Abstracted Chapter:
Going viral
The Transformation of Biological Risks

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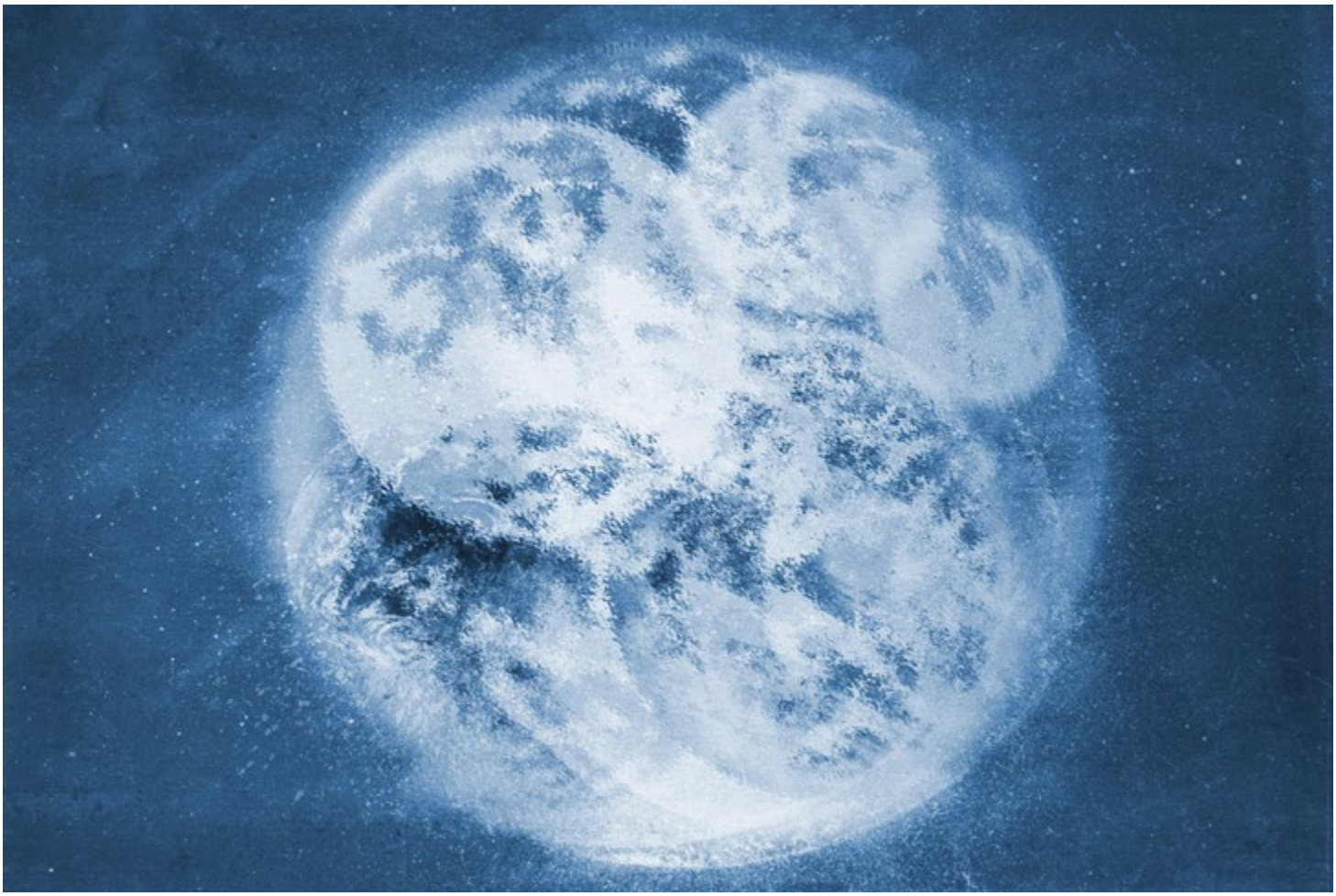
Insight Report

The Global Risks Report 2019
14th Edition

In partnership with Marsh & McLennan Companies and Zurich Insurance Group



The Global Risks Report 2019
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Going Viral

The Transformation of Biological Risks

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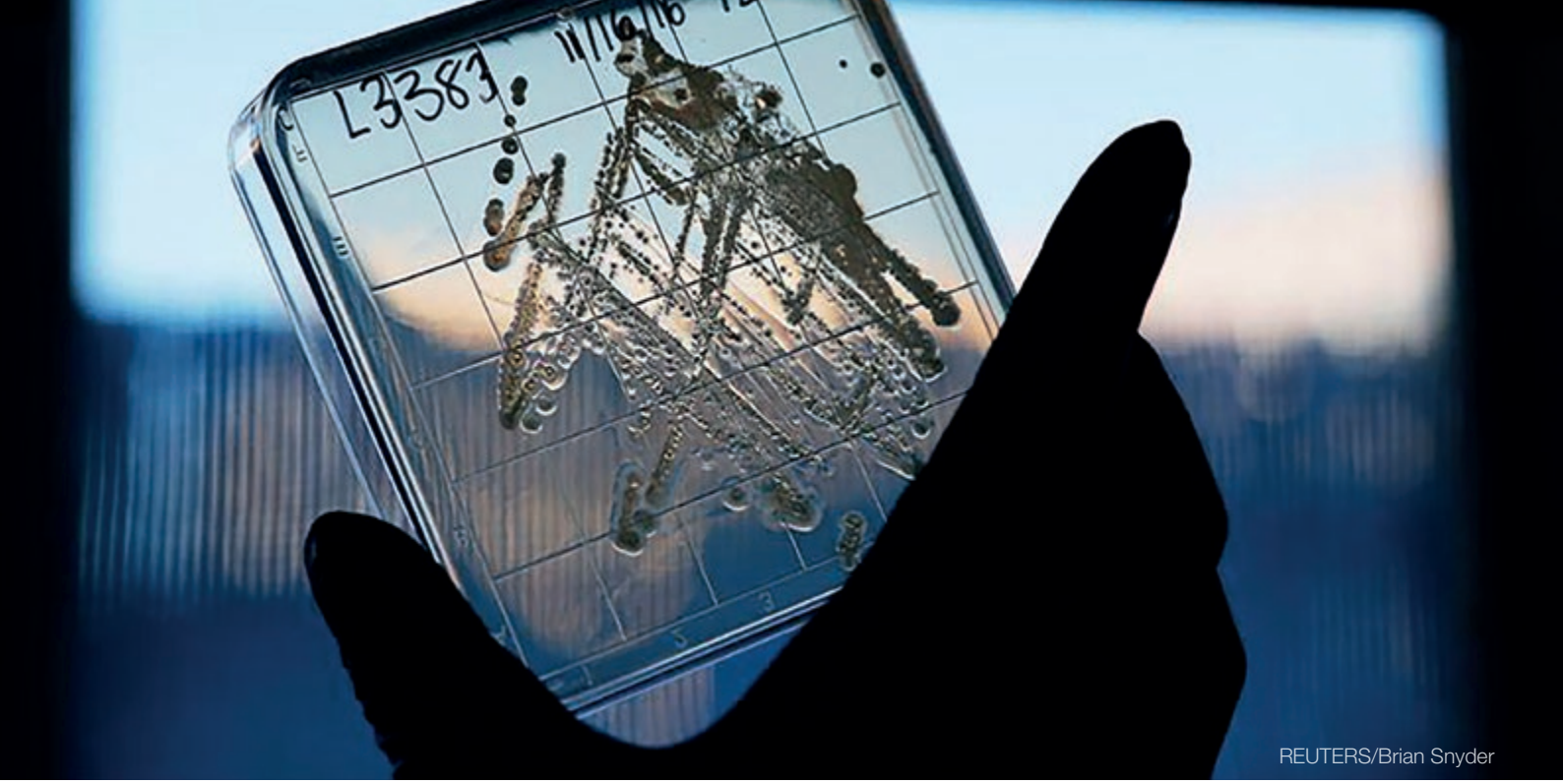
The previous chapter looked at the emotional and psychological impact of the multiple transformations the world is undergoing. This chapter considers another set of threats being shaped by global transformations: biological pathogens. Changes in how we live have increased the risk of a devastating outbreak occurring naturally, while emerging technologies make it increasingly easy for new biological threats to be manufactured and released—either deliberately or by accident.



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The world is badly under-prepared for even modest biological threats. We are vulnerable to potentially huge impacts on individual lives, societal well-being, economic activity and national security. Revolutionary new biotechnologies promise miraculous advances, but they also create daunting challenges of oversight and control. Progress has made us complacent about conventional threats, but nature remains capable of "innovating" a pandemic that would cause untold damage.

The sections that follow examine the way biological risks are evolving both in nature and in laboratories. We are at a critical juncture. If there is one area in which a turn inward by societies could be needlessly destructive, it is global health security. Yet, as new risks emerge, there are early signs that important governance systems and protocols are eroding.

Outbreaks are increasing

In the past, naturally emerging infectious diseases have caused extraordinary health, economic and security impacts—often assisted by propitious conditions created by changing patterns of human behavior. Many years of global headlines have made various threats familiar: Ebola, MERS, SARS, Zika, yellow fever and each year's strains of influenza.

The frequency of disease outbreaks has been rising steadily. Between 1980 and 2013 there were 12,012 recorded outbreaks, comprising 44 million individual cases and affecting every country in the world.[1] Each month the World Health Organization (WHO) tracks 7,000 new signals of potential outbreaks, generating 300 follow-ups, 30 investigations, and 10 full risk assessments. In June 2018 there were—for the first time ever—outbreaks of six of the eight categories of disease in the WHO's "priority diseases" list. If any had spread widely, it would have had the potential to kill thousands and create major global disruption.[2]

Five main trends have been driving this increase in the frequency of outbreaks. First, surging levels of travel, trade and connectivity mean an outbreak can move from a remote village to cities around the world in less than 36 hours. Second, high-density living, often in unhygienic conditions, makes it easier for infectious disease to spread in cities—and 55% of the world's population today lives in urban areas, a proportion expected to reach 68% by 2050.[3]

Third, increasing deforestation is problematic: tree-cover loss has been rising steadily over the past two decades, and is linked to 31% of outbreaks such as Ebola, Zika and Nipah virus.[4] Fourth, the WHO has pointed to the potential of

climate change to alter and accelerate the transmission patterns of infectious diseases such as Zika, malaria and dengue fever.[5]

Finally, human displacement is a critical factor in this regard. Whether due to poverty, conflict, persecution or emergencies, the movement of large groups to new locations—often under poor conditions—increases displaced populations' vulnerability to biological threats. Among refugees, measles, malaria, diarrheal diseases and acute respiratory infections together account for between 60 and 80% of deaths for which a cause is reported.[6]

Fewer deaths, higher costs

Globalization has made the world more vulnerable to societal and economic impacts from infectious-disease outbreaks, even though impacts of those outbreaks on human health are declining because medical breakthroughs and advances in public health systems have enabled us to contain the effects on morbidity and mortality.[7] The 2003 SARS outbreak—which infected about 8,000 people and killed 774—cost the global economy an estimated US$50 billion.[8] The 2015 MERS outbreak in South Korea infected only 200 people and killed 38, but led to estimated costs of US$8.5 billion.[9]

Revolutionary new biotechnologies promise miraculous advances, but also daunting challenges of oversight and control

One estimate of potential pandemics through the 21st century puts the annualized economic costs at US$60 billion.[10] Including the imputed value of life-years lost, another estimate puts the cost of pandemic influenza alone at US$570 billion per year—the same order of magnitude as climate change.[11]

Given that many outbreaks occur in comparatively poor countries, even economic costs that may appear low in absolute terms can have a severe impact on the countries concerned. The World Bank has estimated that the three countries most badly impacted by Ebola in 2014–15—Guinea, Liberia and Sierra Leone—suffered combined GDP losses of $2.2 billion.[12] However, including the cost of associated social burdens—direct impacts on health as well as indirect effects on food security and employment—that figure jumps to US$53 billion.[13]

The relatively low recent death toll of infectious outbreaks—for comparison, in 1918 Spanish Influenza killed more than 50 million people—can be seen as evidence of the success of counter-measures: vaccines, antivirals and antibiotics greatly reduce the risk of massive loss of life. But another way of looking at the outbreaks since 2000 is as a "roll call of near-miss catastrophes", which should be prompting increased vigilance but is instead lulling us into complacency.[14]

Preparedness gaps

The WHO has begun to caution against such complacency. In 2015 it introduced a "priority diseases" list, reviewed annually. The purpose of the list is not to forecast which pathogen is most likely to cause the next outbreak, but to highlight where increased research and development is most warranted. In 2018 the WHO included "Disease X" in its list to focus researchers' attention on pandemic risks posed by diseases that cannot currently be transmitted to humans, or transmitted only inefficiently.

The priority diseases exercise builds on work that saw the first

effective vaccine against Ebola developed in 12 months, rather than the normal development cycle of 5–10 years. The estimated costs of developing vaccines for other key diseases greatly exceeds the resources currently devoted to such work. One 2018 study assessed the minimum cost of developing a vaccine for each of 11 infectious diseases previously highlighted by the WHO at between US$2.8 and 3.7 billion.[15] By contrast, the Coalition for Epidemic Preparedness Innovations (CEPI), set up in 2017 to coordinate and finance vaccine development, has committed to invest just US$1 billion by 2021.[16]

The weakness of basic preparedness in individual countries is an important obstacle to pandemic responses. Progress has been made, particularly since the 2014–16 Ebola epidemic, but most countries have not yet reached minimum international standards of capacity to detect, assess, report and respond to acute public health threats as set out in binding regulations that took effect in 2007.[17] Thus when an outbreak hits, appropriate responses may be absent or delayed, and resources will be stretched to deal with other epidemic events that may emerge.

A pattern of panic and neglect tends to affect pandemic preparedness. During and after every major outbreak, leaders are quick to call for increased investment in preparedness. Real progress often follows these calls—but as the effects of the outbreak fade, neglect sets in again until a new outbreak erupts; this prompts a new burst of panic, in which time and energy may be wasted on unnecessary and potentially costly measures. For example, throughout the 2014–16 Ebola epidemic, the WHO advised that general travel restrictions were unnecessary but still registered 41 instances of restrictions being placed on international travel.[18]

Our ability to respond to biological risks is also being hampered by carelessness. Misuse and overuse of antibiotics continues to undermine the efficacy of one of the most important medical countermeasures ever discovered. Similarly, an erosion of vaccine norms is leading to a resurgence of older biological threats that were thought to have been defeated: for example, incidents of measles—which pose a serious threat for babies, toddlers and young people—are increasing across Europe because vaccination coverage rates are falling as a result of unfounded safety concerns.[19]

Synthetic biology is amplifying risks

Synthetic biology technologies have the potential to transform the risk landscape. The possible gains are profound—they include new ways of producing chemicals, pharmaceuticals, fuels and electronics—but so is the risk of things going badly wrong. The skills and equipment required to replicate and alter the building blocks of life are proliferating rapidly. Driven by scientific advances and market forces, the cost of DNA synthesis has decreased at a rate faster than Moore's Law: more and more people around the world have access to powerful biotechnologies that were once accessible only to well-established and well-funded scientists.[20] A state-of-the-art DNA synthesis facility can already be built in a space the size of a shipping container, and miniaturization is advancing rapidly—enzymatic DNA synthesis can now be accomplished with a desktop device.[21] Carrying out this kind of work does not create any external "signature" that would distinguish a facility synthesizing

Outbreaks since 2000 have been described as a "roll call of near-miss catastrophes"

DNA from one performing other biological work.

It is possible now for a small research team to conduct experiments with potentially profound global consequences. For example, in 2018 a group of researchers in Canada demonstrated that a budget of US$100,000 is enough to synthesize horsepox virus. Horsepox is benign to humans, but a close relative is *Variola major*, which causes smallpox—a disease that was eradicated in 1980, having killed 300 million people since 1900. Live samples of smallpox virus now exist in just two highly secure facilities, one in the United States and one in Russia.

By publishing the synthesis process for horsepox virus, the Canadian research team sharply lowered the barriers to smallpox synthesis and increased the risk of smallpox being released into the world, either accidentally or intentionally. The researchers argue that these risks of their work are outweighed by the potential benefits of creating a new vaccine.[22]

This is not an isolated dilemma. The H5N1 strain of influenza, for example, has a staggering case fatality rate of above 50%; by comparison, the fatality rate for Spanish Influenza in 1918 was under 2.5%, and for seasonal influenza it is less than 0.1%. Human cases of H5N1 are rare, in part because the virus is inefficient at transmitting from person to person. If that were to change, a pandemic risk greater than any previously encountered could result. In 2011, researchers studied H5N1 transmissibility with the aim of enabling more rapid responses to new variants. The research was controversial—biosecurity experts worried that it could lead to a highly transmissible virus being released into human populations, by accident or as a deliberately deployed bio-weapon.[23]

Deliberate attacks

Received wisdom is that biological agents are an unattractive weapon, in part because of the perceived risks involved in their production, and also because of the difficulty of targeting particular groups or populations. But this is not an area for complacency. A report commissioned last year by the US Department of Defense highlights the "almost limitless list of malicious activities that could potentially be pursued with biology" and draws parallels with the importance of advances in physics and chemistry during the Cold War.[24]

State-sponsored development of biological weapons has broadly ceased since the Biological Weapons Convention (BWC) entered into force in 1975. However, the BWC has weaknesses. First, it is plagued by financial woes, struggling even to sustain a modest meeting programme.[25] Second, the only mechanism for demonstrating compliance is a system of annual "confidence-building measures"—but no more than half the signatories submit such measures in any given year, and a third have never done so. Third, the BWC has limited application to cutting-edge research—a growing problem, given revolutionary biological advances.[26]

Even if restraint on the part of state actors could be guaranteed, biological weapons still have attractions for malicious non-state actors. The current state of microbial forensics would make it difficult to reliably attribute a biological attack, and the impact could be incalculable: the direct effects—fatalities and injuries—would be compounded by potentially grave societal and political disruption.

In contrast to other types of terrorist attack, which require resources that are difficult to scale and replenish, the technical knowledge required to launch a catastrophic biological attack can be deployed repeatedly once it is mastered. This potential to "reload" creates the potential for successive high-impact attacks. According to one expert, this means that the national security vulnerabilities revealed by the 9/11 terrorist attacks in the United States were smaller than those revealed by the series of "anthrax letters" that killed five people in the weeks that followed.[27] In June 2018, German police intercepted a potential

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biological attack when an arrest led to the discovery of 84 milligrams of the poison ricin.[28]

Responses that would work against a natural pandemic might not be as effective against a deliberate attack, given such an attack's military and political dimensions and the lack of reliable governing frameworks.[29] For example, states might be reticent about sending resources and personnel to assist other countries if they perceive a risk of being affected themselves by any subsequent attacks.

The potential impact of a deliberate attack was highlighted last year by a pandemic preparedness exercise in the United States. This involved a war-gaming scenario in which a terrorist group released a virus that had been modified to combine a high case fatality rate with ease of transmission.[30] The results? A failed vaccine, tens of millions of deaths, incapacitated governments, over-whelmed healthcare systems and stock markets down by 90%.[31] This may have been a hypothetical scenario, but it is not in the realm of science fiction.

Governance challenges

Current governance systems risk creating the conditions for bioterrorism. Scientists often take the lead, developing self-governance frameworks to define acceptable limits for synthetic biology research. For example, DNA synthesis companies have developed new systems to screen orders for synthesized DNA to look for potential indications of malicious intent. However, screening is voluntary; it does

not apply in many countries; and screening standards, technologies and incentives have not kept pace with the rapid evolution of DNA synthesis technologies and business models. More rigorous transparency and oversight requirements are needed, as well as stronger norms applying to work that might increase pandemic risks.

In another example of self-governance, in 2015 the National Academy of Sciences of the United States, the Institute of Medicine, the Chinese Academy of Sciences and the Royal Society of London convened scientists to consider the future of germline editing, which changes the DNA that is passed on from generation to generation. The group issued a recommendation against performing germline editing on human embryos.[32] However, this kind of recommendation is difficult to enforce and researchers in China subsequently used CRISPR to correct a mutation in nonviable human embryos.[33] Some top-tier journals refused to publish this research, in part on ethical grounds, but that has not prevented further work in this area. In November last year the dividing line between technology and humanity was further blurred when a researcher in China claimed to have created the first gene-modified babies, twin girls whose genomes had been altered to make them resistant to HIV.[34]

The challenges of regulating synthetic biology will intensify as mutually reinforcing advances are made across the various technologies that make up the Fourth Industrial Revolution. For example, machine learning can identify which influenza mutations would prove most deadly.[35] The rationale for this research was to enable more efficient outbreak responses, but machine learning could equally be deployed to help a hostile actor build a better biological weapon. Work is also being done at the intersection of artificial intelligence and gene editing, with consequences that are uncertain—not only practically but ethically too.[36] While continued innovation must be encouraged, too little attention has so far been paid to emerging risks of high-impact events.

The challenge of establishing norms that can be enforced globally is exacerbated by geo-economic competition across advanced technologies, as discussed in Chapter 2 (Power and Values). But the field of synthetic biology is still young enough for norms and practices to be put in place that will steer its development in the years and decades ahead. There is an analogy with the internet: with hindsight, a much stronger security focus could have been incorporated in its building blocks at an early stage. Cybersecurity experts see a similar opportunity in synthetic biology today.

Governance challenges also exist in relation to "conventional" pandemic preparedness, despite advances such as the establishment of a Global Preparedness Monitoring Board and a Pandemic Emergency Financing Facility.[37] The WHO's Contingency Fund for Emergencies, established in 2015 to enable rapid responses to disease outbreaks and health crises, is funded at only one-third of its annual US$100 million target. The international system for sharing biological samples, vital for disease surveillance and response, appears to have been weakened since the introduction of the Nagoya Protocol. This is an agreement on "access and benefit sharing" that has been interpreted to give states greater rights over virus samples collected on their territory.[38] It has revived concerns in some countries about samples being used to create vaccines generating benefits that are not fairly shared.[39]

Negotiations around access and benefits have already delayed responses to novel outbreaks and even started to complicate the exchange of seasonal influenza samples. It would be dangerous if differences between countries were not swiftly and equitably resolved: in few areas is apolitical commitment to open and collaborative exchange as crucial as in global health security.

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