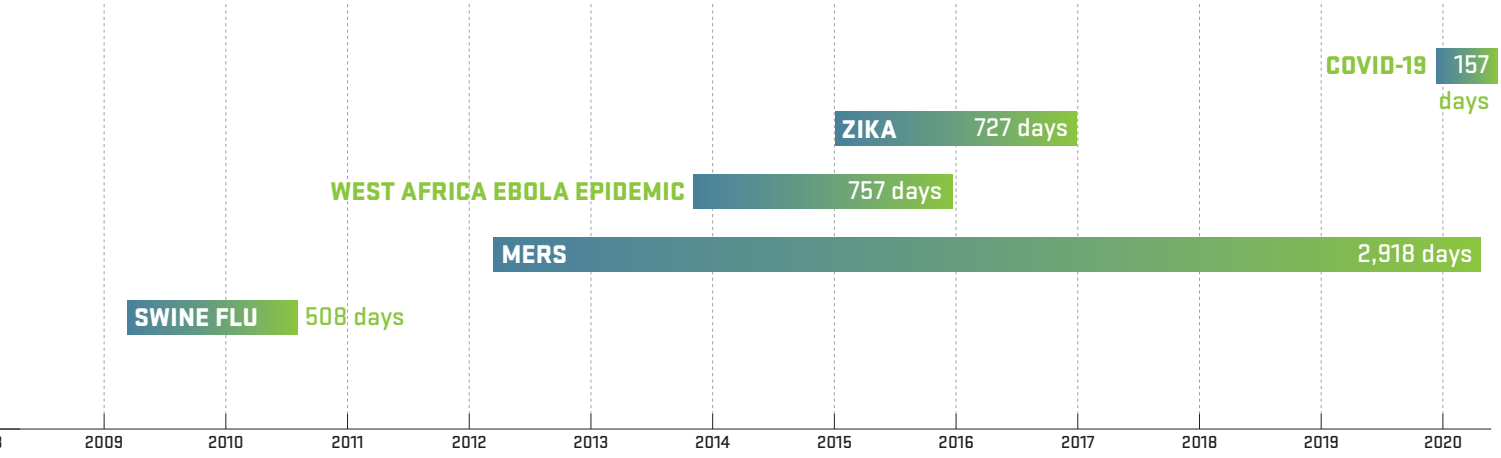


TOTAL INFECTED 5,625,588

FATALITY RATE 6.3%

TOTAL DEATHS

351,809



SOURCES: LOCAL GOVERNMENTS

A year after the SARS outbreak Taiwan set up a health command center to act as the operational command point in the case of a large outbreak. On December 31 2019, the day the WHO was notified of a pneumonia of unknown cause in Wuhan, officials began boarding planes arriving from Wuhan to test temperatures. With response structures in place, officials were able to quickly assess and manage capacity while identifying cases, implementing quarantine, and reassuring and educating the public.

It took just one day to leverage big data by integrating national health insurance records with immigration histories so that staff in clinics, pharmacies and hospitals were able to identify high-risk individuals. Under the Communicable Disease Control Act, a platform was set up to ensure epidemic information was quickly released to the population. Daily press conferences began on January 23. People placed under quarantine were monitored using their mobile phones. Those unable to self-isolate at home were given hotel rooms. The military was brought in to increase mask production and, by January 20, the government had under its control 44 million surgical masks, 1.9 million N95 masks and 1,100 negative-pressure isolation rooms. Conscious of the risk of panic buying, the authorities set up "epidemic prevention maps" to inform the public about the location and stock levels of epidemic prevention supplies in 6,000 pharmacies. Public health messaging was designed to address disease stigma, while those in quarantine were provided with an income, food, frequent health checks and encouragement.

Like Taiwan, South Korea will also be studied for its early model response to Covid-19, born of its experience with ↘

MERS in 2015. South Korea's decision to overhaul its testing system after the MERS outbreak is credited with providing the capacity to effectively respond to Covid-19 when the first cases presented themselves in late January 2020. By the end of March, South Korea had tested a quarter of a million people through a national network of 600 testing sites. Results were available within six hours via SMS. This comprehensive testing regime allowed for an infected person's history to be tracked so that all those who had come into contact could be traced. South Korea's policy of testing, tracing and treating successfully stemmed the spread of the virus while avoiding a damaging economic lockdown.

BEYOND MEDICAL EPIDEMIOLOGY

The 2014 Ebola outbreak in West Africa, which claimed over 11,000 lives, proved the importance of social science input when tackling an epidemic. As the disease unfolded, field workers witnessed resistance to certain WHO measures. Top-down approaches to epidemic control were not working. The breakthrough moment came with the discovery that 20 percent of Ebola infections were happening as a result of religious rituals during the burial of victims. By working with local communities and faith groups it was possible to help the bereaved find safe alternatives to deeply cherished burial practices.

"It became rapidly evident that unless you have a better understanding of people's political and economic context and their cultural beliefs it becomes very difficult to enforce a particular set of measures all the way from quarantine through to burial," explains Hayley MacGregor, research fellow at the Institute of Development Studies, who sits on the WHO social science expert group on Covid-19.

Social scientists argue that the sophistication of healthcare systems does not necessarily make a nation well-prepared for an epidemic. It is only when governments are informed by a broad base of scientific disciplines that they will be able to address some of the wider questions arising from the current pandemic. One factor that has been underestimated in all countries during Covid-19 is how we deal with death and dying. Psychologists fear long-term mental health problems as family members have been unable to say goodbye or grieve for their loved ones.

Other societal fault lines include how the virus is impacting low income families, the strain placed on children in lockdown, support for those suffering mental health problems, the protection of family members from domestic violence, the impact on the homeless and, one of the most contentious issues to emerge out of Covid-19, the protection of the elderly in care homes.

"It is only when you ask who are the most marginal groups and try to preempt unintended consequences for them through your preparedness planning that you will avoid the care home scenario unfolding the way it has or the impact on the homeless and the mentally unwell," says MacGregor.

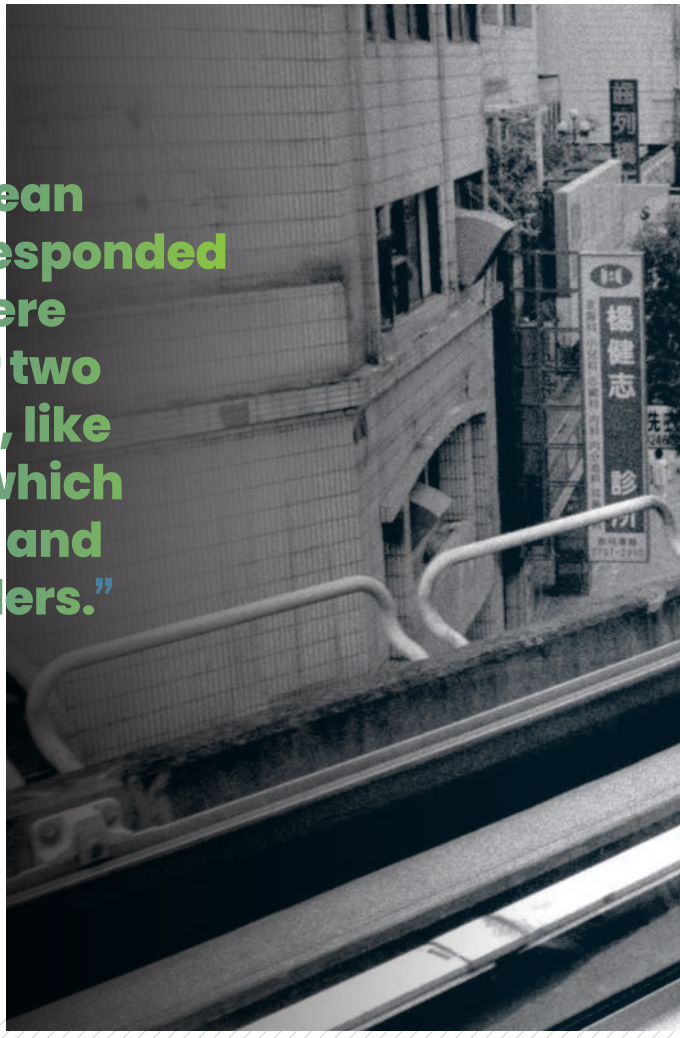
DIFFERENT RESPONSES

As Europe and the United States went into lockdown through March, two strategies emerged. The first was mitigation by slowing the epidemic spread to reduce the peak of healthcare demand and protect the most vulnerable. The second was suppression, the reversal of epidemic growth by cutting infection rates to the lowest levels possible. Most countries, with the exception of Sweden, adopted the latter with varying degrees of severity. As

> **"Most European countries responded too late. There were one or two champions, like Denmark, which acted early and closed borders."**

PROFESSOR ILONA KICKBUSCH

Member of WHO Global Preparedness Monitoring Board



PHOTOS: CHIEN-CHI CHANG/MAGNUM PHOTOS/AGENTUR FOCUS, PRIVAT

Wearing a mask on public transport in Taipei, Taiwan, during the height of the SARS epidemic in 2003 – now a common feature throughout the world.

CALL TO IMPACT

1 Despite facing the continuous threat of a global pandemic, we were unprepared for the Covid-19 crisis. Unless something changes, we will be unprepared for the next major disease outbreak as well.

2 Those nations hit hardest by past crises were able to tackle the outbreak more effectively. Public health officials need to do more to learn from the healthcare crises of other nations, even if not directly impacted.

3 It is not enough to focus on one area of preparation. Governments must ensure that transport, homeland security, social services and finance ministries are ready to swing into action.

the Covid-19 story unfolds, global health specialists will have the opportunity to see how different countries of broadly similar demographics responded, and what can be taken forward for future preparedness.

Professor Ilona Kickbusch, member of the WHO Global Preparedness Monitoring Board and Director of the Swiss Global Health Centre, says the first lesson learned is that most were just too slow in their responses. "Most European countries responded too late. There were one or two champions like, for example, Denmark, which acted early and closed borders with a tough lockdown."

Portugal was also fast off the mark, going into full lockdown after recording only 448 cases, compared to its neighbor Spain, which delayed implementing extreme measures until case numbers had reached 6,000. Germany has had fewer deaths than other countries in part because of its ability to test its population on a large scale through an existing network of public and private laboratories.

Meanwhile, in the Middle East, having previously fallen victim to MERS, the United Arab Emirates and Saudi Arabia took early action, implementing harsh lockdowns with curfews and heavy fines.

PREPAREDNESS PAYS OFF

The experience of Covid-19 so far suggests that countries that have learned from experience have come off lightest in this global pandemic. According to Kickbusch, another key message is the need to improve the health literacy of populations and the conversations leaders have with citizens prior to a crisis. "We need to know how to communicate issues around a situation like this. One answer would be to simulate together as communities. We are also learning that cities are important actors. It is not enough to do this with national governments – just look at New York, Berlin and London." Kickbusch believes there is now an opportunity for governments to learn from community experiences of Covid-19 and include these in future pandemic plans.

As the Covid-19 story unfolds across the globe, health experts are now hoping that their long-standing warnings about the need for greater preparedness will finally be heard. ■

FIGHTING BLIND

PROFESSOR DAVID HEYMANN, ADVISOR TO THE W.H.O. ON COVID-19, SAYS THERE ARE MANY UNKNOWNS ABOUT THE DISEASE, BUT VALUABLE LESSONS TOO.

THE ONE CONSTANT that has characterized Covid-19 is uncertainty. With some big epidemiological questions unanswered, we are struggling to predict the destiny of the virus. Will Covid-19 disappear as fast as it arrived, or will it become endemic, like seasonal influenza? Will catching it provide immunity or will it, like the dengue fever viruses, be more severe the second time around? Without a sensitive antibody test, we cannot be certain about community spread. We also do not fully understand the clinical spectrum. With 80 percent of symptoms being mild and around 9 percent of cases showing no symptoms, we do not know why some otherwise healthy people succumb, and some with underlying health conditions get away with mild symptoms.

For Professor David Heymann, a veteran of disease outbreaks, the gaps in our knowledge are troubling. He is currently chair of the independent advisory group to the WHO on Covid-19 and led the global response to SARS in 2003. Some of the decisions taken by governments to protect their citizens worry him. His biggest surprise is the speed and severity with which societal lockdowns came into force

"With no certainty about a vaccine it is wrong for countries that have locked down to say that they will now keep the reproductive level low until there is a vaccine, it is the wrong hypothesis. The way forward is to do everything you can to keep the virus at a level you feel your country can sustain." The big unknown is whether we will come up with an effective vaccine. Heymann believes there is no guarantee we will. "My fear is that many countries have entered these lockdowns without a clear exit strategy," he says.

He points to Sweden, much maligned initially but now attracting growing interest as an example of allowing the virus to enter in a controlled manner. Sweden has implemented rules around gatherings and restaurant seating distances, but has adopted a bottom-up approach to containment by trusting the population to act responsibly. Asian countries such as South Korea and Vietnam have also successfully avoided total societal lockdowns while still managing to stem transmission.

Heymann feels political decisions were driven by an unfortunate sequence of events over the first three months of the outbreak. The Chinese lockdown of Wuhan appeared to be working at the time that Italy's healthcare system became ravaged by the virus. Other governments did not want to take the risk of letting that happen to their countries and wanted to be seen to take firm action. What remained unclear as the lockdowns were introduced was the impact on social inequality. "Especially those who live hand to mouth and then lose their day-to-day employment. In many instances they are also the ones with comorbidities which I find extremely concerning as an epidemiologist," he says.

PROFESSOR DAVID HEYMANN

Professor David Heymann is Professor of Infectious Disease Epidemiology at London School of Hygiene and Tropical Medicine. Previously he was WHO Executive Director of the Communicable Diseases Cluster, a position from which he headed the global response to SARS.

VARIED IMPACT

Another unknown about Covid-19 is why it initially appears to be disproportionately affecting the developed world. There are a number of theories in play around travel interconnectivity, the low average

ILLUSTRATION: SÖREN KUNZ

> **"In my role for the WHO, I have access to all of this information, and it really is quite amazing how freely data is being shared."**

age of those in developing countries, and that it may be too early to tell what the full impact will be. "It is possible all these are working together, and we will see different epidemiology in different parts of the world," says Heymann.

While there is a lot to be concerned about with Covid-19, one of the most encouraging responses has been the level of global technical cooperation, which belies some of the geopolitical tensions at the top levels of government. Heymann points to cooperation between the Chinese and American centers of communicable disease. "As chair of the independent advisory group to the WHO program, I have access to all this information and it really is quite amazing how freely data is being shared," he says. He also recognizes the way scientific journals are allowing open source access and the speed at which research is being peer reviewed as a critical tool in trying to contain the virus.

In mid-May, as many countries in the West were trying different methods to release citizens from lockdown, Asia started to go in the opposite direction. "They are introducing what you could call circuit breakers, where they introduce a lockdown for a few weeks or months and then remove it. An example is Hong Kong, which shut down its nightlife for a couple of weeks," says Heymann.

As the pandemic develops, unanswered questions will be resolved and, with the comfort of time, we will be better able to assess which epidemiological approach is best suited to which circumstances. One of the bittersweet benefits of a global pandemic is that, ultimately, it will provide many different models from which to learn how to combat future diseases. ■

CALL TO IMPACT

1 Immediately develop a full strategy to include societal lockdown measures through to relaxing restrictions.

2 Trust the epidemiological evidence to ensure you protect all citizens, including the most vulnerable.

3 Global cooperation and shared knowledge are inevitable in the face of disease threat. A global crisis can only be solved together.

PART TWO

TECHNOLOGY HELPS STEM VIRAL TIDE

LOOKING AHEAD: WHICH TECHNOLOGIES COULD HELP US STOP THE NEXT DISEASE OUTBREAK IN ITS TRACKS?

WHEN THE COVID-19 PANDEMIC is behind us, we will have discovered a great deal about how to combat disease. And we will need that knowledge, because we live in a world where the threat of infectious disease is rising. New mutations of pathogens and zoonotic diseases that can pass at any time from animal to human pose a constant threat that is difficult to predict. Increasing resistance to antimicrobial drugs means medicines are becoming less effective. As Covid-19 has shown, our interconnected globalized world provides an ideal network for the devastating spread of a life-threatening pathogen. How can we bolster our ability to contain the next potential pandemic?

CONTACT TRACING FOR THE 21ST CENTURY

We have learned from SARS, MERS and now Covid-19 that, in the absence of a vaccine, we are reliant on classic epidemiological controls, which include rapid diagnosis, contact tracing, quarantine, physical distancing and hygiene measures. How efficient these interventions are will in turn dictate how extreme and, therefore, how economically damaging an imposed societal quarantine has to be in order to save lives.

Contact tracing has historically been a slow process of detective work carried out by public health officials involving interviewing a patient, identifying people who may have been in contact with them and alerting them as quickly as possible. The problem with a manual response is that viruses travel too fast to keep up.

With Covid-19, the race is on to leverage the power of big data to speed up this process. Around the world, developers are working on tracing and tracking apps, and testing their efficacy. South Korea's ability to cut cases of Covid-19 from 909 on February 29 to 76 on March 24 showed how effective this approach can be. The Chinese app gives citizens a red, amber or green travel code depending on risk of contagion. In South Korea, apps publish the movements of people with Covid-19 so that you can track them and stay away.

THE PRIVACY PROBLEM

Two challenges have been raised around contact tracing apps: data privacy and take up. According to Stefaan Verhulst, co-founder and chief research and development officer for the Governance Laboratory at New York University, this is a symptom of a lack of preparedness. He argues we need to use big data better to ↘

To contain future disease outbreaks, we have to improve and speed up our methods of identifying the infected and those they have been in contact with.

PHOTO CREDIT FOR MINOR CREDITS RUN HERE

Big data, robotics and AI all have great potential to help us contain future disease outbreaks, provided these solutions are fully developed ahead of time.

PHOTO: KEVIN FRAYER/GETTY IMAGES

reduce uncertainty during a pandemic. This is particularly pertinent when we are forced, as with Covid-19, to take an iterative approach to policy, seeing daily which strategies work and which do not.

"One of the tragedies of Covid-19 is that despite having heralded the arrival of big data for the last 15 years, and the fact we are in a so called data age, we have not managed to connect the vast amount of data collected and archived with the demand side to become smarter about the pandemic and our options moving forward," says Verhulst.

He argues that to properly utilize the benefits of data collection and analysis in the future, we must create a framework to use data in an ethical manner. This would involve a governance framework, establishing what data is actually needed, funding for a data infrastructure and a conversation with citizens about the reuse of their data.

ROBOTS OFFER A HELPING HAND

While privacy issues are putting in question the efficacy of contact tracing apps, some other means of containment do not raise such difficulties. China, for example, has explored the use of robots to help contain the spread of Covid-19 and keep human workers away from risk.

Robot technology is now advanced enough to be deployed in many settings, from monitoring compliance with quarantine rules to delivering medication and food, measuring vital clinical signs and handling contaminated waste. It can be particularly useful in clinical settings for diagnosis, screening and patient care. Diseases are easily spread through hospital surfaces. Rather than expose workers to this risk, robots can carry out disinfection. Mobile robots are also being considered for temperature measurement in public areas and for automated disease testing, freeing up frontline medical staff for other duties.

All these advantages had already been recognized during the 2014 Ebola outbreak, but funding for development has remained limited. Professor Guang-Zhong Yang, Dean of the Institute of Medical Robotics at Shanghai Jiao Tong University, and his fellow researchers have called for a more sustainable approach to research so that, in a future outbreak, we have cost-effective robots that can be rapidly deployed in a range of scenarios.

Covid-19 could be a catalyst for developing robotic systems that can be deployed to combat infectious diseases in environments unsuitable for human workers.

ACTIONABLE INSIGHTS FROM BIG DATA

It is not just frontline services that need to be better prepared for disease outbreak; governments and businesses must be prepared, too, in order to mitigate the risks and minimize the wider societal impact of an epidemic.

Nita Madhav is Chief Executive Officer of California-based Metabiota and a leading epidemiologist. Her company curates data from over 400 sources on past and present outbreaks in order to help governments and businesses identify, quantify and mitigate the specific risks they face. "We have developed a historical database that contains over 2,500 epidemics that we've painstakingly structured the data for, while also doing full-scale probabilistic modeling using hundreds of thousands of simulations to show on a global scale how diseases can spread from country to country and person to person to help better understand what resources are needed to respond to these events," she says. "We also track the level of public fear caused by different pandemics, as this is tightly linked to economic loss."

> "Preparedness is about understanding a range of potential events."

NITA MADHAV

Chief Executive Officer, Metabiota, California, USA

As growing computer power enables faster computation, and each outbreak brings new understanding, so the modeling improves, and it is possible to create faster and more accurate predictions. But a big challenge is that the warnings can get lost in a surfeit of modeling simulations. "Each group has their own set of modelers they turn to," says Madhav. "There needs to be some mechanism where multiple models can be compared with assumptions documented, because some models are coming out with wildly different results."

There may still be gaps, and none of these solutions will replace traditional epidemiology. Nevertheless, advances in big data, robotics and AI can bolster our defenses against the next outbreak, enabling us to contain diseases better before they spread and ensure that our key institutions and businesses do not buckle under the pressure. ■

PHOTOS: AFP/GETTY IMAGES; MIGUEL MEDINA/GETTY IMAGES; PRIVAT

Remote-controlled disinfection robots at work during the Covid-19 outbreak in Wuhan, China.

A robot at the Circolo di Varese hospital in Italy helps treat patients with Covid-19.

CALL TO IMPACT

1 Technology predicted the crisis, and we ignored it. We need to use big data better to reduce uncertainty during a pandemic.

2 Robots can meet many patient needs, offering a solution to shortages in healthcare personnel. However, robot technology requires significant investment.

3 Public health officials must rationalize big data modeling, so we do not ignore the warning for the next major public health crisis.

AFRICA'S UNITED FRONT GALVANIZED BY EXPERIENCE OF PAST DISEASES, AFRICA'S LEADERS ACTED SWIFTLY TO CONTAIN THE SPREAD OF COVID-19. THERE ARE LESSONS FOR THE REST OF THE WORLD.

PHOTO: SEYLLOU/AFP VIA GETTY IMAGES

AS COVID-19 SPREAD from China to Asia and into Europe, it provided Africa with the one thing they needed most – time. The first case to be reported on the continent was in Egypt on February 14, and it sparked an instant political response. Just one week later all Africa's health ministers had gathered to coordinate their actions, leading to the launch of the Africa Joint Continental Strategy for Covid-19.

Toughened by the experience of dealing with diseases such as Ebola, Lassa fever, TB and HIV AIDS, the ministers needed no convincing of the need to act. Countries with zero cases began enhanced surveillance, border checks and lockdowns. The Africa Centres for Disease Control and Prevention (ACDC), established in 2017 in the wake of the Ebola outbreak, launched the pan-Africa response, anchored around the four Cs: cooperation, coordination, collaboration and communication. Community workers were quickly marshalled to go into rural communities and unplanned urban settlements to look for possible cases and isolate them.

"We get local people who have been well-trained and know their area and can get to those who are really vulnerable," says Dr. Ahmed Ogwell Ouma, deputy director of the ACDC. "We are trying to protect not just the old and the ones with comorbidity but also children, particularly under five, who in Africa are vulnerable due to weakened immune systems."

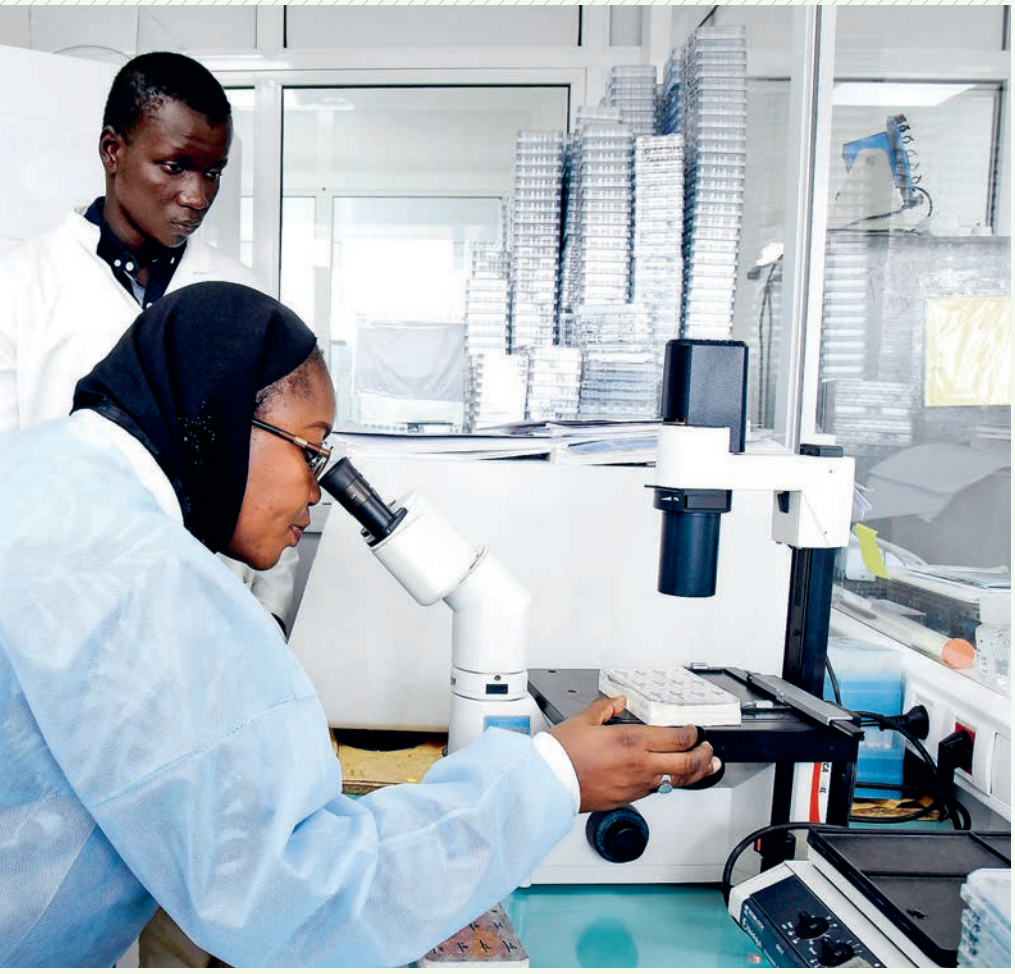
ACT HARD AND FAST

Africa has several points in its favor that have bought the continent time. Most travel is relatively local, especially south of the Sahara. Disease spread through international travel nodes has largely been avoided. Around 60 percent of the continent's population lives in relatively isolated rural communities, and the median age across Africa is just 20. Like elsewhere, it is anticipated the young will be more resilient. Finally, unlike Europe, disease containment is nothing new in Africa, which means citizens understand the need to shut down hard and fast.

By the first week of May, ACDC figures showed 50,000 cases and 1,800 deaths across the continent. Dr. Ouma acknowledges that Africa's response suffers worrying vulnerabilities. "We are very candid about them, especially to ourselves because if we do not address them, we are in trouble," he says. Africa's healthcare systems are not equipped to deal with the acute symptoms of Covid-19. With no local capacity, sourcing ventilators and testing equipment on the world market has been a challenge. The ACDC is setting and monitoring quality standards for domestically produced PPE equipment while also negotiating with overseas sources. Another challenge has been building clinical expertise when medical experts are restricted to online training rather than face-to-face tuition.

Laboratory testing is one area where Africa has witnessed remarkable success. "When Covid-19 was first reported in

The Pasteur Institute in Dakar in Senegal has been designated by the African Union as one of two reference centers on the continent for the detection of Covid-19.



China there were no laboratories able to test for it in Africa. Just three months later, 52 countries were able to carry out tests across many, many laboratories in each and every country. From zero to 52 in three months is impressive," says Dr. Ouma.

Responses across Africa have not always been consistent. South Africa saw early success with containment. With its densely populated townships and cities, it drew on its past experience with tuberculosis and HIV to combat the virus. It used its army of 28,000 community workers to implement mass screening by calling on citizens to present themselves for testing and then tracing their contacts. It also implemented one of the toughest lockdowns globally before it had registered a single case. Kenya closed its bars and clubs when it had only 50 cases, while Uganda was similarly quick off the mark. Tanzania, on the other hand, has had less success and questions are being asked about the efficacy of its early response. Unlike most other African states, it failed to implement early controls.

COMMUNICATION IS ESSENTIAL

Africa has learned from Ebola that risk communication is critical to the pandemic response. In Ghana, for example, health ministers feared that anyone suffering Covid-19 symptoms would be reluctant to present to health workers for quarantine, as isolation centers were associated with death during the Ebola outbreak. "We needed to communicate right from the beginning the reasons we are doing quarantine and isolation, so people were not afraid," says Professor Kojo Ansah Koram, epidemiologist and former director of the Noguchi Memorial Research Institute in Ghana. "We got those isolated very early on to come to a ministry press conference to explain the reasons why they went in, telling people 'I had symptoms and they took care of me and I am back and recovered'."

While Covid-19 always posed an extreme threat to African states with weakened primary care systems, their experience with past diseases and their approach to pan-national cooperation meant they launched a remarkably effective early containment of the virus.

"We have learned to never waste an outbreak," says Dr. Ouma. "We picked up big lessons from Ebola and now Covid-19 and we are going to package them together, so we are even better prepared for the next outbreak." ■

CALL TO IMPACT

1 When it comes to the availability of medical and protective equipment in a pandemic, often each country has to fend for itself. Local production is key to protecting citizens when global procurement networks become unreliable.

2 The public's fear has to be harnessed in the correct way. Citizens should be scared enough to take precautions, but not feel any hesitation about coming forward if they exhibit symptoms.

3 Lessons from previous outbreaks, speed and pan-national cooperation to achieve effective early containment of the virus are key to winning the fight against the Covid-19 pandemic.

VACCINATIONS SAVE LIVES – EVERYWHERE

DR. JEROME KIM, DIRECTOR GENERAL OF THE INTERNATIONAL VACCINE INSTITUTE (IVI), HAS BOTH A SCIENTIFIC AND POLITICAL ROLE. HE TALKS WITH US ABOUT HIS WORK WITH MANUFACTURERS TO CREATE VACCINES FOR THE DEVELOPING WORLD, WHILE WORKING WITH GOVERNMENTS TO GENERATE DEMAND AND THE CAPACITY TO DELIVER VACCINE PROGRAMS.

Impact: What is the role of the IVI?
Dr. Kim: IVI's mission is to discover, develop and deliver safe, effective and affordable public health vaccines. It is one of the few organizations that has devoted itself to providing cost-effective vaccines for diseases that many of the larger pharmaceutical companies are not concerned with.

What are the challenges?
→ The vaccines needed in the developing world are often for diseases that no longer trouble the developed world. We work with organizations like Gavi, the Vaccine Alliance, that make it worthwhile for companies to develop vaccines for what we call neglected tropical diseases. They can then supply vaccines at low or no cost to the countries that need them. We help to ensure the countries are able to implement a vaccination program, and work with them to increase the uptake.

How do you achieve this?
→ Our objective is to reduce the burden of infectious diseases through vaccination. Of course, the most important person in that process is the one who is vaccinated and protected. But behind it all is a very complex system. First, you have to convince a manufacturer it is worth their while to produce the vaccine. That means you need to generate demand. To do that you have to convince a country's ministry of finance to buy the vaccine. They only do that on the recommendation of their ministry of health, which in turn may only recommend purchasing a vaccine if WHO technical experts say it will reduce the disease burden. Finally, in the case of developing countries, the country can only buy it if Gavi can provide it at the right price.

> "The market for Covid-19 could be 7 billion people, so we hope there will be more than one vaccine."

What is the biggest obstacle?
→ Probably funding. When you look at Group A Strep, which kills 500,000 women of child-bearing age a year through rheumatic heart disease, it is hard. Until last year, there was only a million dollars a year in research funding for vaccines for it, because it is not a big problem in the United States and Europe.

And vaccines for diseases common to both developed and developing countries?
→ Rotavirus vaccine is a good example. It is a premium vaccine that was licensed in the United States in 2007. By 2009, the US hit 70 percent vaccination and the number of cases dropped to almost undetectable. The WHO decided the world should use it, and its expert group, SAGE, recommended it. So far, 90-plus countries have put it into their national vaccination programs. But by 2015 only 20 percent of children worldwide had received all three doses. The problem is the amount of vaccines the big companies commit to Gavi. Sometimes they renege on their commitments, as Merck did in 2018. In addition, in developing countries there are often not enough people to administer and run vaccine campaigns.

How confident are you that a Covid-19 vaccine would get global distribution?
→ It is an issue. The US is developing a vaccine at warp speed and will make a lot of it. But who is going to distribute it to Tanzania, Mozambique or Ghana? CEPI, the Coalition of Epidemic Preparedness

> **“Every $1 you invest in vaccination saves a total of $44 in cost to society.”**

DR. JEROME KIM

Director General
International
Vaccine Institute

Innovations, is willing to fund vaccine development at a cost accessible to developing countries, but someone will still have to manufacture and distribute it. The market for Covid-19 could be 7 billion people, so we hope there will be more than one vaccine.

What are the issues around vaccine delivery in developing countries?

→ It is far safer to give a cholera vaccine by opening a bottle and telling someone to swig it or giving them a patch to put on their arm, rather than getting a nurse to inject it. But big manufacturers are not incentivized to spend the millions required to transition their injectable vaccines into these methods of delivery, since the countries that need them receive them at low or no cost.

CALL TO IMPACT

1 Large pharmaceutical companies must be incentivized to focus their resources on developing vaccines for infectious diseases.

2 Manufacturing a vaccine is only part of the solution; the infrastructure and capacity to run a vaccine campaign must be built up.

3 Fostering cross-country collaboration in the development of vaccines to make vaccines more affordable in the developing world.

How can you build global manufacturing capacity?

→ The majority of vaccines – by number, not value – used by Gavi are produced in India, Korea, China and Indonesia. So, capability is distributed around the world, but needs to be rationalized. It is probably not tenable for every African country to have their own vaccine manufacturing capability, but you might develop it in South Africa, Kenya or maybe Senegal. It would depend on the market, technical capability, and their commitment to buying, say, 90 percent of what is produced. In the end it is a business. To make manufacturing sustainable and produce at scale to a lower price, you need a population of about a hundred million.

What are the advantages of vaccination beyond disease immunity?

→ There is a far broader societal impact. If you vaccinate children with pneumococcal conjugate vaccine, their grandparents do not die of invasive pneumococcal disease. If you are a family with a daily income of $2 and a child is sick, mom has to stay home and they drop below the poverty level, often for months after the child recovers. This means the children work and do not go to school. Infections also contribute to delays in cognitive and physical development. Unvaccinated children have lower performance in school. Vaccination also lowers birth rates because mothers no longer fear their children dying. With vaccinations you have a more productive society. For all these reasons, every $1 you invest in vaccination saves a total of $44 in cost to society. ■

ILLUSTRATION: SÖREN KUNZ

PREVENTION TRUMPS CURE

NEW TECHNOLOGIES AND LESSONS LEARNED COULD HELP US CONTAIN THE SPREAD OF INFECTIOUS DISEASE MORE EFFECTIVELY. BUT WHAT IF WE COULD PREVENT OUTBREAKS? ALTOGETHER?

Rapid urbanization, overcrowding and climate change are drivers of disease that must be addressed to prevent future outbreaks.

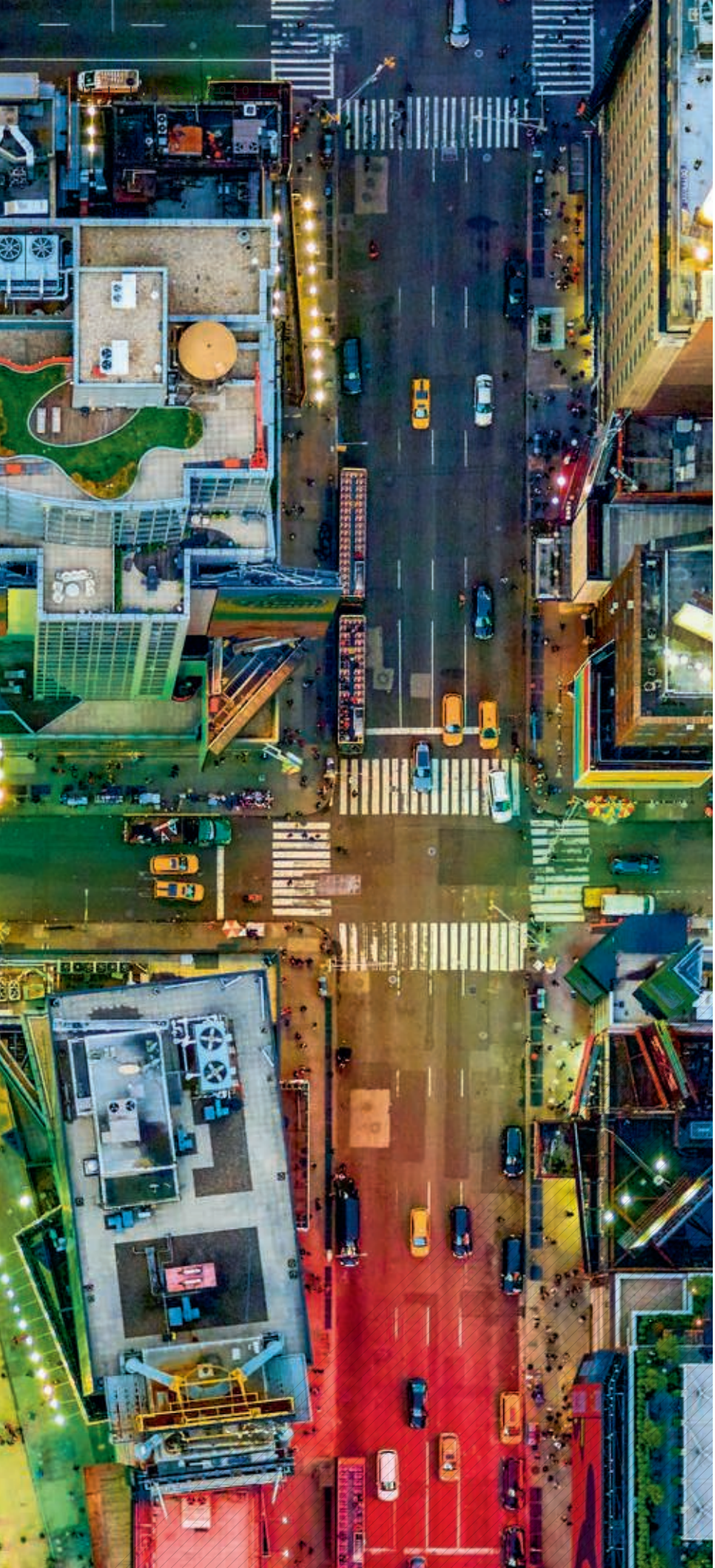


PHOTO: JEFFREY MILSTEIN

PUBLIC HEALTH EXPERTS had been warning for years that a new pandemic was long overdue, but when Covid-19 finally arrived it still found most governments unprepared. This global outbreak, if nothing else, will have focused minds on how best to prevent the next one.

One of the basic elements is deciding which diseases to focus on. The World Health Organization (WHO) maintains a list of priority diseases for research and development. There is a vast number of potential pathogens but only limited resources, so the list includes only those thought to pose the greatest potential public health threat, whether through their epidemic potential or the fact that there are still few countermeasures in place. Beside Covid-19, it currently includes SARS, MERS, Ebola, Lassa fever and Rift Valley fever.

With this list as its base, the WHO's R&D Blueprint is a global strategy and preparedness plan that provides a research roadmap and target product profiles for each disease. "The roadmaps identify key interventions, as well as important R&D gaps," says WHO spokesperson Christian Lindmeier. WHO regularly brings together experts ↘

↘ from a wide range of disciplines to revise which diseases need investment and more R&D. The experts include microbiologists, clinical experts, epidemiologists, public health policy experts, veterinarians, anthropologists, bioethicists, and biological weapons experts, among others.

THE UNKNOWN THREAT

At the end of WHO's priority disease list sits Disease X. This represents the knowledge that a serious international epidemic could result from a pathogen currently unknown to cause human disease. It could be a new pathogen such as the coronavirus that causes Covid-19, a known pathogen that does not usually cause human disease epidemics, or one that is suddenly subject to a change in epidemiology or pathogenicity, like Zika.

"Although we have experienced a series of these threats, we cannot predict when or how Disease X will strike," says Lindmeier. "We need to be ready with basic capabilities for multidisciplinary research and product deployment in the affected countries so that they reach the populations who need them. Access considerations must always be at the heart of all R&D efforts."

Among the most effective tools to prevent an epidemic are vaccines. They bolster the body's immune system and help it fight disease. The problem is that each vaccine only works against a specific pathogen, and development take years. This means that in the case of a previously unknown or a rapidly mutating virus like Disease X, producing a vaccine ahead of an outbreak or in its early stages has, up to now, been impossible.

Platform technologies could be the solution and are being deployed in the search for vaccine for Covid-19. The Coalition for Epidemic Preparedness Innovation (CEPI) is leading these efforts. It was founded in 2017 to advance vaccines against both known threats and previously unknown pathogens. A platform technology uses the same basic components as a backbone and can be adapted for use against different pathogens. The new pathogen's genetic

We must reassess our relationship with the animal world if we are to reduce the risk of exposure to new pathogens.

PHOTOS: QILAI SHEN/PANOS PICTURES, PRIVAT

> **“Access considerations must always be at the heart of all R&D efforts.”**

CHRISTIAN LINDMEIER
WHO spokesperson

or protein sequence is simply “slotted in,” like a video game cartridge, to produce the vaccine.

AI AGAINST RESISTANCE

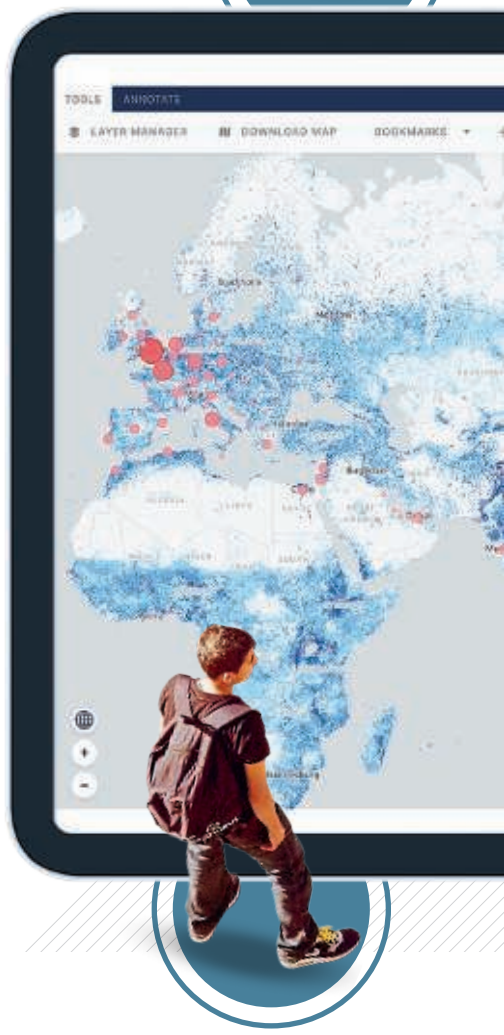
Disease X also refers to pathogens that acquire resistance to treatment. Overuse of antibiotics and intensive farming methods have contributed to the growth in resistance, and it is now a significant global threat. A growing number of infections, from TB to pneumonia, are becoming harder to treat. Given the pace at which microbes are able to evolve, the number of infections resistant to almost any available antibiotic is going to grow. The UN’s Interagency Coordination Group on Antimicrobial Resistance has warned that the number of annual deaths as a result of drug-resistant infections could reach 10 million by 2050.

One tool that shows considerable promise for preventing drug-resistant outbreaks is AI. Databases containing the genomes from different strains of pathogen are growing, along with information about whether they were susceptible to antibiotics. Using this data, AI can allow scientists to identify the DNA sequences that indicate resistance. This can speed up treatment of diseases like TB. Normally it takes a series of time-consuming tests to determine whether a patient has multidrug-resistant TB, but if the genetic code of the bacterium is known, the patient could be prescribed the right drugs more quickly.

Machine learning can also speed up the discovery of new antibiotic compounds. Using a machine learning algorithm, researchers at the Massachusetts Institute of Technology have identified a new antibiotic compound that kills disease-causing bacteria that are resistant to known antibiotics. The computer model screens more than 100 million chemical compounds in days and selects potential antibiotics that can kill bacteria using mechanisms different to those of existing drugs.

PREDICTIVE POWER

AI can also help alert the world to the threat of a disease outbreak. We ↘



↘ were first made aware of Covid-19 in December 2019 by BlueDot, a company in Toronto. It used an algorithm to trawl notifications, disease networks, global news stories and even airline ticketing information to accurately predict how the outbreak would spread.

BlueDot founder and CEO, Kamran Khan, is an infectious disease and public health physician. His career as a doctor began during the SARS epidemic of 2003, during which he saw colleagues become infected and die. "What we experienced in Toronto was a microcosm of what we're now witnessing around the world," he says. "That virus crippled our city; this virus has crippled the planet."

BlueDot's team of data engineers, physicians and health experts has built algorithms that can read text in 65 languages, 24 hours a day, looking for more than 150 diseases and syndromes, and organize and structure this vast amount of text data. "It is about having a machine play to its strengths, and humans play to theirs," says Khan. "AI relies on large amounts of historical data to train a machine to understand patterns. But with many of the things we're dealing with there are no historical patterns. We do not have 10,000 of these outbreaks that we can train a machine on – we have a handful." This means we still rely on human knowledge of history and context. "Human intelligence is augmented by artificial intelligence. The two are complementary; one does not replace the other."

THE HUMAN-ANIMAL INTERFACE

Like other experts, Kahn believes that, to get ahead of the game, we have to look more carefully at what triggers this type of outbreak. "Some of the biggest drivers are the mass consumption of wildlife, industrialization of agriculture and the disruption of wildlife ecosystems," he says. "While the life and health of every person is more connected than ever to those of everyone else, it is also more connected to the health of every living system on the planet."

Covid-19 has inevitably put the focus on zoonoses – diseases that originate in animal populations. These account for some 70 percent of all new emerging diseases. One idea is to track pathogens that have the potential to leap over into humans. The Global Virome Project was founded to do just that. It aims to identify the estimated 500,000 as yet undiscovered animal viruses capable of transmission to people, and build a global atlas of zoonotic viruses.

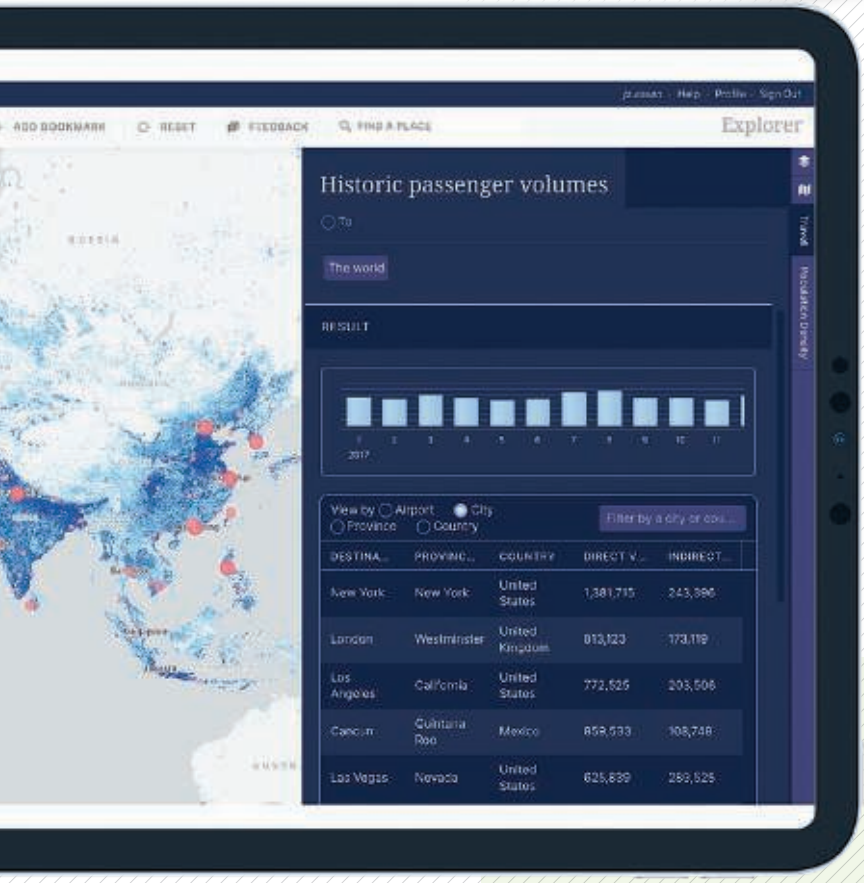
These diseases are opportunistic, thriving where there is change to the environment, to animal or human hosts, or in the pathogen itself. "The mechanisms are complex and vary among diseases," says Doreen Robinson, Chief of Wildlife at the UN Environment Programme. "This means we need to

"Human intelligence is augmented by artificial intelligence. The two are complementary; one does not replace the other."

KAMRAN KHAN
CEO, BlueDot

PHOTOS: GETTY IMAGES (2), PR, PRIVAT (2)

Infectious diseases can spread fast in a globalized world. BlueDot's risk software uses flight and mobile phone data to predict their dispersion and impact.



> "When we protect our planetary health, we are protecting ourselves."

DOREEN ROBINSON

Chief of Wildlife
UN Environment Programme

understand the ecological dimensions much better."

ONE HEALTH

As humans encroach on forests and other natural habitats, they increase their risk of exposure to potential pathogens. Understanding the relationship between environmental degradation and the spread of disease is likely to be key to preventing future outbreaks. It will mean taking action on hugely challenging areas like animal welfare, intensive farming, rapid urbanization, overcrowding, sanitation and climate change.

Robinson argues that now is the time to improve our monitoring and risk assessment for zoonotic diseases, while also improving sanitary measures for wild and domestic animals consumed as food. As our economies return and lockdowns ease, she sees an opportunity to launch a robust and accountable post-2020 global biodiversity framework to be adopted by all countries, with enough resources to take the necessary action.

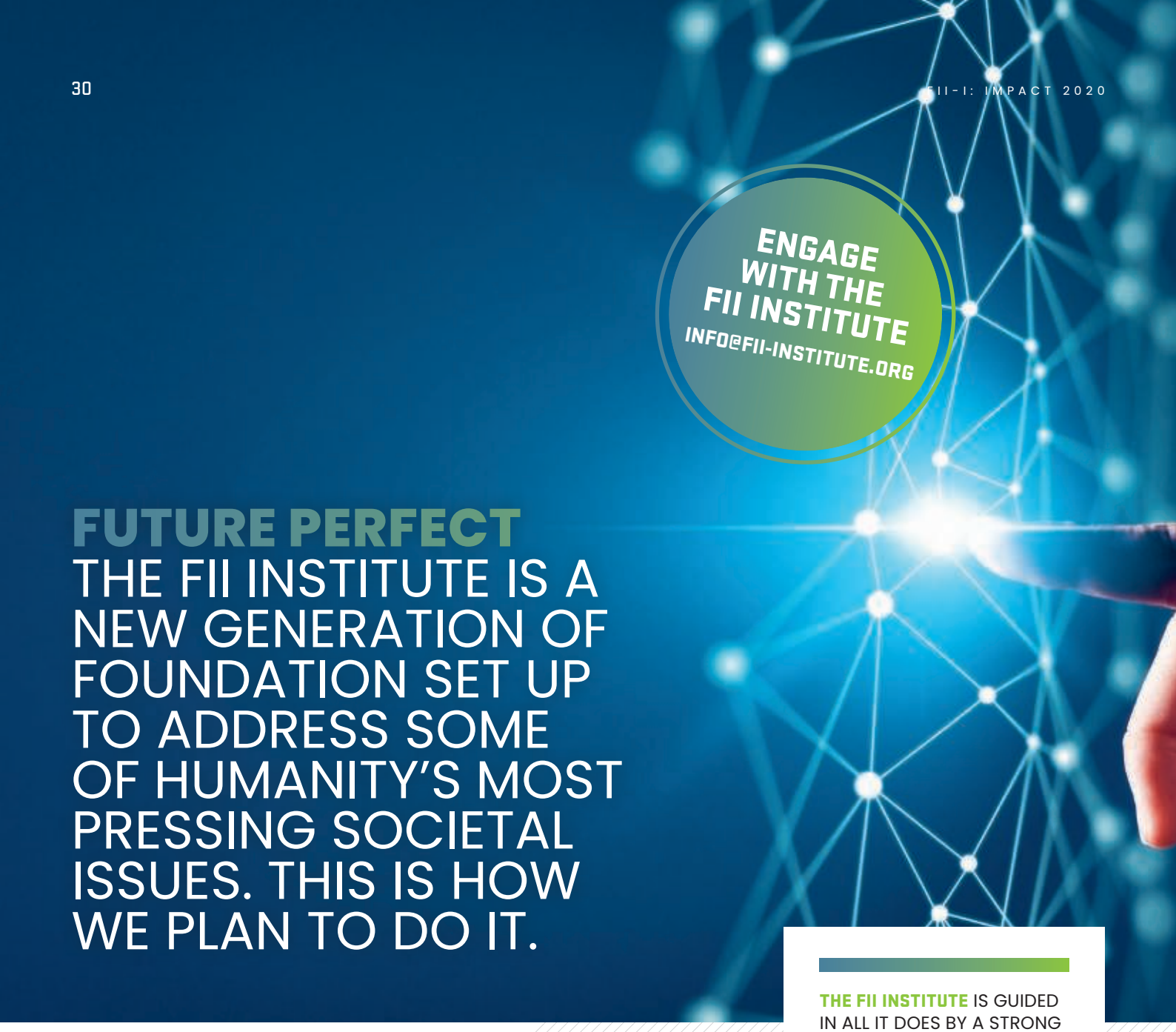
But that remains only part of the picture. "Equally, we cannot lose momentum on setting new targets to reduce greenhouse gas emissions. We need to work more closely across human, animal and environmental health to find systemic, holistic solutions and mitigate future risks," says Robinson. "When we protect our planetary health, we are protecting ourselves." ■

CALL TO IMPACT

1 We must invest in AI and machine learning to further accelerate the development of vaccines and speed up the discovery of new antibiotic compounds.

2 In our interconnected world, it is vital that we leverage the power of big data to better predict where infectious diseases could emerge so that we can take swift action to prevent them spreading.

3 New pathogens are emerging, known viruses are mutating. The next outbreak could be far deadlier than Covid-19. We need to prepare today!



FUTURE PERFECT

THE FII INSTITUTE IS A NEW GENERATION OF FOUNDATION SET UP TO ADDRESS SOME OF HUMANITY'S MOST PRESSING SOCIETAL ISSUES. THIS IS HOW WE PLAN TO DO IT.

COVID-19 perfectly illustrates the need for global cooperation in the face of adversity. It also gives us a blueprint for moving forward. As we address issues such as climate change, biodiversity loss and population growth, we need to look to our brightest minds for solutions. We also need to create partnerships throughout the world – in government, business, academia and civil society – to act on those innovations and ideas. And to facilitate this we need the right platform. The FII Institute aims to bring together people from different disciplines and regions, and act as a curator to work on these goals.

Our mission statement is "curating and enabling ideas to impact humanity sustainably." We plan to achieve this through three delivery pillars: Think, Act and Xchange. Think will identify societal challenges and then curate the brightest ideas to solve them. Act will then bring partners together, form strong consortia and catalyze innovations and initiatives. Finally, Xchange will provide a forum for live discussions and the sharing of knowledge, stories and publications among global stakeholders.

The impact areas we have chosen to focus on initially are healthcare, sustainability, artificial intelligence

THE FII INSTITUTE IS GUIDED IN ALL IT DOES BY A STRONG PURPOSE, VISION AND MISSION.

PURPOSE

"Enabling a brighter future for humanity"

VISION

"Empowering the world's brightest minds to shape a brighter future for ALL, and with ALL"

MISSION

"Curating and enabling ideas to impact humanity sustainably"

PHOTO: ADOBESTOCK

FII-I has three pillars to deliver its mission: THINK, ACT and XCHANGE

1 FII-I THINK
Identify societal challenges and current inhibitors
Curate the brightest ideas to address societal issues

2 FII-I ACT
Catalyze innovation and initiatives by mobilizing partners and resources

3 FII-I X CHANGE
Create platforms for live discussions on the future of humanity
Share knowledge, stories and publications with different stakeholders

and robotics. Each has the potential to positively impact humanity. In the coming months, we will marshal our resources to facilitate global networks and spark collaborations around these impact areas that will shape the future.

We hope you enjoyed this first issue of Impact. Our next report on healthcare will look more broadly at healthcare systems around the globe, examining strengths and challenges, exploring promising technologies that can help deliver equitable healthcare for all.

Please join us and together we can work toward a brighter future for humanity. ■

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Overview of key sources used for this report

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VACCINATIONS SAVE LIVES – EVERYWHERE

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PREVENTION TRUMPS CURE

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who.int/teams/blueprint/about

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unenvironment.org

BlueDot
bluedot.global

Coalition for Epidemic Preparedness Innovation
cepi.net

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