

JOHN V. PARACHINI, JENNIFER BOUEY, DANIEL M. GERSTEIN, ALISON K. HOTTES, BRADLEY MARTIN, TRUPTI BRAHMBHATT, KATHERINE GRACE CARMAN, ANITA CHANDRA, K. JACK RILEY, BARBARA BICKSLER

Lessons Learned from the COVID-19 Outbreak

Preventing and Managing Future Pandemics



Contents

| | |
|---|-----------|
| Chapter One. Introduction | 3 |
| Chapter Two. “You Warned Me, but You Did Not Convince Me” | 9 |
| Chapter Three. Outbreaks and Governance: Lessons from Wuhan, China, During the COVID-19 Pandemic..... | 21 |
| Chapter Four. Reforming Global Pandemic Preparedness and Response Institutions | 29 |
| Chapter Five. Balancing Risks and Benefits from Gain-of-Function Research on Dangerous Pathogens..... | 35 |
| Chapter Six. Making Biosafety and Biosecurity a Priority | 39 |
| Chapter Seven. Meeting the Medical Supply Needs of the Next Pandemic | 45 |
| Chapter Eight. American Attitudes About Vaccine Globalism | 51 |
| Chapter Nine. Conclusions..... | 57 |
| Notes..... | 63 |
| References | 69 |
| Abbreviations | 82 |
| About the Authors..... | 83 |

About RAND

The RAND Corporation is a research organization that develops solutions to public policy challenges to help make communities throughout the world safer and more secure, healthier and more prosperous. RAND is nonprofit, nonpartisan, and committed to the public interest.

Research Integrity

Our mission to help improve policy and decisionmaking through research and analysis is enabled through our core values of quality and objectivity and our unwavering commitment to the highest level of integrity and ethical behavior. To help ensure our research and analysis are rigorous, objective, and nonpartisan, we subject our research publications to a robust and exacting quality-assurance process; avoid both the appearance and reality of financial and other conflicts of interest through staff training, project screening, and a policy of mandatory disclosure; and pursue transparency in our research engagements through our commitment to the open publication of our research findings and recommendations, disclosure of the source of funding of published research, and policies to ensure intellectual independence. For more information, visit www.rand.org/about/research-integrity.

RAND’s publications do not necessarily reflect the opinions of its research clients and sponsors. **RAND**® is a registered trademark.

Limited Print and Electronic Distribution Rights

This publication and trademark(s) contained herein are protected by law. This representation of RAND intellectual property is provided for noncommercial use only. Unauthorized posting of this publication online is prohibited; linking directly to its webpage on rand.org is encouraged. Permission is required from RAND to reproduce, or reuse in another form, any of its research products for commercial purposes. For information on reprint and reuse permissions, please visit www.rand.org/pubs/permissions.

For more information on this publication, visit www.rand.org/t/PEA1481-2.

Cover image: WHO/Ruziev M.

© 2022 RAND Corporation

CHAPTER ONE Introduction

John V. Parachini

In early December 2021, a bipartisan group of congressional representatives called for the creation of a bipartisan commission to “get the answers the world deserves about this pandemic’s origin and a comprehensive health and national security strategy to protect and equip the United States in the event of another devastating emergency”¹—“this pandemic” being the coronavirus disease 2019 (COVID-19) pandemic that began in late 2019, spread throughout the world in early 2020, and was in the midst of yet another worldwide surge in cases as 2021 drew to a close.

At a World Health Assembly meeting in the same week in December 2021, only the second such meeting held by the World Health Organization (WHO), government officials from WHO member states began negotiations on a global pandemic treaty. The WHO Director General Tedros Adhanom Ghebreyesus told the assembled member state representatives that he welcomed their decision “to establish an intergovernmental negotiating body to draft and negotiate a WHO convention, agreement or

other international instrument on pandemic prevention, preparedness and response.”² He went on to argue that negotiating new international instruments was necessary to “keep future generations safer from the impacts of pandemics.”³ As new variants of the COVID-19 virus emerge, it is encouraging to see some leaders leaning forward to prepare to address a future pandemic.

The deadly havoc the COVID-19 pandemic has caused around the globe has highlighted many shortcomings that need to be addressed so that nations are able to better respond to future outbreaks. Incursions into natural environments increase the chances of human contact with animals that might result in *zoonotic* (between humans and animals) spillover of disease. Environmental effects of global warming make it likely that deleterious changes in natural environments will increasingly bring humans and animals in contact and the planet will experience outbreaks of new diseases with widespread effects.⁴

Although not all future outbreaks will be as severe as once-in-a-century pandemics like those caused by the 1918 influenza or COVID-19, the pace of outbreaks in the past two decades suggests that such occurrences may become an increasingly common phenomenon. In the past 20 years, multiple outbreaks of zoonotic diseases have occurred.

The pathogens responsible for West Nile virus (1999), Rift Valley fever (2000), Severe Acute Respiratory Syndrome (SARS) (2002), H1N1 influenza (2009), Middle East respiratory syndrome (MERS) coronavirus (2012), and Asian highly pathogenic avian influenza H5N1 (2014) are all believed to be zoonotic transfers from animals to humans. As Tom Tugendhat, chair of the UK foreign affairs committee, observed, “The Industrialisation of animal husbandry and human intrusion into areas replete with wild animals raises the risk of viruses jumping species. The more viruses we encounter, the greater the risk that a more virulent pathogen will take hold, leading to an even more deadly pandemic.”⁵

In responding to the COVID-19 pandemic, policymakers in countries around the globe have, in some instances, made serious errors in judgment and bowed to bureaucratic and political malfeasance. Despite these failings, other policymakers, public health officials, and scientists showed great courage and produced amazing medical and scientific breakthroughs. For example, the rapid production of effective vaccines has been game changing in many respects. However, the failure to quickly share information about the outbreak, take measures advocated by scientific and health authorities, stick with policies aimed at reducing virus transmissibility, and swiftly distribute vaccine supplies worldwide are just a few of the factors that contributed to the pandemic’s tragic and enduring results.

Investigating the origin and response to COVID-19 will inevitably uncover significant errors in judgment by leaders of China, the United States, other nations, and the WHO. Some mistakes stemmed from encountering a once-in-a-century event that, despite many warnings, policymakers and public health officials were not prepared

to swiftly counter with sound actions. Chinese officials took actions to stem the adverse political fallout from the outbreak that furthered its spread. Local and provincial officials failed to appreciate the outbreak’s danger and continued to hold events when doing so likely furthered the spread of the disease, and then withheld information that might have helped others respond to the outbreak.

When local doctors in Wuhan, China, attempted to warn of the danger, they were silenced. When Wuhan residents expressed concern and anger on Chinese social media, authorities at all levels of government clapped down on the flow of information and developed a narrative about the outbreak that skewed the initial facts and deflected blame to reduce political and bureaucratic fallout. The Chinese mistakes and misdeeds in handling the outbreak have been detailed in several accounts.⁶ Since others have so ably chronicled this history, authors contributing to this volume sought to add new information and identify issues that warrant discussion and debate to help prevent, warn, and/or better manage a future pandemic.

China was not the only country whose actions contributed to the pandemic’s extended reach. On multiple occasions, as the virus spread throughout the United States, President Donald Trump and other senior members of his administration downplayed the severity of the outbreak, did not follow evidence-based recommended health practices like mask wearing, and endorsed false treatments, such as hydroxychloroquine or ivermectin, neither of which medical authorities recommended; several of the promoted treatments were dangerous. Whether these actions were motivated by a disdain for expertise, eschewing public health in favor of perceived economic benefits, or an attempt to improve political fortunes, the net result

was disastrous.⁷ Many preventable deaths resulted.⁸ A growing body of literature chronicles the official U.S. mistakes, misdeeds, and political manipulation of the response to the pandemic.⁹ As with the early events in China, the authors contributing to this volume sought not to repeat what others have already written on this subject.

Instead, this collection of short essays examines topics that will help the United States and others prepare for and respond to future outbreaks of infectious disease. Each essay describes a problem that arose in response to the outbreak and suggests options that may address it. Given their brevity, these essays are not designed to be the final word on any of the topics raised. Instead, they are designed to stimulate informed discussion and further research on measures to take in the future.

Any complete analysis of the pandemic response needs to account for the degree to which blatantly political considerations by national leaders exacerbated the tragic situation. Similarly, the controversy regarding the origin of the SARS—CoV-2 (the virus that causes COVID-19) in Wuhan, China, cannot go without mention. Throughout this Perspective, we reference studies that argue that the historical pattern is a zoonotic spillover to a human, or, conversely, that the failure to find a genetic match with animal host and considerable circumstantial evidence suggest the Wuhan Institute of Virology (WIV) is the source. While several authors take note of this controversy, the essays do not attempt to resolve those issues.

The interdisciplinary group of RAND Corporation researchers that contributed to this volume provides policy perspectives to inform future commissions and negotiations that are relevant for a range of origin explanations. These essays aim to provide options for national and inter-

national leaders charged to “keep future generations safer from the impacts of pandemics,” to use the words of the WHO director-general, Tedros Adhanom Ghebreyesus.¹⁰

These essays are organized loosely according to the chronological evolution of the pandemic. Chapters with related content are also put in successive order. They investigate the following topics.

Warning about threats without actors. The first essay outlines the abundance of warning that a major outbreak of some kind was possible, even imminent. Yet warning about threats to national security that do not have an obvious perpetrator—state or terrorist—poses an inherently difficult challenge for analysts to alert policymakers in a way that persuades them to take proactive measures. Analyzing threats without actors and effectively communicating the danger to busy policymakers places a burden on analysts to come up with new ways to assess threats and alert policymakers and responders of all types to the implications of the danger (Chapter Two).

Lessons from China’s early decisions. The next essay explains the challenges Chinese officials faced in discerning the severity of the outbreak and then communicating to international authorities and other nations what they discovered and what the implications might be. Following the SARS outbreak more than a decade earlier, Chinese authorities attempted to make improvements in the response plans and procedures for handling a new infectious disease outbreak. Unfortunately, their response to the SARS-CoV-2 outbreak that led to COVID-19 was adversely influenced by internal Chinese bureaucratic government practices, regional political concerns, and, ultimately, national political concerns about the country’s reputation in the international community (Chapter Three).

Reforming the WHO. Transparency gaps at the outset of COVID-19 raised questions about the role and responsibility of the WHO during a regional outbreak that quickly had global implications. The WHO's role and responsibilities are largely defined by its member states. When an outbreak occurs and appears to start in one country, tensions between national sovereignty, economic stability, security, and international responsibilities ultimately emerge. The essay on WHO reform describes how these challenges influence the operations of the WHO and presents various options that have been put forward to “reform” and “empower” the WHO in the wake of the current pandemic. The recently announced negotiations for a convention on pandemics will serve as a forum to discuss proposals that would enhance the role and capabilities of the WHO to address future pandemics (Chapter Four).

Conducting complex scientific research with dangerous biological materials. Whether or not the COVID-19 pandemic originated from laboratory work with bat coronaviruses, questions remain about the nature of the research undertaken with these viruses at the WIV.¹¹ There are concerns not only about the safety and security of the institute's procedures for handling coronaviruses, but also that the institute engaged in risky and dangerous research on coronaviruses. This type of research may be well intentioned to assess spillover potential, figure out the characteristics of future viruses, or aid in the development of vaccines and therapeutics to address them. Richard Ebright, lab director at Rutgers University's Waksman Institute of Microbiology, observed in congressional testimony that “Because gain of function research of concern poses high—potentially existential—risks and provides limited benefits, the risk-benefit ratio for the research almost always is

unfavorable and in many cases is extremely unfavorable.”¹² Attempting to get ahead of nature runs the risk of creating something nature has not, and if it somehow escapes from the lab, as Ebright noted, the dangers greatly outweigh the benefits. Another concern is that some research of this kind can be perverted for military purposes to develop a new infectious disease that no one else can defend against. Ultimately, this type of research challenges laboratory leaders and research funders to balance potential risks and benefits. Easy solutions involving greater regulatory measures may reduce potential benefits and achieve limited practical restraint. Even if new regulations are designed to reduce risks, policymakers and public health officials should advocate training and education on lab leadership, mentorship, and research ethics (Chapter Five).

Prioritizing biosafety and biosecurity. Concern about laboratory safety practices as a possible cause of the COVID-19 outbreak in China and the proliferation of high containment laboratories raise questions about future research with dangerous pathogens. Even if the COVID-19 pandemic did not originate from a lab leak, the historical record of accidents must be addressed. Prior to the COVID-19 outbreak, the proliferation of high containment facilities being built around the globe was significant. In the wake of the pandemic, even more labs are planned. The upside of this proliferation of labs is that more countries will have testing and genetic sequencing capabilities that help policymakers effectively manage a future outbreak. The downside is the risk that not all countries have the skills, experience, or regulatory structure to ensure safe and secure operations of laboratories to handle dangerous pathogens. More labs may result in more lab accidents. The biotechnology revolution offers great promise but also has

inherent risks that need to be managed effectively (Chapter Six).

Ensuring access to medical supplies. The COVID-19 pandemic exposed flaws in the stockpiling of medical supplies essential for responding to a pandemic, as well as national supply chain vulnerabilities affecting these materials. In the United States, chronic underfunding of programs to ensure an adequate supply of personal protective equipment (PPE), adequate testing capabilities, and medical equipment, such as ventilators, catalyzed a search around the globe for supplies. Much of the needed equipment was in short supply because of the unanticipated emergency demand and the lack of adequate stockpiled reserves. The United States was not alone in facing these shortages. With a host of vulnerabilities exposed, the challenge U.S. policymakers confront is how to hedge against uncertain health risks at a reasonable cost and how to manage the supply chain risks for those supplies that are not cost effectively made in America (Chapter Seven).

American public support for vaccine globalism. With support from the Robert Wood Johnson Foundation, RAND researchers conducted a survey of American public opinion about the U.S. sharing of vaccines with other countries. Conventional wisdom was that the United States should first meet all the vaccine needs of the homeland before sharing any of the vaccines that resulted from U.S. government (USG)-sponsored research and development. As the Biden administration aggressively promoted

vaccinations throughout the United States, the head of the WHO and other foreign leaders chastised the United States for its policy of promoting booster vaccine shots before providing vaccines to developing countries facing the prospect of significant outbreaks with much of their populations unvaccinated. The RAND survey revealed that the American public supported vaccine sharing, in part because it was persuaded that the pandemic would endure longer in the U.S. homeland if it were not contained abroad as well. These findings suggest that policymakers and public health officials may have more opportunity for alignment in public health attitudes and practice than previously perceived (Chapter Eight).

Conclusions. In this final chapter, the project leaders highlight key findings from the preceding chapters and briefly outline three additional areas that warrant examination. First, a comparative examination across countries is needed to identify best practices and pitfalls. Countries faced the waves of infection differently and had different approaches for managing them. Second, policymakers and public health officials need to figure out how to achieve a unity of public health purpose at all levels of government. Initial consensus on public health guidance broke down over time in some states and regions and resulted in preventable deaths. Third, disinformation—some of it coming from national leaders—contributed to the fraying of national consensus on public health measures (Chapter Nine).

CHAPTER TWO

“You Warned Me, but You Did Not Convince Me”

John V. Parachini

President Joe Biden told intelligence officials, during a visit to the National Counterterrorism Center, that “More people have been killed in the United States of America because of COVID than in every single major war we fought combined,”¹³ a sobering observation. While the president’s comment may overstate the historical record for effect, the quantity of deaths, economic damage, and collateral physical and mental health effects is staggering. He went on to say to the assembled audience, “you’re going to have to increase your ranks with people with significant scientific capability relative to pathogens.”¹⁴ Two months later, Scott Gottlieb, former director of the Food and Drug Administration, wrote in the *Washington Post* that “Deploying intelligence agencies and assets to monitor outbreaks would advance our public health goals and help guard against adversaries who would try to exploit the chaos brought on by a health crisis.”¹⁵ Providing warning of a rare threat before it gets out of control and in a way that policymakers comprehend well enough to take meaningful action is a difficult task, given all the issues that must be taken into account.

Whose Mission Is It Anyway?

Is the U.S. Intelligence Community (IC) the right element of the government to warn about an impending naturally occurring health crisis? Intelligence organizations’ core

mission and comparative advantage is to collect hidden information, frequently government secrets, and make sense of puzzles and mysteries that contain information to give policymakers decision advantage.

Information on naturally occurring events, such as disease outbreaks, comes from a range of sources, most of which are not intentionally hidden. Public health clinics, agricultural stations, epidemiology surveillance units, and research laboratories are just a few sources for this information. While some intelligence analysts may weave information from these sources into their analysis of global health issues, the profession typically focuses on states or individual actors who pose intentional threats or present opportunities to further American interests. Intelligence analysts may assess how nonactor forces affect states or individuals, but they do not necessarily have a comparative advantage over university researchers, investment bankers, health professionals, or environmental scientists in understanding observable phenomena in the natural world. The IC is not inherently better configured to provide early warning on naturally occurring events than organizations that do not have clandestine missions as part of their charter.

Human incursion into pristine natural environments, causing unexpected environmental changes, increases the likelihood that people will become infected by novel diseases—zoonotic diseases that will jump from animals to humans. Jeffrey D. Sachs, President of the United Nations (UN) Sustainable Solutions Network, observed that diseases “that emerge from the transmission of viruses from wildlife to humans (so-called natural zoonoses) call for precautionary measures in human farming, consumption of bushmeat, and rearing and trade of livestock.”¹⁶ Intelli-

gence services have little comparative advantage at discovering these types of disease outbreaks.

Intelligence services may provide some insight into the work and safety practices of research laboratories, particularly if the laboratories are suspected of having links to military organizations. Two decades of U.S. and Russian collaboration on cooperative threat reduction programs associated with the nuclear, biological, and chemical weapons programs of the former Soviet Union suggests that scientist-to-scientist exchange programs provide insight into the activities of a lab without the costs and risks inherent in clandestine operations.¹⁷ These types of exchanges also serve as a deterrent to labs embarking on either risky or internationally prohibited types of research activities. The challenge with these types of exchanges is that they survive as long as political relations between states allow them to do so.

Laboratories that hide their activities because of links to military or dual-use research and are not transparent with the international scientific community are another matter. The prospect that the COVID-19 outbreak resulted from a lab leak in Wuhan, China, where safe and secure research practices were known not to have been consistently employed and where local and national officials downplayed these lapses, changes the nature of the mission in a way that the intelligence community, rather than the scientific community, may be better positioned to investigate.¹⁸

If authorities hide or prevaricate about valuable information that might have prevented millions of deaths concerning the origin of an outbreak, this is hidden information worth getting. However, finding ways to promote trust, diminish the stigma associated with outbreaks, and

make transparency about outbreaks the norm of responsible state behavior will likely be an easier and cheaper way to obtain critical information than trying to acquire it clandestinely. Ultimately, some combination of means is probably needed, given how governments fear reputational damage from outbreaks and the difficulty in building trust with some governments. If a foreign government is determined to hide the existence of a disease outbreak within its borders, and that event risks cascading in a way that affects the well-being of neighboring countries or the United States, then the IC should use all its means to obtain that information for the benefit of U.S. policymakers.

Outlines of the Intelligence Community's Biosecurity Mission Take Shape

The U.S. Congress is already taking steps to expand the mission of the IC to include biological events that endanger the country, regardless of their origins. When announcing the bipartisan agreement on the 2022 Intelligence Authorization Action (IAA), committee chair Adam Schiff stated that he was “particularly pleased by the significant progress made with this authorization act . . . to protect against future pandemics and global health threats”¹⁹ It remains to be seen whether congressional direction will be acted upon by IC leaders. If funds are allocated for this specific purpose, the chances are greater than if there is just an exhortation to do something.

The IAA outlines three measures designed to augment the IC's responsibilities to address biological threats. First, the IAA calls for expanding the mission and changing the name of the National Counterproliferation Center to the *National Counterproliferation and Bio-Security Center*.²⁰

The IAA calls upon the President to charge the Center to serve as “the lead for the intelligence community for the integration, mission management, and coordination of intelligence activities pertaining to biosecurity and foreign biological threats, regardless of origin.”²¹

Second, the Act calls for “Biennial Reports on Foreign Biological Threats,” defined as “biological warfare, bioterrorism, naturally occurring infectious diseases, or accidental exposure to biological materials, without regard to whether the threat originates from a state actor, a nonstate actor, natural conditions, or an undetermined source.”²²

There are many talented scientists employed by the IC, but many more will need to be added to meet the expansion and higher priority of this mission. Keeping scientists current on developments in a rapidly evolving scientific field will be a challenge when they serve as intelligence analysts rather than working in laboratories.

Finally, the IAA requests a report on the pros and cons of adding the Office of National Security, currently a part of the U.S. Department of Health and Human Services (HHS), as a “new element” to the IC. The intent of this recommendation is to facilitate information sharing within the government about health events around the globe. Public health personnel have historically been reluctant to publicly align too closely with intelligence organizations for fear of being branded as spies and making foreign public health authorities reluctant to engage with them. Transparency and trust are essential elements for sharing information about health events, and anything that might jeopardize sharing health information raises concern.

Policymakers tend to focus on immediate problems and may not readily invest political capital to understand or address low-probability but high-consequence threats that do not seem imminent.

The Warning and Convincing Conundrum

When Henry Kissinger was National Security Advisor, he reportedly once said to intelligence officials, “you warned me, but you didn’t convince me.”²³ As this chapter will describe, the IC did warn policymakers of the possibility of a devastating global pandemic. Policymakers tend to focus on immediate problems and may not readily invest political capital to understand or address low-probability but high-consequence threats that do not seem imminent.

Intelligence officials face a different dilemma. If they warn too soon and too often, their message frequently gets ignored. This *crying wolf syndrome* occurs when the threat does not seem to appear. Yet, if intelligence officials

wait until the evidence is clear and compelling—when the proverbial wolf is at the door—then policymakers cannot do much about it. Add to this dilemma the challenge that policymakers do not necessarily perceive threats according to their likelihood but according to other fears. For example, terrorist acquisition and use of biological weapons has received disproportionate policymaker attention and resources versus a natural outbreak.

Policymakers, and the public for that matter, perceived an intentionally caused outbreak by a malicious human actor as more likely and warranting great government action. In contrast, natural outbreaks, which have been more common in the past two decades, evoke less fear than terrorist use of biological materials as weapons. Terrorist attacks with unconventional materials, such as disease, poisons, or radioactivity, have been rare and ineffective but nonetheless have stimulated considerable government response relative to the health and economic impacts.²⁴ Meanwhile, the COVID-19 pandemic has caused far more deaths than some major wars. The efforts to address natural outbreaks as opposed to the fear of intentionally caused outbreaks have received disproportionate attention, given the probability and the consequences.

One of the challenges in warning of the threat posed by nonactor events, such as pandemics, is the difference between how analysts work and how policymakers work. As one long-time intelligence analyst described the difference in approaches, “intelligence analysts typically do their work (linear, cerebral, mostly written) and . . . policymakers do theirs (nonlinear, transactional, mostly oral and interactive).”²⁵ These fundamentally different approaches can lead to different assessment of risks, opportunities, and the perceived imminence of pending events.

Another complicating element is the difference between *strategic warning* and *tactical warning*. When intelligence analysts warn about a tactical event, a policymaker needs to make an immediate or near-term decision on something about to happen. In contrast, analysts warning about strategic challenges alert policymakers to forces and events that have an uncertain probability or are slow to evolve. The best a policymaker can do to address strategic challenges is take defensive and proactive measures to shape the future development. Warning about an imminent threat with high probability gets more immediate attention than warning about a low-probability threat that is difficult to understand and carries uncertain consequences. The lower-probability event may not seem likely enough to get policymaker attention. Two-year and four-year election cycles in the United States add to this dilemma. The immediate crowds out the strategic.

Warning Given

The IC provided plenty of strategic warning about the possibility of a pandemic over the past 20 years. Since 1997, the National Intelligence Council has produced a *Global Trends* report every four or five years that highlights issues, threats, and opportunities 15 years in the future. These reports provide each newly elected presidential administration a long view into the future. Aside from the first report issued in 1997, every report issued since—2000, 2004, 2009, 2012, 2017—warned of the prospect of a global pandemic. Similarly, since 2006, five of the six Directors of National Intelligence (DNIs) identified infectious disease or pandemics as a serious threat to the nation in their annual threat assessments.

The *Global Trends* report issued in 2004 was remarkably prescient on the prospect and implication of a global pandemic given that it was published after the 9/11 attacks and was contemporaneous with high-tempo U.S. military operations in Iraq. Perhaps because it was finished during the 2003 SARS outbreak, the report looked out to 2020 with a section entitled “Asia: The Cockpit for Global Change?” It stated that “High population concentrations and increasing ease of travel will facilitate the spread of infectious diseases, risking the outbreak of pandemics.” In another subsection entitled “What Could Derail Globalization?” the report offered that “Short of a major global conflict, which we regard as improbable, another large-scale development that we believe could *stop* globalization would be a pandemic.”²⁶ Later in the subsection, the report stated that “Some experts believe it is only a matter of time before a new *pandemic* appears, such as the 1918–1919 influenza.”²⁷

Even if the *Global Trends* reports seemed to look too far into the future for policymakers to act upon, DNIs’ annual threat assessment testimony to Congress repeatedly warned of the implications a pandemic might have for national security. For example, in February 2006, the first DNI, John Negroponte, testified that “In the 21st century, our Intelligence Community has expanded the definition of bio-threats to the U.S. beyond weapons to naturally occurring pandemics. The most pressing infectious disease challenge facing the U.S. is the potential emergence of a new and deadly avian influenza strain, which could cause a worldwide outbreak, or pandemic.”²⁸ His successor as DNI, Michael McConnell, offered a similar view in his annual threat assessment testimony two years later. DNI McConnell argued that “The most pressing infectious disease

challenge for the United States is still the potential emergence of a severe influenza pandemic.”²⁹

In the *Global Trends* report published in 2008 that looked out to 2025, there is a text box entitled “Potential Emergence of a Global Pandemic.”³⁰ It notes that “The emergence of a novel, highly transmissible, and virulent human respiratory illness for which there are no adequate countermeasures could initiate a global pandemic.”³¹ The report goes on to outline a scenario where “a pandemic disease emerges . . . probably . . . first . . . in an area marked by high population density and close association between humans and animals, such as many areas of China and Southeast Asia.”³² Anticipating some of the measures employed during the COVID-19 pandemic, the report hypothesizes that “Despite limits imposed on international travel, travelers with mild symptoms or who were asymptomatic could carry the disease to other continents.”³³

The following year, consistent with the preceding DNIs, Dennis Blair testified in 2009 that the “most pressing transnational health challenge for the United States is still the potential for emergence of a severe pandemic, with the primary candidate being a highly lethal influenza virus.”³⁴

Global Trends 2030: Alternative Worlds, issued in 2012, identified a “severe pandemic” as one of seven “Potential Black Swans that would cause the greatest disruptive influence.”³⁵ While this report looked out to 2030, the foresight offered eerily resonates with the current COVID-19 pandemic. “Any easily transmissible novel respiratory pathogen that kills or incapacitates more than one percent of its victims is among the most disruptive events possible. Such an outbreak could result in millions of people suffering and dying in every corner of the world in less than six

months.”³⁶ In the text box entitled “Pandemic: Unanswered Questions,” the report observed that “No one can predict which pathogen will be the next to start spreading to humans, or when or where such a development will occur, but humans will continue to be vulnerable to pandemics, most of which will probably originate in animals.”³⁷

In DNI James Clapper’s annual threat assessment testimony, he acknowledged the difficulty of anticipating health risks and stated that “No one can predict which pathogen will be next to spread to humans or when or where this occurs. However, humans remain vulnerable, especially when a pathogen with the potential to cause a pandemic emerges.”³⁸ In 2017, during the Trump administration, DNI Daniel Coats testified that “A novel or reemerging microbe that is easily transmissible between humans and is highly pathogenic remains a major threat because such an organism has the potential to spread rapidly and kill millions.”³⁹

The *Global Trends* report published in 2017 contained a vignette occurring in 2023 that presaged the COVID-19 outbreak as it hypothesized that “The global pandemic of 2023 dramatically reduced global travel in an effort to contain the spread of the disease, contributing to the slowing of global trade and decreased productivity.”⁴⁰ A “major trend” in the report is that environmental changes may result in “the emergence, transmission, and spread of human and animal infectious diseases.” There is abundant evidence that the coronavirus that ignited the COVID-19 disease originated from bats in China. What remains unclear is whether the disease lodged in humans came directly from bats or from laboratory work with bat viruses.⁴¹ The IC report that President Biden directed the DNI to prepare was not able to conclude with a high degree of confidence whether the outbreak resulted from a natu-

ral zoonotic spillover or a laboratory accident involving coronavirus in bats.⁴² Thus, the question about the origin remains an open one.

One of the imperfections of the annual threat assessments is that they also are characterized by a long list of threats. Given all the near-term clear and present dangers, it is hard for policymakers to dedicate the attention and energy to low-probability but potentially high-consequence threats that come from nature rather than adversary states or terrorist groups. All these issues are important. Busy policymakers must make many choices and factor in the political implications, which affect their freedom of action on any major issue. If the implications are vague or far in the future, they are difficult to gauge and not likely to be addressed in the short term.

Part of the problem with the *Global Trends* reports is that they look out so far in the future on so many issues that it is hard for policymakers to sort through all the issues and make decisions that shape outcomes that may occur years after they have left office. The report written in 2000 that looked out to 2015 discusses “surveillance of infectious disease outbreak” along with such issues as monitoring international financial flows, warning of extreme weather events, humanitarian assistance for refugees, counterterrorism, the protection of intellectual property rights, and at least 12 other topics. This is a time frame that extends far beyond the political time horizon of most policymakers. The tendency of policymakers is to act upon the issues that have clear human perpetrators and bear near-term political consequences. It is harder to grasp the political value of addressing evolving issues that are not driven by human perpetrators.

No matter the quality or timeliness of the warning, the worldview and judgment of the policymaker is the element that no number of organizational, investment, or human capital changes can address.

DNIs appointed by successive presidents from different political parties consistently warned about the national security danger of a pandemic. During the Bush and Obama administrations, the national security staff took actions to increase pandemic preparedness across the government. These preparedness measures included assembling response plans and conducting exercises with relevant government entities. Table 2.1 is a Centers for Disease Control and Prevention (CDC) table depicting 20 years of pandemic planning guidance, exercises, and relevant events.⁴³

This timeline of official planning documents, exercises, and responses to biological events was complemented by many exercises and studies by private, nongovernmental organizations.⁴⁴ The exercises and studies aided public officials in preparing for large-scale disasters, but they also added to the perception of the terrorist biological weapons threat. Whatever was gained in the 40 years of exercises, planning events, and studies proved insufficient to address many of the public health challenges posed by the COVID-19 pandemic.

The IC was not alone in warning about the danger and implications of a pandemic outbreak. Microsoft Founder

Bill Gates also warned of an outbreak.⁴⁵ In a 2015 TED Talk, Gates discussed the 2014 Ebola outbreak and argued that “if there’s one positive thing that can come out of the Ebola epidemic, it’s that it can serve as an early warning, a wake-up call, to get ready.”⁴⁶ According to Gates “The failure to prepare could allow the next epidemic to be dramatically more devastating.”⁴⁷

During the Bush and Obama administrations, plans were developed, revised, and exercised. After the SARS outbreak in 2002–2003, the Bush administration drew up extensive plans to handle a pandemic.⁴⁸ Unfortunately, the Trump administration “jettisoned the Obama playbook,” which built on efforts by the Bush administration, on how to manage a pandemic.⁴⁹ In April 2018, President Trump’s newly appointed national security advisor John Bolton refocused the national security staff in the White House on traditional security threats on the grounds that, as Michael Lewis describes in his history of the U.S. response to the pandemic, “the only serious threats to the American way of life came from other states” and the focus should be on hostile foreign powers “rather than, say, natural disasters or disease.”⁵⁰ Thus, no matter the quality or timeliness of the warning, the worldview and judgment of the policymaker

TABLE 2.1

Timeline of Selected Key Events in Pandemic Planning, United States, 1978–2008

| Year | Event | Outcome or Follow-up |
|------|---|---|
| 1978 | First U.S. pandemic plan, drafted by Federal Interagency Working Group on Influenza | Planning workgroup and its process assisted in strategy for addressing 1977–1978 influenza A(H1N1) outbreak. |
| 1983 | Revision of 1978 U.S. pandemic plan | The revised plan laid groundwork for subsequent planning documents. |
| 1988 | Institute of Medicine report, <i>The Future of Public Health</i> ^a | The report recognized the need to improve public health surveillance and response. |
| 1992 | Options for the Control of Influenza II meeting, Courchevel, France | The meeting led to formation of the U.S. Federal interagency Group on Influenza Pandemic Preparedness and Emergency Response in 1993. |
| 1997 | Publication of elements of the U.S. pandemic preparedness plan in <i>Journal of Infectious Disease</i> ^b | The report updated the action plan, and a further update was published in 2002 in <i>Clinical Infectious Diseases</i> . |
| 1998 | Centers for Disease Control (CDC) emerging infectious disease strategic plan update | Pandemic influenza was noted as an emerging infection. |
| 1999 | Council of State and Territorial Epidemiologists survey data published | Enhanced influenza surveillance was recognized as a cornerstone of pandemic preparedness. |
| 1999 | WHO Guidelines for Regional and National Planning | The WHO strongly recommended all countries establish National Pandemic Planning Committees. |
| 2001 | Anthrax-related bioterrorism in the United States | The federal response increased state and local preparedness funding. |
| 2003 | SARS outbreaks worldwide | The outbreak led to a globally coordinated response to emerging respiratory pathogens. |
| 2003 | Initial detection of human avian influenza A(H5N1) cases in China and Vietnam | The outbreak enhanced attention to pandemic preparedness by HHS and the USG, accompanied by additional funding. |
| 2005 | HHS pandemic strategic plan | The plan engendered multiple subsequent high-level policy documents and plans from the USG. |
| 2006 | Implementation plan for the national strategy for pandemic influenza | This plan led to action steps and a timeline for all pandemic planning pillar areas. |
| 2007 | Pandemic influenza vaccine allocation guidance | This document preceded the 2009 influenza A(H1N1)pdm09 vaccine recommendations. |

SOURCE: CDC.

^a Institute of Medicine, Committee for the Study of the Future of Public Health, *The Future of Public Health*, Washington, D.C.: National Academies Press, 1988.^b Tara O'Toole, Mair Michael, and Thomas V. Inglesby, "Shining Light on 'Dark Winter,'" *Clinical Infectious Diseases*, Vol. 34, No. 7, April 1, 2002.

is the element that no number of organizational, investment, or human capital changes can address.

Even if one argues that the strategic warning about a global pandemic seemed abstract to some policymakers, it is harder to ignore tactical warning amid a crisis. The IC reportedly provided President Trump numerous tactical warnings about the threat the virus posed via the Presidential Daily Briefing.⁵¹ The IC reportedly gave President Trump “more than a dozen classified briefings” mentioning the danger of the virus, outlining its spread around the globe, revealing that Chinese officials misunderstood and withheld information about its transmissibility and deadly nature, and the implications it held for the U.S. and global economies. Despite these warnings, the President downplayed the danger the virus posed, failed to take actions to address it, and suggested that it would not last long and then quickly disappear. Tragically, in some cases, regardless of the clarity of the evidence or urgency of the circumstances, some policymakers discount the warning and make decisions that turn out to be deeply flawed.

What Is to Be Done?

When one looks around the USG to figure out who has the lead on warning about a rapidly spreading infectious disease outbreak, the best answer is that there are entities whose capabilities are periodically woven together into an interagency structure that works depending upon the leadership involved. The CDC, overseen by HHS, is a natural entity to lead. Its reputation was damaged by its initial fumbling of the COVID-19 response and White House interference in its operations. Among its domestic public health coordination role; support to the interagency Global

Health Security Agenda (GHSA), with programs in some 19 different countries; Epidemic Intelligence Service; and, as of 2020, its National Wastewater Surveillance System, the CDC has capabilities to provide insight about the advent of an outbreak and how it is spreading. Too often during the pandemic, officials had to rely on lagging indicators, such as hospitalizations and deaths. The low-tech surveillance of wastewater offers a near-real-time picture of disease spread. Public health officials in Houston and New York City detected “the omicron variant 11 days before anyone in the U.S. tested positive for the variant.”⁵² Unfortunately, this low-tech system is not widespread throughout the country, and the curtailment of federal spending on COVID-19 measures may hamper its expansion.

The Department of Homeland Security’s National Bio-surveillance Integration Center has a role to play in warning about a disease outbreak. However, it is a center within the Department of Homeland Security’s Office of Health Affairs. Like the department itself, it has struggled to get the leadership, staffing, funding, and interagency buy-in to evolve into a robust organization. The Department of Defense’s National Center for Medical Intelligence is an important national asset and has capabilities that probably should be augmented, but its mission is to support Department of Defense leadership and forces in the field. In sum, these organizations should be reviewed for the contributions they can make to warning of a future pandemic, and they all likely need additional funding and mission tasking. Other than the White House staff, there is no governmental structure that links them together into what could be a health equivalent of the National Weather Service.⁵³

The problem does not seem to be warning about the prospect of a pandemic, but rather how to collect suf-

ficiently insightful data and how to warn about it so policymakers can take effective preventive and response measures. This problem is a whole-of-government challenge that no one government body is tasked to handle as the National Weather Service is charged to issue storm warnings.⁵⁴ During the Obama administration, much of the coordination task was housed in the White House, but this risks the vicissitudes of administration change and overextended national security staff advisors. What makes the task of predicting the evolution of a pandemic more difficult than forecasting tomorrow's weather is human behavior. Modeling storms entails physical properties that have been studied for decades. Pandemics are rare, and human behavior—such as getting vaccinated or not, wearing masks or not, testing and contact tracing assiduously or not—makes it very difficult to predict how an infectious disease will evolve and what response measures are going to be most effective.

In the case of the COVID-19 pandemic, many academic and research organizations around the country took it upon themselves to model the outbreak, how it might spread, who might be at greatest risk, and what impact potential measures might have on mitigating the effects. Columbia University, Johns Hopkins University, University of Washington, and Emory University are just a few of the many institutions that undertook sophisticated biostatistical modeling projects. A centralized National Weather Service–like entity with the capabilities to model a pandemic's effects does not yet exist in the United States; the CDC's new Center for Forecasting and Outbreak Analytics has a different mission with as-yet-unproven value.⁵⁵ Building this type of institution with enough credibility to convince

policymakers that its forecasts should be heeded will take time, sustained investment, and a track record of success.

One measure to improve warning about the course of future outbreaks is to capitalize on the many modeling and research innovations that organically developed during the current pandemic, which the CDC has started to do with its new forecasting center. With \$200 million in funding to get started, the center is “designed to advance the use of forecasting and outbreak analytics in public health decision making . . . [and serve] as a hub for innovation and research on disease modeling.”⁵⁶ Attempting to coordinate the accumulation of data from a dispersed public health system scattered across the states is a daunting challenge. Lacking a centralized health data collection system makes the accumulation of good data in consistent format inherently difficult. Creating a centralized system is complicated because, while the CDC provides guidance and funding and analyzes data the states provide, it lacks authorities to direct the states' data collection formats and processes. This center will have to prove it can leverage the many independent efforts that have emerged around the country and the world to track and model the COVID-19 outbreak.

In September 2021, like the CDC's Forecasting and Outbreak Analytics center, the WHO established in Berlin a “Hub for Pandemic and Epidemic Intelligence” designed “to strengthen pandemic and epidemic intelligence through better data, better analytics and better decisions across all aspects of managing public health emergencies.”⁵⁷ WHO Director General Ghebreyesus observed at the Hub's launch that “The world needs to be able to detect new events with pandemic potential and to monitor disease control measures on a real-time

basis to create effective pandemic and epidemic risk management.”⁵⁸

Whether the WHO Hub can get data from member states and their health care institutions any better than the CDC’s new center can get data from state public health departments remains to be seen. Both efforts are constructive and will improve national and international capabilities to anticipate the evolution of outbreaks, but they both will struggle with the challenges of decentralized sources of information. In the case of the WHO Hub, the challenge will be getting member states to share data in a timely fashion.⁵⁹

Given how a disease outbreak can start in one corner of the globe and eventually bedevil the U.S. homeland, international cooperation to detect and counter these types of health crises is essential. Working with international bodies, such as the WHO and other country health authorities, is critical. Pulling out of the WHO and blaming health authorities of other countries for the spread of diseases was a short-term political gesture. Given its capabilities in medicine in general—vaccine development in particular—and its position of global leadership in many forums, the United States needs to assert leadership during global health crises.

Making additional investments to advance genetic sequencing capabilities, biosurveillance, testing capabilities, and new data sources in uniform formats to quickly and credibly gather information to supply forecasting models are all important measures to improve warning of the advent and direction of a future pandemic. Different data sources provide insight for different time horizons. Detecting an initial outbreak via an index case provides one point in time and patient samples that can be analyzed.

New data sources and analytic techniques need to advance to a stage where policymakers trust the findings and act upon them, as when the National Weather Service forecasts impending hurricanes.

Once the genetic sequence is known, then other means of monitoring can provide valuable information; for example, analyzing wastewater for the presence of the disease can provide insight and a sense of its spread. A combination of samples and analytic methods are needed to provide actionable insights at different stages of an outbreak. New data sources and analytic techniques need to advance to a stage where policymakers trust the findings and act upon them, as when the National Weather Service forecasts impending hurricanes.

Finally, if a foreign government hides and/or lies about a domestic disease outbreak that threatens other nations, it is a mission for the IC to use all its collection and analytic tools to obtain actionable details of the situation. As the

COVID-19 pandemic demonstrated, early insight on the outbreak might have given policymakers warning about the need to take preventative measures. Knowing what and when Chinese local, provincial, and national authorities knew about the outbreak and what they planned to do was difficult to discover—and doubly so as some Chinese authorities delayed, sought to hide, and/or obfuscated information for political and bureaucratic purposes.

Relevant intelligence reporting developed via clandestine means can provide critical context and understanding

that policymakers and public health officials can leverage in their interactions with foreign governments, international organizations like the WHO, and state and local authorities in the United States. Given the quantity of lives lost, social disruption, and economic losses that resulted from COVID-19, David Franz, former head of the U.S. Army Medical Research Institute of Infectious Diseases, described the COVID-19 pandemic as the international public health community’s “mushroom cloud.”⁶⁰ Preventing an event that is the magnitude of a “mushroom cloud,” regardless of its origin, is certainly a mission for the IC.

CHAPTER THREE

Outbreaks and Governance: Lessons from Wuhan, China, During the COVID-19 Pandemic

Jennifer Bouey

The COVID-19 pandemic has been the most unprecedented public health and humanitarian crisis of the past century. The novel coronavirus was first detected in Wuhan, China, in November 2019, and by March 11, 2020, cases were reported by 114 countries.⁶¹ As we approach another year of this pandemic, two different narratives have emerged about how China has handled the pandemic—one narrative dominates inside China, another is common in the rest of the world.

Inside China, public anger about mishandling during the early stage of the pandemic was largely quelled as China successfully contained initial and subsequent outbreaks by stringent public health interventions and rapid vaccine development—mortality was reported by Chinese authorities to be low and the economy robust.⁶² The story outside China was very different. Media stories focused on the mysterious origin of the virus, Chinese government obfuscation and disinformation, and questions regarding the efficacy of the Chinese vaccine.

These competing narratives have received much attention. But another narrative about the early days in Wuhan is perhaps even more noteworthy: It is a story that focuses on the challenges Wuhan faced as the first clusters of pneumonia emerged. The chaos and human errors made during that time—which can happen in any country with similar economic, health, and political systems—offer a textbook

scenario of what to avoid in future pandemic response. The delay in setting the early epidemic alert, confused expert investigations, undercount of the early infections, and suppressed voices of concern from physicians were all too similar to what happened in 2002–2003 SARS. These repeated failures pointed to two systematic problems: (1) the evading communication between the provincial government and the central government investigations, which was rooted in the second problem: (2) the provincial government was primarily tasked and incentivized to develop economic growth and maintain stability rather than protect the well-being of the citizens and the environment. These provincial goals were disrupted by a disease outbreak that many provincial government officials dreaded to admit, and so they initiated a chain of coverup and disinformation extending to the delay in notifying the WHO and the international society of an epidemic. COVID-19 showed that these systemic problems could not be easily fixed by the large investment in public health after the 2003 SARS outbreak. Reflecting on and learning from what occurred during that early period can inform and strengthen future pandemic preparedness systems for China and other countries around the world.

What Went Wrong in Wuhan, China?

It is likely that the COVID-19 virus was circulating in Wuhan, China, in the last quarter of 2019, according to the findings of current research.⁶³ Wuhan, with a population of 11 million, is the capital city of Hubei province. It is a megacity and a manufacturing and transportation hub in the heart of China that contributed \$224 billion to the country's Gross Domestic Product (GDP) in 2018. The city

features three national-level development zones and hosts over 350 research institutes and 1,656 high-tech enterprises that receive investment from 230 Fortune global 500 firms.⁶⁴

Wuhan is a bustling city that routinely hosts national and international events. In September 2019, the city welcomed a visit by German chancellor Angela Merkel; in October of that year, more than 9,000 international athletes from more than 100 countries traveled to Wuhan for the Military World Games; in November, a five-day Wuhan Motor Show attracted 82 domestic and international exhibitors and thousands of visitors from around the world.

The Wuhan government itself continued to host many grand events in early January 2020. There were two big party conferences held in Wuhan, one starting on January 6, 2020, and the other starting on January 12, 2020.⁶⁵ On January 18, 2020, even after COVID-19 cases were on the rise and the first epidemiologic investigation led by central government experts was underway, the city government held an annual Chinese New Year banquet for 40,000 families in the Baibuting district.⁶⁶ Visitors traveling to and from Wuhan during the early phase of the COVID-19 pandemic served as carriers of the virus to other parts of China and around the world. Chinese officials did not alert the WHO until December 31, 2019, and even then, they said “the disease is preventable and controllable.”⁶⁷ On January 1, 2020, millions of people traveled back to their hometowns for lunar New Year, and an estimated 175,000 people traveled from Wuhan, potentially spreading the disease beyond the city of its origin.⁶⁸ Ultimately, seven million people left Wuhan before the end of January.

During this time, provincial public health officials also suppressed the case number (as described later in more

detail under “A Bungled Investigation”), and investigators from Beijing overlooked some cases that led them to misunderstand the implications of the first two epidemiologic investigations and conclude that the infection transmission was not from person to person. What Wuhan government authorities did not appreciate was that people who were asymptomatic and did not show symptoms were spreading the virus without knowing it.

Chinese central government authorities eventually acknowledged, on January 21, 2020, that human-to-human transmission of the disease was possible, which was after millions of people had left Wuhan and outbreaks were occurring in Beijing and other cities in China.⁶⁹ On January 23, 2020, Chinese authorities finally locked down Wuhan and several other cities where significant outbreaks occurred. By then, it was too late; the virus was out. International travel out of the city continued for months after the first case emerged, and, on average, more than 900 people per month were reported to have traveled to New York.⁷⁰ Soon outbreaks had erupted in 30 cities in 26 countries.⁷¹ The local outbreak was now a global phenomenon.

Wuhan residents suffered most in China during the first wave of COVID-19. When the mysterious clusters of pneumonia emerged and patients filled the emergency rooms in the local hospital, few were expecting a global pandemic. After all, December was the high season for influenza, and the flu cases in Wuhan had already rocketed that winter.⁷² However, several of the atypical cases were linked by exposure to a wholesale seafood market. This pattern detected by a respiratory disease physician triggered the first public health alert in Wuhan, on December 30, 2019.⁷³ On January 1, 2020, the market was shut down for disinfection, and the samples obtained from

patients on December 29–30 later indicated the presence of a novel coronavirus.

The WHO issued its first report about the novel coronavirus on January 5, 2020, and scientists in China published the first genomic sequencing of the novel virus on January 11. By January 20, three Central Expert Teams (CETs) had been dispatched to Wuhan, China, to conduct field investigations. On January 23, Wuhan was the first city in China to mandate a stringent COVID-19 lockdown, which was later extended to 57 million people in many cities of China.⁷⁴ Wuhan was also the city that had had the longest period of lockdown (76 days) when the restriction was lifted on April 8, 2020.

After the sudden lockdown, many Wuhan residents with symptoms, real or perceived, panicked and rushed to nearby hospitals seeking medical attention.⁷⁵ Due to the surge of patients, these hospitals quickly ran out of testing kits and PPE. Patients congregated at the hospitals and overwhelmed the available health facilities. Because of the lockdown and the suspension of transportation means, the overflow of patients could not seek health care elsewhere. Eventually, Chinese officials ordered thousands of health care workers from other provinces to support Wuhan's hospitals, but in the first few weeks, the situation was dire.

By late on April 16, China revised the death toll in Hubei province upward to 4,512 (more than 95 percent of all China's reported COVID deaths). The city's health care system was overwhelmed, leading to an overall mortality rate over three months that was 56 percent higher compared with the previous years.⁷⁶ During this same period, over two million COVID-19 cases and 157,847 deaths were reported around the world.⁷⁷

The COVID-19 pandemic revealed that a chaotic pandemic response can happen quickly and unpredictably even to countries with good public health systems and supportive national leadership.

The COVID-19 pandemic revealed that a chaotic pandemic response can happen quickly and unpredictably even to countries with good public health systems and supportive national leadership. A close examination of how COVID-19 was handled in Wuhan can help health professionals avoid making the same mistakes in the future.

The Early COVID-19 Cases Missed by the Warning Systems

The first hospitalized case of COVID-19 can be traced to November 2019,⁷⁸ and at least a few dozen hospitalized cases in December were retroactively reported by China's CDC.⁷⁹ Yet the country's surveillance system, developed

with extensive investments and designed to alert authorities about potentially dangerous pathogens, did not receive a case report until December 29, more than a month later.⁸⁰ The surveillance system particularly relevant to the coronavirus epidemic is the Pneumonia of Unexplained Etiology (PUE) built by China's CDC after the 2003 SARS pandemic. The PUE system requires all Chinese health care facilities to report pneumonia with an unknown causative pathogen within 24 hours for CDC investigation and rapid response. Dr. Feng Zijian, the deputy director general of the China CDC, commented that the direct reporting system was not activated expeditiously.⁸¹

One reason for the delay was a lack of awareness of and training on the PUE system in smaller community hospitals.⁸² It appeared that many of the first COVID-19 patients from the market and the region went to see doctors in small community hospitals where physicians may not have been trained to recognize a disease outbreak and use the surveillance system. Additionally, patients with severe pneumonia symptoms were transferred, in some cases multiple times, to the four large hospitals in Wuhan.⁸³

On the other hand, the PUE system was also known to be insensitive to new threats. One study found that 29 percent of community-acquired pneumonia cases that met PUE criteria were not reported to the PUE system in 2009, and, during a nine-year period, only 1,016 PUE cases were reported in all of China.⁸⁴ The number of reported cases surged when an outbreak, such as the H5N1 outbreaks, occurred.⁸⁵ Thus, clinicians—especially those working in small-scale community hospitals on whom the system relies for reports—were not likely to report a case unless they were aware of a related pandemic. The lack of report-

ing led to a consequential delay in alerting public health professionals.

A Bungled Investigation

As domestic concerns about the outbreak increased and residents criticized local and provincial officials, national officials in Beijing began to react to the public health emergency. The National Health Commission sent CETs to Wuhan to conduct field investigations. CETs concluded incorrectly that the epidemic was under control and that person-to-person transmission was “preventable and controllable.”⁸⁶ Allegedly, the local China CDC in Wuhan “had been aware of the occurrence of people-to-people infection in late December” 2019.⁸⁷ Subsequent modeling of the outbreak identified “the period between mid-October and mid-November 2019 as the plausible interval when the first case of SARS-CoV-2 emerged in Hubei province.”⁸⁸ The local population was outraged by this error when it was eventually revealed.

Another erroneous conclusion made by the CETs derived in part from an overly restrictive epidemiology case definition that required a direct connection to the seafood market and a fever of over 38 degrees C (100.4 degrees F). This restrictive definition excluded many cases, such as cases among health care workers; artificially created holes in contact tracing; and covered up the explosive nature of the epidemic. While a location-focused epidemiologic definition is common among food- and water-borne diseases, it is not appropriate for a respiratory infection caused by a coronavirus, which is known to be transmitted among people, as is the nature of all six known human coronavi-

ruses. One of the results of this restrictive definition is that it delayed reporting of several cases.⁸⁹

Government Coverup and Delays

Once it became clear that information about a potential epidemic had not been shared in a timely manner, public outrage in China grew, along with demands to know who should be held responsible for the delay. Pressure led to a rare brawl between Wuhan local government officials, the central government, and CETs that received widespread media attention and provided the public with clues about what happened inside the investigation.⁹⁰ The mayor of Wuhan blamed the restriction of China's infectious disease law that prevented the local government from announcing the epidemic to the public.⁹¹ At the same time, several CET members complained that they did not have full cooperation from local partners, who shielded health care worker cases from the team and issued the narrow definition of cases. When the public blamed the CETs for not making a more serious effort to collect accurate data, members of the CETs complained about the lack of political power in public health agencies.

The Wuhan public became increasingly angry with local authorities for several reasons. First, the Wuhan local government withheld information about the epidemic, which led to confusion and concern. Second, authorities reprimanded Dr. Li Wenliang and other whistleblowers who were the first to alert the public to disease clusters through social media. Third, as noted previously, local authorities did not want to acknowledge the outbreak and permitted large-scale public events in December 2019 and January 2020 that undoubtedly increased exposures.⁹²

Once it became clear that information about a potential epidemic had not been shared in a timely manner, public outrage in China grew, along with demands to know who should be held responsible for the delay.

Finally, authorities leaked news of a pending lockdown that led many people to leave the city while they could, endangering other cities.

As a result of the poor local management of the outbreak, four high-ranking local officials in Hubei province, including the Hubei provincial Party Secretary, the Wuhan Municipal Party Secretary, and two senior officials from the Hubei Provincial Health Commission, were dismissed. By February 21, 2020, 620 officials in Wuhan, including six bureau-level and 127 division-level officials, had been disciplined for their problematic performance during the pandemic.

Such large-scale public condemnation of local government officials during a pandemic is not new. During the

Because the early days of any potential epidemic can be fraught with uncertainty about the severity of an outbreak and its economic impact, local officials are incentivized to wait and see and buy time for the picture to become clearer.

SARS pandemic in 2003, more than 1,000 public officials were penalized for failing to report cases.⁹³ In fact, the early days of the SARS and coronavirus pandemics proceeded in similar ways: the local government's slow announcement of the clustered cases, denial of the severity of the epidemic, and incorrect conclusions from the early CET investigations. What can be done to prevent this same scenario from happening again? To answer this question, we first must understand what motivates local government bureaucrats in China.

Systemic Issues Led to the Cover-Up

As Yuen Yuen Ang pointed out in 2018, since China adopted the open-market strategy in the late 1970s, its public administration has increasingly used incentives to transform a communist bureaucracy into a capitalist machine.⁹⁴ The local government bureaucrats' performance targets are closely tied to their ability to promote economic growth while maintaining political stability. GDP and absence of upheaval (“乱”) are the two most important

measures of an official's leadership competency and political future.

A disease outbreak, however, is the perfect disruptor to both desired outcomes. COVID-19 emerged right before the Chinese Lunar New Year, which is the most celebrated holiday in China. Typically, a large proportion of annual revenues for many market sectors comes from the month-long spending spree on food, drink, travel, and entertainment during the new year festivities. Restrictions tied to an epidemic during this celebratory time could disrupt GDP growth and cause instability in the region driven by public panic and anxiety—neither of which is desirable for a Chinese official, especially if the epidemic later turned out to be less severe.

Because the early days of any potential epidemic can be fraught with uncertainty about the severity of an outbreak and its economic impact, local officials are incentivized to wait and see and buy time for the picture to become clearer. Thus, blame avoidance behaviors are common: Look busy but remain inactive, withhold information, muddy the waters, divert attention, and find a scapegoat to

blame later.⁹⁵ While these behaviors may help local government officials avoid problems during uncertain times, they caused a backlash when SARS and COVID-19 hit.

Mitigation Strategies

As the actions of local Chinese officials caused delays in public health intervention, the world suffered. To prevent these pandemic early-day errors, misunderstandings, and cases of government malfeasance, we offer the following recommendations:

First, change China's zero-sum infectious disease alert system to a multiple-scale system. Because local government officials downplayed the severity of the public health emergency, many people were not prepared when the lockdown order was issued for Wuhan.⁹⁶ The local government was also reluctant to alert the public of the potential danger during the initial period of uncertainty. A multi-level system, such as the four-level outbreak alert system in South Korea,⁹⁷ could better prepare the public and provide local governments with options to “walk back” if the outbreak is not as severe as first expected.

Second, take transparency and accountability seriously as performance measures for government officials. Local government officials should be responsible not only to their central government supervisors for economic development and political stability, but also to the public for its well-being.

Third, give more autonomy to local government officials to conduct case investigations and communicate risk to the public. A highly centralized and top-down government can be effective in crisis management when local governments have clear policies to implement. But such

systems can become paralyzed and chaotic when a problem emerges from the ground up before the central government can make decisions on what actions to take. In such circumstances, local governments need to be able to act with greater autonomy and communicate directly with the public. During the early days of COVID-19, the lack of communication from the local government about public health risks increased public anxiety, reduced public trust in the government, and raised questions about its competency.

Fourth, give financial security and political power to public health professionals. Lacking the motivation of a public health crisis, governments tend to underinvest in public health measures, such as disease surveillance and vaccines. Unlike private-sector health care, public health usually does not generate revenue. If a country's public health policies are successful, and crises are averted, public health agencies will become more marginalized. Financially, most public health agencies rely on local government funding.⁹⁸ Even the central CDC in China experienced downsizing and budget cuts before COVID-19. Without financial security or political power, public health investigations are likely to be constrained by other competing interests during a pandemic.

Fifth, link the PUE surveillance system to a regional or global observatory network. Even though the PUE system established in 2005 cost China \$4 million, the system was plagued with problems, including a shortage of routine training and maintenance. A parallel system, the influenza-like illness system built by China in 2009 that later became a regional example for WHO's influenza network, functioned much better because of steady funding

from both domestic and international sources and frequent regional training provided in these centers.⁹⁹

Looking Forward

Public health crises like COVID-19 will continue to hit human societies. China, with one quarter of the world's population and its second largest economy, has a unique governing system and a set of distinctive characteristics that exacerbated mistakes made by local authorities. Following early mistakes, complications compounded as national officials sought to avoid political criticism by seizing control of the pandemic narrative. Blaming the health crisis on local officials and foreign entities was a natural outcome for the powerful central government.

As Ran Ran and Yan Jian presciently concluded their article on transparency and official accountability in the early days of the outbreak in Wuhan, “The selection and framing of facts are always the prerogative of those in the dominant position.”¹⁰⁰ In the case of the outbreak in Wuhan, the central government authorities were in the dominant position. Professor Jonathan Mayer from the University of Washington's department of epidemiology observed that “Epidemics always have become political. . . . Governments seem opposed to admitting that things were handled imperfectly, yet it is only by identifying the imperfections and shortcomings that things can be addressed to do a better job next time.”¹⁰¹ It will never be known

how many lives around the globe might have been saved if the system set up after the outbreak in 2002–2003 had actually functioned as designed and officials had acknowledged what local health officials feared. The lessons from COVID-19 described here will, hopefully, inform future adjustments to China's approach to health crisis and encourage other countries to assess their own health governance systems and response strategies.

The delay in setting the early epidemic alert, confused expert investigations, undercount of the early infections, and suppressed voices of concern from physicians were all too similar to what happened in 2002–2003 SARS. These repeated failures pointed to two systemic problems. The first was poor communication between the provincial government and the central government investigations, and that was rooted in the second problem: The provincial government was primarily tasked and incentivized to develop economic growth and maintain stability rather than protect the well-being of citizens and the environment. The provincial goals were disrupted by a disease outbreak that many provincial government officials dreaded to admit, so they initiated a chain of coverup and disinformation extending to the delay in reporting an epidemic to WHO and the international society. COVID-19 showed that these systematic problems cannot be easily fixed by the large investment in the hardware of public health after the 2003 SARS outbreak.

CHAPTER FOUR

Reforming Global Pandemic Preparedness and Response Institutions

Daniel M. Gerstein

The global response to COVID-19—in particular, the role of the WHO—has led to a growing call for reforms to improve global health emergency preparedness and response. These proposals range from reforming the WHO to development of new forums specifically designed with authorities and responsibilities commensurate with preparing for and mounting an effective global pandemic response.

Over the course of the past 20 years, the WHO has been reforming nearly continuously as a result of criticisms of their performance during major global outbreaks and pandemics. Each major public health emergency during this period has led to the conclusion that the WHO has serious shortfalls that have prevented it from effectively communicating with and supporting member nations and the broader global community in response to these public health events.

WHO History

The WHO was established in 1948 as a policymaking body that directs and coordinates health within the UN system. Specific WHO responsibilities include “engaging international partners on global health; shaping the international health research agenda; establishing norms and standards; articulating evidence-based health policy; providing tech-

nical support to countries; and monitoring and assessing global health trends.”¹⁰²

The WHO also has responsibility to “direct and coordinate the world’s response to health emergencies.”¹⁰³ The centerpiece for WHO pandemic preparedness and response is the International Health Regulations (IHR), which traces its roots back to the cholera epidemics of the mid-1800s.¹⁰⁴ The IHR has been updated in response to subsequent public health emergencies. IHR (2005) stands as the most recent major update.¹⁰⁵ It was revised in response to the 2003 SARS, which is a coronavirus related to the one responsible for COVID-19. IHR (2005) requires all nations to detect, assess, report, and respond to public health events. The IHR also provided specific measures to limit health risks to neighboring countries and prevent unwarranted travel and trade restrictions.

Minor updates and recommendations since the IHR (2005) have occurred after notable global public health events. Following the 2009 H1N1 swine flu outbreak, a committee convened by the WHO Director General identified “systemic difficulties,” including potential ethical issues and excessive influence by the pharmaceutical industry in characterizing the outbreak. The committee issued several policy and program recommendations, some of which were instituted by the WHO.¹⁰⁶

The WHO also received criticism following the 2014–2016 Ebola crisis in West Africa. The main critique was that it was too slow to act.¹⁰⁷ To improve response, the WHO developed a new program for health emergencies that included establishing a \$100 million contingency fund and performance benchmarks for what should occur at 24, 48, and 72 hours after the detection of an outbreak.¹⁰⁸ Some critics even called for a more engaged role, includ-

These limitations have left the [WHO] with no directive mechanisms to deal with public health emergencies of international concern.

ing developing a “unified center that is well resourced and takes accountability for outbreak response, plus a standing emergency committee that can make emergency declarations more independently and transparently, without political influence.”¹⁰⁹

Despite efforts at reform over the past 20 years, fundamental flaws remain. The WHO—and the IHR—include no provisions for conducting investigations, enforcement, or authority to compel nations.¹¹⁰ The WHO can employ only the limited authorities, capacities, and funding that the 194 member nations have allocated to the organization. This lack of agency was not an oversight but rather a deliberate limiting of the authorities of the WHO. These limitations have left the organization with no directive mechanisms to deal with public health emergencies of international concern. Without such authorities, nations that violate the IHR are unlikely to face any repercussions from WHO. It also means that the WHO must take a col-

laborative approach in dealing with nations to gain their cooperation.

COVID-19: Shortfalls and Calls for Reform

Another global public health emergency—this time the SARS-CoV-2 virus—has demonstrated that the WHO remains an “underfunded organization with limited political power, which has struggled to deliver on its official role of guidance and coordination across its member states.”¹¹¹

Several high-visibility missteps provide examples of its underperformance during this recent crisis. The WHO was slow to declare COVID-19 an international emergency and, at times, has provided inconsistent and inaccurate information. As an example, the global risk assessment from a week earlier had to be revised from “moderate” to “high” in late January 2020 after the WHO admitted it had made a mistake in previous reports.¹¹²

The WHO was also slow in its calls for a thorough investigation of the origins of the virus, which contributed to a loss of confidence by some WHO member nations. The organization has also been accused of failing to be independent in its assessments and of being too “China centric.”¹¹³

The calls for reform have been resounding. World leaders, infectious disease experts, and worried citizens alike have voiced concerns about the WHO’s COVID-19 response. The result has been calls for a transparent and independent review of the organization’s preparedness and response for COVID-19, as well as for future pandemics.¹¹⁴

Recognizing the need to examine its early COVID-19 actions, in May 2020, the WHO commissioned an “Independent Panel for Pandemic Preparedness and Response,”

which reported its findings in May 2021. The yearlong independent panel “found weak links at every point in the chain of preparedness and response.”¹¹⁵ These shortfalls are well documented in a voluminous set of assessments, which suggested immediate actions to end the current pandemic and longer-term recommendations for ensuring that a future outbreak does not become a pandemic.

Importantly, the panel recommended development of a “global health threats council,” which would be led by heads of state, separate from the WHO, and able to hold nations accountable for “containing epidemics.”¹¹⁶ The seven specific long-term recommendations of the independent panel were as follows:

1. Elevate pandemic preparedness and response to the highest level of political leadership.
2. Strengthen the independence, authority and financing of WHO.
3. Invest in preparedness now to prevent the next crisis.
4. A new agile and rapid surveillance information and alert system.
5. Establish a pre-negotiated platform for tools and supplies.
6. Raise new international financing for pandemic preparedness and response.
7. National pandemic coordinators have a direct line to Head of State or Government.¹¹⁷

Table 4.1 provides an overview of six potential reform initiatives that have been become the focus of much discussion. These initiatives emerged from a wide range of organizations—from the May 2021 World Health Assembly to the European Union to a group of concerned citizens.

These initiatives are not the only calls for change, but they reflect an interesting range of transformational activities that could be undertaken to improve global pandemic preparedness and response. Some would reform the WHO, others would develop new international agreements and measures, and some would augment existing mechanisms. To date, they represent concepts or frameworks rather than refined proposals that could be evaluated for implementation. Each seeks to address shortfalls that have been observed during COVID-19.

The first reform initiative comes from the 74th World Health Assembly, held in May 2021. At the assembly, the ministers of member nations agreed to hold a special session in November 2021 to discuss developing a “convention, agreement or other international instrument on pandemic preparedness and response.”¹¹⁸ At the special session, the assembled representatives agreed to pursue a standalone, legally binding instrument for addressing future pandemics. It is likely that the seven specific long-term recommendations of the independent panel will inform the development of this pandemic-specific treaty. The implication of this initiative is that any new organization would likely be related to but not under WHO leadership. The global health threats council led by heads of state could serve as a model for this new structure. A key question will be whether the experience of COVID-19 will motivate states to give an international body more authority to act or just create another body with no more independence or authority than the WHO has currently.

Another potential avenue identified for reforming pandemic preparedness and response would be through the development of a UN Security Council Resolution (UNSCR) for pandemics. Under the UN charter, resolu-

TABLE 4.1

Proposed Reform Initiatives to Improve Pandemic Preparedness and Response

| Proposal | Key Provisions |
|---|---|
| World Health Assembly reform meeting for improving preparedness and response to future pandemics ^a | <p>Following the 74th World Health Assembly</p> <ul style="list-style-type: none"> • Member States Working Group on Strengthening WHO Preparedness and Response to Health Emergencies was directed to “prioritize the assessment of the benefits of developing a WHO convention, agreement or other international instrument on pandemic preparedness and response and to provide a report.” • Special session of the World Health Assembly was held in November 2021 to consider the report of the working group. • Reform could be outside of WHO as called for by the “global health threats council.” • During the special session, the representatives agreed to pursue a comprehensive pandemic treaty. |
| UNSCR for pandemics | <p>Develop a UNSCR as a formal expression of the UN regarding pandemics</p> <ul style="list-style-type: none"> • Resolutions are “the common legal instrument for an organ or body to make a recommendation or statement, recall a fact, express an opinion, or undertake any other matter of substance.”^b • In general, resolutions adopted by the Security Council acting under Chapter VII of the Charter are considered binding on all UN member states, in accordance with Article 25 of the Charter.^c |
| European Union proposal for an international treaty on pandemics ^d | <p>Develop a treaty guided by a spirit of collective solidarity, anchored in the principles of fairness, inclusiveness and transparency. The international treaty on pandemics should include</p> <ul style="list-style-type: none"> • “early detection and prevention of pandemics” • “resilience to future pandemics” • “response to any future pandemics, in particular by ensuring universal and equitable access to medical solutions, such as vaccines, medicines and diagnostics” • “a stronger international health framework with WHO as the coordinating authority on global health matters” • “‘One Health’ approach, connecting the health of humans, animals and our planet.” |
| Science academies of the G20 nations pandemic statement ^e | <p>The G20 science academies developed a statement to inform the G20 Summit in Rome in October 2021. The statement calls for the G20 to</p> <ul style="list-style-type: none"> • “promote the creation of a global network of surveillance” • “promote the distributed manufacture and delivery of diagnostics, drugs, vaccines, medical supplies, and equipment” • “launch an International Convention.” |
| Pandemic Mitigation Project | <p>Advocates for adoption of a Pandemic Non-Proliferation Agreement</p> <ul style="list-style-type: none"> • The scope of the agreement would be limited to three elements regarding <ul style="list-style-type: none"> – “notification” – “grant of access” – “enforcement provisions to encourage compliance.”^f |

Table 4.1—Continued

| Proposal | Key Provisions |
|--|--|
| Biological and Toxin Weapons Convention (BWC) expansion ^g | <p>Expand or reinterpret portions of the BWC mandate to include pandemic preparedness and response. Specifically,</p> <ul style="list-style-type: none"> • provisions for using bilateral or multilateral consultations (Art. V) and/or requesting the UN Security Council investigate outbreaks (Art. VI) could be used now if a pandemic was of “suspicious” origins • other articles, such as assistance to states (Art. VII) or exchange of equipment, materials, and information (Art X), could be used to aid preparedness and response to a pandemic. |

^a World Health Organization, 74th World Health Assembly, Agenda Item 17.3 25, May 25, 2021.

^b Justin S. Gruenberg, “An Analysis of United Nations Security Council Resolutions: Are All Countries Treated Equally?” *Case Western Reserve Journal of International Law*, Vol. 41, No. 2, 2009, p. 481.

^c Dag Hammarskjöld Library, “Are UN Resolutions Binding?” webpage, January 17, 2022.

^d European Council, “An International Treaty on Pandemic Prevention and Preparedness,” press release, December 21, 2021.

^e National Academies of Sciences, Engineering, and Medicine, “Science Academies from G20 Nations Urge Their Governments to Promote Creation of Global Surveillance Network to Detect Early Signs of Potential Future Pandemics,” statement, August 6, 2021.

^f Pandemic Mitigation Project, homepage, undated.

^g Daniel M. Gerstein, “Could the Bioweapons Treaty Be Another Tool for Addressing Pandemics?” *Bulletin of the Atomic Scientists*, March 12, 2021.

tions adopted by the Security Council under Chapter VII of the charter are considered binding on all UN member states, carry the force of law, and can be used to compel nations to act.¹¹⁹ This approach has been used successfully in other areas, such as the nonproliferation of weapons of mass destruction. UNSCR 1540, a key nonproliferation agreement, calls for nations to “adopt policies and practices that would keep the financing, technologies and materials needed to create WMDs [weapons of mass destruction] out of the hands of ‘non-State actors.’”¹²⁰ Yet, given the state of major power relations, Russia and China are not likely to support measures that mandate access to investigate real or alleged incidents, require prompt notification, and impose enforcement measures. Their right to veto UNSCRs makes this option unlikely anytime soon.

The European Union developed a proposal for a stand-alone international treaty on pandemics. It identified five major areas that would be covered within such an inter-

national agreement: early detection and prevention, resilience, response, a stronger international health framework, and a “One Health” approach. At this stage, it remains the most encompassing of the six proposed reform initiatives. However, given this comprehensive recommendation, it would undoubtedly need to be deconflicted with current WHO authorities, as many would likely be overlapping.¹²¹

The most recent of the six reform proposals comes from an August 6, 2021, statement of the science academies of the G20 nations. The statement urged their governments to “promote the creation of a global surveillance network that could detect the harbingers of a potential new pandemic” and sought to “inform discussions at the G20 Summit in Rome in October.”¹²² The statement called for development of a global biosurveillance network; a capacity for manufacture and delivery of medical countermeasures and other supplies; and work toward a formal convention.

A fifth proposal, the Pandemic Mitigation Project, comes from a group of nongovernmental, concerned citizens. It calls for the adoption of an agreement that would require countries to provide immediate notice of potential epidemic or pandemic events and grant immediate access to pre-vetted specialists to assist in identification, isolation, and mitigation of the pandemic threat.¹²³ As envisioned, the treaty would be a standalone agreement that would need to be negotiated.

The final initiative considers the possibility of using the BWC, which has some limited elements calling upon signatories to pass implementing legislation that can further preparedness and response capabilities, to address disease events. This initiative could have the most relevance in cases in which outbreaks and pandemics are suspected to have come from an illicit biological weapons lab. The BWC already has articles for bilateral and multilateral consultations in the event of questionable biological events. Moreover, the UN has a mechanism for bringing BWC-related issues to the UN Secretary General.¹²⁴ At the BWC expert meeting held in August 2021, questions about COVID-19 preparedness and response led to calls “to revamp the biological weapons convention . . . to make the convention effective in the modern age.”¹²⁵

Which Path to Reform?

No single path for reform of the preparedness and response capabilities for global outbreaks and pandemics seems superior at this point. More detail would be required before such a decision could be made. However, each of the six

initiatives provides interesting elements for consideration in a future international mechanism—either a convention, agreement, instrument, or other obligation—for ensuring global preparedness and response capabilities are in place and functional.

The decision on a path forward should also account for the realities of international cooperation and collaboration. Developing new agreements and treaties is normally a time-consuming process and does not assure that the final products will provide the authorities and mechanisms to achieve the desired outcomes. Adapting existing organizations or multilateral agreements, such as the WHO and BWC, can also be challenging because their long histories can get in the way of comprehensive reform efforts. Organizations that rely on consensus are often challenged to take definitive positions and normally arrive at compromise or “least common denominator” solutions.

It is also unlikely that the seven specific long-term recommendations of the independent panel would be adopted in their entirety. While comprehensive, they would likely be costly to implement and provide the implementing body authorities that could exceed what potential member nations might be comfortable supporting.

An important first step for the United States could be to determine goals and potential redlines that should not be crossed for a new pandemic convention, agreement, or other international instrument. All six proposals provide interesting provisions that warrant consideration. Those that show the most promise for gaining consensus should be “stress-tested” to determine whether they will accomplish the U.S. goals without crossing any potential redlines.

CHAPTER FIVE

Balancing Risks and Benefits from Gain-of-Function Research on Dangerous Pathogens

Alison K. Hottes

China's WIV is a leading authority on coronaviruses and published the genetic sequence for the virus that causes COVID-19.¹²⁶ The recorded appearance of the COVID-19 pandemic near the WIV, which was carrying out gain-of-function research with bat coronaviruses, has reignited debate over what gain-of-function research of concern (GOFROC) (if any) should be conducted, who should do it, and what precautions and processes should be employed.¹²⁷

Gain-of-function experiments modify the genetic sequences of biological agents to give them new properties. A small portion of gain-of-function experiments, such as those that increase the pathogenicity of a biological agent capable of causing substantial mortality and illness in humans, are GOFROC and include higher risks than experiments with naturally occurring agents.¹²⁸ GOFROC often probes the molecular determinants of virulence and transmission to understand what might emerge from nature in the future and creates tools for developing and testing medical countermeasures, sometimes providing insights and benefits not available through other experimental approaches.¹²⁹

A previous round of GOFROC deliberations occurred during the 2010s and left behind a large corpus of analysis. (The types of GOFROC to which different policies apply vary; for brevity, this essay does not attempt to delineate the distinctions between the GOFROC covered by differ-

ent policies.) In 2014, following concerns over experiments that increased the transmissibility of a highly pathogenic avian influenza virus¹³⁰ and biosafety lapses in federal laboratories,¹³¹ the USG paused funding of some types of GOFROC in the United States to give the National Science Advisory Board for Biosecurity (NSABB) time to study the issue and formulate recommendations.¹³² Ultimately all requests to the National Institutes of Health (NIH) for waivers were granted, and work was permitted to proceed.

To support the NSABB's efforts, the National Research Council conducted two international conferences that each produced over 100 pages of proceedings,¹³³ and the NIH commissioned an ethical analysis¹³⁴ and a thousand-plus-page risk and benefit analysis on GOFROC.¹³⁵ During this time, other countries and scientific organizations also deliberated on GOFROC.¹³⁶ In 2016, the NSABB published recommendations (summarized below).¹³⁷ In January 2017, the Office of Science and Technology Policy (OSTP) announced that federal entities could lift the 2014 moratorium after developing review processes for GOFROC aligned with the NSABB's recommendations.¹³⁸

More recently, multiple studies have considered possible causes of the COVID-19 pandemic,¹³⁹ including exposure of a human to an infected animal and laboratory accidents with naturally occurring or genetically engineered biological agents (such as from GOFROC).¹⁴⁰ Some of the analyses have included an examination of WIV's work, including its contribution to an NIH-funded study led by the University of North Carolina at Chapel Hill that combined portions of bat viruses and a mouse-adapted version of the virus that causes SARS to examine contributors to pathogenicity.¹⁴¹ The work with the chimeric viruses was completed before the NIH's GOFROC funding pause.¹⁴²

The NIH later reviewed the experiments and approved them for continuation.¹⁴³ The WIV also did other work with coronaviruses at the Biosafety Level 2—likely not GOFROC—with fewer biosafety precautions than a U.S. laboratory would have typically employed.¹⁴⁴

COVID-19 Stimulates New Policy Responses

Regardless of the cause, one of the possible consequences of biosafety and biosecurity failings with GOFROC (as well as other biocontainment laboratory work) has been made all too real by the COVID-19 pandemic. Thus, it is an opportune time for U.S. officials to revisit the subject of GOFROC, including the NSABB’s recommendations, how those recommendations have been operationalized, and what additional measures might be considered. In February 2022, the Acting Director of NIH requested that the NSABB review the scope and effectiveness of its previous recommendations.¹⁴⁵ The NIH held a virtual meeting in spring 2022 soliciting comments on the oversight of research involving enhanced potential pandemic pathogens.¹⁴⁶

The NSABB originally made seven recommendations to the USG:

1. Subject proposals for USG funds for GOFROC to a multidisciplinary review to confirm that they satisfy a variety of principles, including that the benefits justify the risks.
2. Use an advisory body to provide transparency into how the USG oversees GOFROC.
3. Adapt policies for oversight of GOFROC over time to keep up with changes in risks and benefits and

collect and analyze data (e.g., information on biosafety and biosecurity incidents) to inform such modifications.

4. Integrate mechanisms to oversee GOFROC into existing policy frameworks when possible.
5. Examine options to ensure that all GOFROC conducted within the United States or conducted by U.S. companies, regardless of how it is funded, receives oversight.
6. Enhance laboratory biosafety and biosecurity.
7. Discuss GOFROC oversight and norms with the international community.¹⁴⁷

In 2017, the OSTP announced that federal entities could lift the 2014 moratorium after developing review processes for GOFROC that aligned with the NSABB’s recommendations.¹⁴⁸ However, no other federal agency has publicly released a similar policy,¹⁴⁹ and some nongovernmental experts have criticized aspects of the way the HHS has implemented its policy. For example, while HHS staff have mentioned the number of GOFROC proposals HHS has reviewed, HHS has not named the members of the multidisciplinary review panel or described the substance of their deliberations.¹⁵⁰ Additionally, despite language in the OSTP Potential Pandemic Pathogen Care and Oversight (P3CO) guidance stating that “to the maximum extent possible, agencies’ [GOFROC] review mechanisms should provide transparency to the public regarding funded projects involving [GOFROC],”¹⁵¹ HHS does not flag the grants it funds that received GOFROC reviews within its NIH Reporter database.¹⁵²

Despite the 2017 changes in federal guidelines, research with potential pandemic pathogens did not receive intense scrutiny until after the COVID-19 pandemic. In an

October 2021 letter to the ranking member of the House Committee on Oversight and Reform, the NIH revealed that grants it provided to the EcoHealth Alliance, which in turn funded the WIV, supported research that increased the lethality of coronavirus in a mouse model and changed the virus that causes MERS.¹⁵³ The NIH indicated that it determined that the research did not fall under the P3CO framework prior to funding it because “these bat coronaviruses had not been shown to infect humans” but acknowledged that EcoHealth Alliance did not comply with the terms of the grant that required it to promptly report such findings as the increased pathogenicity in the mouse model.¹⁵⁴ The NIH also stated that the viruses used in the experiments in question were too dissimilar from the virus that causes SARS-CoV-2 to have caused the COVID-19 pandemic.¹⁵⁵ Similar research proposed to the Defense Advanced Research Projects Agency in 2018 was rejected as too risky.¹⁵⁶ Previously referenced public meetings called by the NIH Acting Director should provide an opportunity to revisit the federal guidelines and how they are implemented, including the scope of the research that should be subject to increased oversight and the nature of that oversight.

Additional Measures to Address the Issue

In addition to enhancing laboratory biosafety and biosecurity (the topic of another essay in this Perspective), the USG (ideally with other governments and international organizations) might consider several options. First, other government organizations could follow HHS’s lead and either publish the processes they use to decide whether to fund GOFROC or indicate that they do not fund such

research.¹⁵⁷ Any agency that does not have a GOFROC review process thereby remains bound by the terms of the 2014 moratorium.

Second, since the existing guidance over GOFROC research governs only government-funded activity, the USG (and others) could examine ways to provide oversight for GOFROC that is privately funded.¹⁵⁸ One option is to allow industry to use government review processes on a voluntary basis.¹⁵⁹ This approach is similar to how the Recombinant DNA Advisory Committee that was established in the 1970s is employed.¹⁶⁰ Rather than seeking to avoid oversight, industry provided many of the committee’s first cases out of a desire to understand and meet the new standards.¹⁶¹

Third, the USG (and others) could examine the trade-offs associated with making additional information about GOFROC public. For example, HHS might disclose the members of the GOFROC review panel, similar to the way the membership of other NIH scientific review panels is published.¹⁶² In contrast, discussions during the peer review process are normally kept confidential to protect intellectual property and encourage an open exchange of ideas, and publicizing details of proposed GOFROC experiments and any new protocols could add to biosecurity risks by providing to lab personnel with insufficient biosafety practices or malicious intent the information needed to attempt the work. On the other hand, NSABB did not recommend a specific method for comparing risks and benefits and deciding whether the latter justify the former. Describing the approach the committee employs for that task would provide an opportunity for the United States to influence international norms.¹⁶³

While the three options previously described would provide a measure of transparency, they would have limited usefulness in assessing potential causes of a future pandemic. What is needed instead are insights into the genetic sequences of the biological agents that laboratories are testing and creating—information of high value to attribution efforts. For that reason, WIV’s removal of a database of bat virus sequences from its website in September 2019 created suspicions.¹⁶⁴ Similarly, CNN reported that the IC analyzed genetic sequences from WIV as part of its investigation into the origins of COVID-19.¹⁶⁵

Current protocols regularly generate billions of bases of raw sequence in a single experiment. Many of the sequences produced as part of research at biocontainment laboratories would have biological structure like those of dangerous but naturally occurring pathogens whose sequences have been previously published. (For example, the genetic sequence of *Variola major*, the causative agent of smallpox, is available at the NIH’s National Center for Biotechnology Information website.¹⁶⁶) A single, complete genetic sequence from GOFROC published along with information that identifies the characteristics of the associated biological agent presents high biosecurity risks because it might inspire researchers, including those with inadequate biosafety protocols, to construct the pathogen.¹⁶⁷

In contrast, raw, unannotated sequence data generated by a biocontainment lab that include data from multiple

experiments (both GOFROC and non-GOFROC) and multiple biological agents that are released without context would likely be difficult to interpret and of low risk from a biosecurity perspective. With numerous minor unexplained differences from published sequences—some due to experimental manipulations and some due to sequencing errors—such data, under ordinary circumstances, would be unlikely to inspire follow-up. However, if a disease outbreak of interest occurred, and the genetic sequence of the outbreak’s causative agent was known, then such a dataset would be a ready-made resource in which to search for evidence that a laboratory had been working with that or similar biological agents.

While some technical details (e.g., whether raw sequence reads beyond a particular length should be spilt into shorter segments) and the full implications (including concerns private companies might have about revealing proprietary information that is not sufficiently obscured in the volume of sequence information) would need to be investigated, the accountability provided by the regular and proactive release (e.g., daily or weekly) of raw sequence data from biocontainment labs would likely outweigh the associated risks. The ongoing NSABB review and the associated discussion are an opportunity to reexamine the issues associated with research on dangerous pathogens in the postpandemic period.

CHAPTER SIX

Making Biosafety and Biosecurity a Priority

Trupti Brahmhatt and Daniel M. Gerstein

COVID-19: Why Biosafety and Biosecurity Matter

The debate regarding the origin of the SARS-CoV-2 virus that produced the COVID-19 pandemic has once more brought to light the danger of laboratory accidents, agent leaks, biosafety and biosecurity issues, and potential mitigation strategies to prevent them.

The proliferation of high-containment labs around the globe increases the chance that an inadvertent microorganism transmission might occur in the future, giving rise to yet another pandemic.¹⁶⁸ According to one recent estimate, there are at least 59 Biosafety Level 4 (BSL-4)¹⁶⁹ and at least 2,904 Biosafety Level 3 (BSL-3) laboratories worldwide, at least 1,643 in the United States and 600 in the United Kingdom.¹⁷⁰ The number of BSL-4 labs in operation, under construction, or planned across 23 countries is close to 60, with 75 percent of them in urban areas, by one account.¹⁷¹ These biosafety levels determine the type of infectious research that can be conducted in a laboratory and the requisite safety requirements, with BSL-4 being the highest safety level.

Infections acquired as a result of laboratory leaks do not consistently get reported, and there are not good surveillance procedures to detect them. According to Laura H. Kahn, a physician and research scholar at Princeton's Program on Science and Global Security, "Laboratory-acquired infections are not 'notifiable' diseases under

CDC guidelines, so they don't get reported to local and state health officials."¹⁷² Given this history of laboratory leaks that have led to eventual outbreaks that have become reportable events, the proliferation of laboratories around the globe increases the prospect of outbreaks stemming from leaks unless better biosafety is practiced around the world and alerts about leaks are incorporated into disease surveillance processes.¹⁷³ In conditions under which there is such a nexus, either in nature or in a laboratory environment, it is possible that the disease formation took place in either an animal host or in a laboratory. This possibility also highlights the critical need for safe housing and handling of animals in commercial environments, such as laboratory environments where experiments with animals are conducted and live animal markets that may not be carefully regulated.

A second possibility is that SARS-CoV-2 was transmitted to a human being because of poor handling of the virus isolates from animals. This transmission could have occurred when the original sample of the viral isolate was removed from its natural environment and brought back to the laboratory or through improper handling of the sample in laboratory conditions. Much about the harvested samples and even many of the isolates within any lab is not known, such as their transmissibility and virulence. Such was certainly the case at the WIV, where many of the samples had not yet been analyzed. As a result, it is imperative to employ proper caution in dealing with bacteriological and viral isolates. Furthermore, bacteria and viruses can mutate to form different strains. In this way, it is possible for a nonpathogenic strain of a virus to become highly adapted to a human host to make it more infectious and/or virulent to humans. In working conditions where good

laboratory practices are not followed and safe handling is not practiced, such a laboratory-acquired infection could occur.

A third possibility is that the research materials, contaminated reagents, infectious cell-lines, or animal remains were poorly handled and not disposed of properly at the WIV. The scientists or lab workers could have handled the infectious materials and transmitted the virus to other people or wild animals. As in the case of the second possibility, the pathogen could have become adapted and therefore able to more efficiently transmit to the human host, meaning it posed a greater potential for infection and even for human-to-human respiratory transmission.

It is also quite possible that the virus spread from a nondeliberate random accident in handling the virus, a laboratory animal infected with the virus, or a wild animal infected with the virus unbeknownst to the handler. Regardless of the origin of SARS-CoV-2, the safe and secure management of high-containment laboratories to prevent the occurrence of a future pandemic from poor laboratory practices needs to be a priority for the international community as the number of high-containment laboratories increases around the globe.

While concerns remain about the possibility of the deliberate development of the virus, the origins report on COVID-19 stated,

[The] IC was able to reach broad agreement on several other key issues. We judge the virus was not developed as a biological weapon. Most agencies also assess with low confidence that SARS-CoV-2 probably was not genetically engineered; however, two agencies believe there was not sufficient evidence to make an assessment either way. Finally, the IC

assesses China's officials did not have foreknowledge of the virus before the initial outbreak of COVID-19 emerged.¹⁷⁴

While the origins of SARS-CoV-2 may never be known, the above potential modes of transmission highlight the importance of biosafety and biosecurity as inherent in the handling and security of especially dangerous pathogens.

International Agreements to Bolster Biosafety and Biosecurity

Activities employing biological material and biotechnology are governed by a wide range of established conventions, regulations, and protocols. This section is not intended to be comprehensive but rather to highlight the types of ongoing activities that contribute to laboratory biological safety and security.

The BWC, which entered into force in 1975, bans the development, production, stockpiling or otherwise acquiring or retaining of “microbial or other biological agents or toxins . . . that have no justification for prophylactic, protective or other peaceful purposes.”¹⁷⁵ While the BWC serves as an unequivocal norm against the use of biological weapons and does concern biosafety and biosecurity, its mechanisms to investigate alleged violations, encourage transparency, and support an organizational body to ensure compliance are limited.¹⁷⁶

As part of the BWC regular program of work, discussions are held, papers are shared at preparatory conferences, and member states provide outreach and training programs on ways to improve biosafety and biosecurity in laboratories of the member state parties. The BWC also

has a requirement for all member state parties to develop national mechanisms in the form of laws, policies, and regulations to ensure compliance.

There are other international agreements that provide some means to enhance biosecurity. UNSCR 1540 is concerned with preventing the “proliferation of nuclear, chemical, and biological weapons, their delivery systems and related material, particularly related to non-state actors.”¹⁷⁷ Per this 2004 resolution, states are called to establish appropriate domestic controls over related materials to prevent their illicit trafficking. Domestic controls for secure production, use and transport, physical protection measures, and law enforcement against trafficking of agents are covered by the resolution. It does not expressly cover licensing personnel, registration and certification of pertinent facilities, or measures to ensure personnel reliability.¹⁷⁸

The WHO,¹⁷⁹ the World Organization for Animal Health,¹⁸⁰ and the Food and Agriculture Organization of the United Nations¹⁸¹ have all published biosafety and biosecurity guidelines. ISO 35001 is the International Standard for any organization that tests, stores, transports, works with, or disposes of hazardous biological materials.¹⁸² It builds on elements adapted from the International Organization for Standardization’s (ISO’s) occupational health and safety management system standard, ISO 45001,¹⁸³ but with emphasis on the unique aspects of biorisk management. The standard, which enables identification, assessment, control, and monitoring of risks associated with hazardous biological material, was developed by the ISO technical committee for clinical laboratory testing and in vitro diagnostic test systems. ISO 35001, along with ISO 45001, “Occupational Health and Safety Manage-

ment Systems,” and ISO 15190, “Medical Laboratories—Requirements for Safety,” round out available international standards relevant to biosafety and biosecurity.¹⁸⁴ However, all these guidelines are voluntary, and there are no enforcing mechanisms associated with them.

The Australia Group, which consists of 41 states, has the main objective of controlling exports of certain chemicals, biological agents, and equipment to prevent both direct and inadvertent involvement in the spread of chemical and biological weapons.¹⁸⁵ The Middle East and North African countries have formed the coalition of Region Network High-Containment Laboratories¹⁸⁶ to implement biosafety and biosecurity strategies at the national and regional levels, improve the infrastructure of laboratories, and emphasize staff training.¹⁸⁷ These regional efforts, however commendable, are also voluntary in nature, without any underlying enforcement mechanisms.

The GHSA has “more than 70 countries, international organizations and non-government organizations, and private sector companies that have come together to achieve the vision of a world safe and secure from global health threats posed by infectious diseases.”¹⁸⁸ Inherent in the GHSA strategic objectives is the strengthening of institutions that promote health security through the sharing of information, best practices, and lessons learned. The GHSA also seeks “to prevent, detect and respond to infectious disease outbreaks, including health system strengthening.”¹⁸⁹ This mission includes promoting responsible biosafety and biosecurity within member nations.

The United States also promotes global biosafety and biosecurity through such programs as the Nunn-Lugar Cooperative Threat Reduction program,¹⁹⁰ the CDC’s Global Disease Detection Centers,¹⁹¹ and the Department

of Defense Global Emerging Infections System (DoD-GEIS)¹⁹² program. While each of these programs has broader missions, an important component of each is the promotion of responsible laboratory programs through biosafety and biosecurity assistance and training.

The United States also has a Biological Select Agent and Toxins program, Biological Personnel Reliability Program, facility and principal investigator registration requirements, strict inventory controls, and packaging, handling, transport, and transfer requirements and procedures. Other countries have similar programs; however, they are not standardized across the globe, and many nations do not have these basic provisions for safely managing research and development of dangerous pathogens. For example, the WIV was experimenting with bat coronaviruses using BSL-2 precaution, which is not the recommended level for working with these types of dangerous pathogens. It is risky to conduct this type of research using this level of precautionary practices. However, all these approaches, whether international, regional, or national, have not proven to be entirely effective in eliminating lab accidents.¹⁹³

Laboratory Management Best Practices

There are best practices for safe and secure laboratory management. These best practices include standards and norms of behavior, codes of ethics, institutional bio committees, and national laws, policies, and regulations.

The Biosafety in Microbiological and Biomedical Laboratories (BMBL)—first released in 1984 and now in its 6th Edition—serves as the “cornerstone of biosafety practice in the United States.” The BMBL stemmed from early

efforts “to promote the use of safe microbiological practices, safety equipment, and facility safeguards that reduce LAIs [laboratory-associated infections] and protect public health and the environment.”¹⁹⁴ The BMBL has become the authoritative source for biosafety and biosecurity in the United States. It provides definitions and principles for working with a wide variety of biological pathogens at well-defined biosafety levels.

While the BMBL provides the basics, those laboratories and organizations that conduct research or store biological pathogens also have direct responsibilities for biosafety and biosecurity. Laboratory facilities generally have standard operating procedures and internal policies that guide the work that is being done in those facilities. Codes of ethics outline the expectations for responsible laboratory behavior. Institutional biorisk committees within research organizations are responsible for approving experiments to ensure they meet rigorous standards of professional behavior, that the science is being done correctly following the scientific method, and that proper safety measures are in place. However, according to one study of institutional biorisk committees published 18 years ago, these committees do not consistently comply with NIH regulations, and NIH does not consistently enforce them.¹⁹⁵

The BMBL contains specific guidance on the development of a biorisk management system for all laboratories working with biological pathogens. It is based on a system approach, which enables an organization to effectively identify, assess, control, and evaluate the biosafety and biosecurity risks inherent in its activities. The biorisk management system establishes the biorisk management principles that enable laboratories and related facilities to achieve their biosafety and biosecurity objectives; defines

Biosafety and biosecurity are imperatives for any nation, organization, facility, or laboratory that does research on or stores biological pathogens.

the essential components of a biorisk management system framework to be integrated into a laboratory or other related organization's overall governance, strategy and planning, management, reporting processes, policies, values, and culture; and describes a comprehensive biorisk management process that mitigates biosafety and biosecurity risks.

A comprehensive *biosurety* approach encompasses biosafety and biosecurity. *Biosafety* is achieved through documented standard procedures in addition to physical controls for containment functions and PPE use for the safety of people working in a laboratory. Biosafety includes equipment and the construction of the laboratory itself, as well as the practices used by laboratorians. *Biosecurity* is the protection of facilities or laboratories against theft or diversion of agents that could be used for nefarious purposes. Biosecurity employs pathogen access control; inactivation and viability testing standard operating procedures and testing; strict inventory and secure storage; and safe handling, packaging, and transport of the agents. *Biosurety* adds to the biorisk framework by including the *agent accountability* and personnel reliability needed to prevent unauthorized access to the agents. *Personnel reliability* includes initial personnel vetting and periodic evaluation of fitness via medical screening for physical and mental health.

To prevent an agent from escaping a high containment laboratory, a worldwide biosurety management system of this sort is urgently needed. Currently, various standards and best practices at international and national levels are followed with varied degrees of rigor, but no comprehensive system exists. Some nations lack some or all the biosurety practices.

Strengthening Current Systems

Biosafety and biosecurity are imperatives for any nation, organization, facility, or laboratory that does research on or stores biological pathogens. While there are international guidance documents, there are no mandated policy guidance or regulatory requirements for those who are working with biological pathogens. The lack of requirements means there are no international standards but rather a hodgepodge of national approaches to biosafety and biosecurity. Furthermore, there is no quality control or inspection criterion that guides work done in these international facilities and laboratories.

There is an overwhelming need for a new approach to biosurety. There are several options for enhancing global biosafety and biosecurity. The first priority is encouraging BWC signatory countries to adopt national laws that further the implementation of the convention. While the

BWC requires that nations develop national implementation laws that relate to the articles of the convention, only a small percentage have thus far complied with this requirement.¹⁹⁶ The Verification Research, Training and Information Center (VERTIC) compiles a list of BWC legislation by country that captures which countries have laws, executive orders, and regulations.¹⁹⁷ Some nations have few specific measures for enforcing BWC-related issues. Regardless of the exact numbers for each nation, examining several countries indicates the different approaches being undertaken across the international community. Greater standardization in this regard would be beneficial.

Second, developing a “BMBL equivalent” international standard that defines standards for basic areas—such as the principles of biosafety and biosecurity, definitions of biological safety levels (i.e., levels of containment), and the use of safety equipment—is also imperative.

Third, specific requirements should be developed that relate the dangers of the biological pathogen to the level of security at the facility or laboratory. These requirements should include the physical, cyber, and information security at the facility. For especially dangerous pathogens, those for which there are either no or limited medical countermeasures, such as vaccines and therapeutics, spe-

cial precautions should be undertaken to ensure the security of these pathogens.

Fourth, national inspection protocols should be required for all laboratories and facilities within a country’s borders that conduct research on pathogens requiring a BSL-3 or higher level of facility. This requirement should also pertain to laboratories and facilities that conduct what the United States calls *Dual Use Research of Concern*. Any laboratory personnel working at BSL-3 or above should also have regular training and education. Finally, BSL-3 or above laboratories should have national-level inspections on an annual basis.

Finally, the leadership of all biological laboratories should be required to attend training and education emphasizing biosafety and biosecurity. Following attendance, the head of the laboratory should be required to conduct a self-assessment of the laboratory. Leaders should also be responsible for conducting periodic training and education with their staffs and promoting a culture of responsibility within their laboratories. This set of measures would greatly enhance lab biosecurity and biosafety around the globe.

CHAPTER SEVEN

Meeting the Medical Supply Needs of the Next Pandemic

Bradley Martin and Daniel Gerstein

The COVID-19 pandemic strained the resources of the United States at every level and in numerous communities. It has hospitalized millions of people, and estimates of the number of deaths worldwide range from more than six million reported to WHO¹⁹⁸ to as many as 18 million.¹⁹⁹ The pandemic laid bare some significant vulnerabilities in the highly interconnected economies of the current era, and it reemphasized China's importance in the U.S. supply chain. The vulnerabilities described in this chapter are, in many ways, national security issues because unless they are addressed, they could be leveraged by a foreign power to hold hostage the U.S. public health supply chain.

The effects on U.S. supply chains can be seen across all goods and services and within all critical infrastructure areas. COVID-19 exposed critical vulnerabilities that have come to define our economy. For materials that are important for contending with a global pandemic, the U.S. economy lacks resilience and has prioritized efficiency over preparedness. We have a just-in-time logistics system that does not work in times of crisis, including during a pandemic. The results are measured in unforeseen disruptions and increased risks.

Early in the pandemic, it became clear that the virus and responses to it were wreaking havoc with supply chains. The People's Republic of China's (PRC's) lockdowns and stringent limitation of economic activity consequently restricted many other nations' access to critical medical

supplies. However, even where preparedness and response through planning, stockpiling, training, and exercises had occurred, the United States experienced shortfalls in its supply chains from lack of timely decisions, mixed messages to the public, and the presidential decision not to employ such capabilities as the Strategic National Stockpile (SNS) and Defense Production Act (DPA). In short, problems with our supply chains were exacerbated by leadership failures.

The COVID-19 pandemic also illustrates the importance of early and decisive decisionmaking, especially as it pertains to supply chains. This would be true even in the absence of a strategic competitor. However, China's role as a competitor, major trading partner, and manufacturer of key commodities (including medical supplies) exacerbated the supply chain issues faced by the United States and the broader international community. Under different circumstances, China or another foreign power might withhold key public health supplies to extract favors.

The COVID-19 Pandemic

COVID-19 surfaced as a serious public health concern in early 2020. As the number of critically ill patients increased in the United States, it became clear that the nation's supply of intensive care units was insufficient. Surge facilities were constructed, but then the lack of trained personnel to staff the expanded facilities became an issue.²⁰⁰ Simply identifying hospital capacity and trained medical personnel was a serious problem and continues to be a challenge as new variants emerge and the epidemic ebbs and flows.²⁰¹

While this chapter focuses on medical supply chain issues, it is useful to examine the state of our supply chains

across other commodity areas to appreciate the scope and scale of the broader issues the U.S. economy and medical supply chains faced as a result of COVID-19. A March 2020 report indicated that COVID-19 had “disrupted supply chains for nearly 75% of U.S. companies.”²⁰² These disruptions caused multiple problems for the workforce, manufacturing, transportation, and loading and shipping of goods in China. Of the companies interviewed, 44 percent offered that they did not have a plan to address these disruptions.²⁰³

These shortfalls also occurred in medical supplies and PPE. The nation was faced with such unexpected dilemmas as shortages of nasal swabs and chemicals for testing kits.²⁰⁴ Shortages of N-95 protective masks became apparent and even may have affected the early advice about the desirability of mask-wearing. “I don’t regret anything I said then because in the context of the time in which I said it, it was correct,” said Dr. Anthony Fauci, the government’s top infectious disease advisor. “We were told in our task force meetings that we have a serious problem with the lack of PPEs and masks for the health providers who are putting themselves in harm’s way every day to take care of sick people.”²⁰⁵ The shortages in PPE and medical supplies resulted in unhealthy competition rather than collaboration, hoarding of supplies across the globe, and a form of supply chain nationalism.

Shortages of basic components of complicated medical equipment, such as ventilators, also became a cause for concern. Ventilators are commonly used in hospitals to support breathing by getting additional oxygen into patients’ lungs. In February 2020, as far as the U.S. medical and public health establishment knew, there was a sufficient supply of ventilators. Several thousand ventilators

were also contained within the U.S. SNS that was established originally to stockpile medical countermeasures and equipment that could be needed in the event of a bioterrorism attack.²⁰⁶ However, public health planners had failed to appreciate the necessity of larger numbers of ventilators in the case of a pandemic. The COVID-19 pandemic resulted in an explosion in the demand for ventilators that eventually exceeded the supply available for critically ill patients whose numbers were neither anticipated nor planned for.²⁰⁷ Demand went up 500 to 700 percent, and the shortage of ventilators was dire.²⁰⁸

Shortages in factory capacity and components and, in some cases, a lack of experience in manufacturing ventilators limited capabilities to build to the anticipated requirements. Components such as filters, alarms, tubing, and power supplies were produced in different countries worldwide, with indeed some produced in the Wuhan District of the PRC, which was largely shut down due to COVID-19.²⁰⁹

The spike in demand for some commodities was challenging in itself; the lack of information on commodity origin was even more problematic. Not knowing where all the components for a product are made is not a problem for most users. If supplies move freely and production moves toward the places where these parts can be readily obtained, few notice the sourcing. However, in a crisis, whether manmade or externally imposed, not knowing the origins of materials can become a serious problem when normal flows cease. The rush to find parts for and build ventilators provides an example of the supply chain challenges.

Some supply chain shortages stem from long-term business arrangements that increasingly rely on overseas markets for vital ingredients. One such example is APIs,

which are essential for the pharmaceutical market. According to one source, “28% of manufacturing facilities making active pharmaceutical ingredients (APIs) for the U.S. market are based in the U.S. The remaining 72% of API manufacturers supplying the U.S. market are outside the U.S., this includes 13% in China.”²¹⁰ To further highlight the concern, the Food and Drug Administration identified “approximately 20 drugs which solely source their active pharmaceutical ingredients or finished drug products from China.”²¹¹

Other medical supply chain problems come from scarce ingredients that are only available (in this case grown) in certain areas of the world. One example is the *Quillaja saponaria* tree that is only found in Peru, Chile, and Bolivia, which is used as an adjuvant in the shingles vaccine and as an immunostimulant.²¹²

The Implications for U.S. National Policy

The rapid development of COVID-19 vaccines stands as a remarkable scientific and medical achievement. The ability of the U.S. pharmaceutical industry and laboratories to generate advanced medical technology does not appear to be at issue. What is at issue is access to such routine items as PPE, laboratory supplies, parts for medical equipment, and potentially the APIs for generic medications.²¹³ With no effort by any malign actor to undermine supply, supply chains across the world were disrupted, with risk imposed on all countries, including the United States. Factor in possible actions by a competitor bent on exerting influence, and the problems may prove difficult and have serious national security implications.

Structural Issues with Medical Supply

Although this pandemic has illuminated medical supply deficiencies in a profound way, solutions to these challenges are not so easily identified. A major factor has to do with the structure of the U.S. health care system and how care is delivered and distributed. There are no incentives for the private sector to take steps to address these problems; instead, public health entities will need to take the lead. The economics of medical delivery are complicated, and this Perspective is not intended to grapple with the policy (or ethical) questions that attend the process of care delivery and distribution. RAND has an extensive body of research on this broad set of topics.²¹⁴

The U.S. health system is effectively a fragmented, for-profit enterprise in which the actors expect private gain for goods and services delivered. This is not necessarily an inducement to broad competition and has in fact resulted in near monopoly of drug manufacturing and distribution.²¹⁵ Without even attempting to address questions of equity, we can say that private incentives would not, in and of themselves, naturally create conditions of readiness for a pandemic. Public health and national security are providing public goods, which involves a set of incentives beyond what individual economic actors will provide.²¹⁶

So, What Can Be Done?

We do not specifically know what public health challenges the world might face in the future. Challenges could come from diseases, man-made or natural, intentionally or unintentionally spread, or they could come from natural disasters, wars, or market collapses. Any of these circumstances would require a response from the USG because the problems are so large that neither local jurisdictions nor the

The government must take action to replenish its stockpiles.

private sector would be able to muster the resources to deal with them. Response efforts will also require coordination with geopolitical allies, commercial partners, international organizations, and the range of stakeholders in public health. But the United States can take steps to improve response capabilities and consider hostile interference in the supply chain by adversaries, particularly when dealing with potential supply shortages like those the nation has experienced with the COVID-19 pandemic over the past two years.

As a first step, critical supply chains must be mapped to enable a more complete understanding of where critical components and finished goods are sourced and to identify potential challenges. This undertaking is well beyond the scope of individual government agencies, individual companies, or even industry trade groups. HHS and the Department of Homeland Security have led discussions with trade groups that indicated that they were both surprised by and unprepared for the complex relationships among suppliers for things as simple as nasal swabs and as complex as APIs for generic drugs.

Second, the government must take action to replenish its stockpiles. Both the executive branch and the Congress have a role in making sure stockpiles are adequately funded and maintained. Some high-demand commodities can be readily stored for extended periods or regularly rotated as they reach shelf life. These commodities include PPE

and components common to medical equipment (such as tubing or pressure valves). U.S. policymakers must also reevaluate the SNS to clarify missions, stockage types and levels, and distribution procedures to ensure that the SNS will be responsive to the needs of the local authorities during crises. But stockpiles are not the answer to everything.

When the SNS was originally envisioned as the National Pharmaceutical Stockpile in 1999, it was intended for preparedness and response against bioterrorism. However, since its inception and the changing of the name to the SNS in 2003, the missions have continued to expand, as has the inventory within the stockpile. The SNS now has mission to support “all hazard” preparedness and response, yet it still retains a focus on bioterrorism, which can be seen in the medical countermeasures that are contained within the SNS. Furthermore, the SNS was never intended to be able to completely service a widespread, national-level event.

The need for some items may not be known, or they could not realistically be kept in reserve pending an emergency. For example, ventilator storage becomes difficult over an extended period because the equipment needs periodic maintenance.²¹⁷ Moreover, ventilators cannot be manufactured quickly.²¹⁸ To address the challenges inherent in having an adequate supply of ventilators requires investing in more manufacturing and maintenance capa-

bilities with the understanding that there will be sunk costs and, potentially, unused capacity. Similarly, drugs have a shelf life and, without specifically knowing which will be necessary, trying to keep a sufficient amount on hand for an unknown future pandemic might be unrealistic.

Third, we must take a network approach to developing a strategic national supply chain that brings together all the different methods that can be used for ensuring that the necessary supplies are available when needed for future pandemics. The SNS is only one component of a larger network of capabilities that must be harmonized through planning, training, and exercises and adapted as necessary for specific crises. Government subsidies to maintain warm production lines could be established for some key commodities required in the event of certain emergencies. For example, response to a pandemic requires a ready and continuous supply of N-95 masks, certainly more than is reasonable to stock for the nation over a two-year period, as has been the case with COVID-19.²¹⁹

To the extent possible, procurement should be conducted as a collaborative effort between the federal and local (i.e., state, local, tribal, and territorial) authorities. Such an undertaking means bringing together key stakeholders to coordinate efforts and, where possible, relying on national-level procurement to take advantage of economies of scale. It can also mean working with manufacturers—both pre-crisis, during planning, and for crisis response—to have direct contracting agreements in place. As part of this analysis, we should examine where it might be possible to shorten supply lines by reshoring commodities that are critical to our preparedness and response. The role of the DPA should also be considered as an available resource for obtaining critical supplies, equipment,

and services.²²⁰ The DPA provides the federal government with the authority to access industry “to prepare for and respond to military conflicts, natural or man-caused disasters, or acts of terrorism within the United States.”²²¹

Lastly, meeting the medical supply needs of the next pandemic will continue to depend on research, development, and innovation conducted prior to the next crisis or as that crisis is unfolding. Today’s scientific discoveries and technology development provide the capabilities for tomorrow that support crisis preparedness and response.

Operation Warp Speed (OWS) provides an interesting example to illustrate the importance of research, development, and innovation. OWS was a comprehensive program that sought “to begin delivery of 300 million doses of a safe, effective vaccine for COVID-19 by January 2021, as part of a broader strategy to accelerate the development, manufacturing, and distribution of COVID-19 vaccines, therapeutics, and diagnostics (collectively known as countermeasures).”²²² While OWS was officially established in March 2020, the science undergirding the vaccine development can be traced to research and development programs that had been ongoing for decades, including the Human Genome Project—the international effort to map the human genome led by NIH and the Department of Energy—and the Defense Advanced Research Projects Agency’s early research and development funding of messenger RNA technologies that formed the foundation for two of the earliest and most successful of the COVID-19 vaccines that employed this technology.

OWS also revealed some difficult lessons about supply chains that should be considered for future distribution of medical countermeasures. Specifically, supply chains must be considered to extend from the development and

distribution of key equipment, supplies, and medical countermeasures to the “last tactical mile,” which, in the case of vaccines, means to the point of getting shots into arms. In the early stages of vaccine distribution, OWS took responsibility only for the supply chain that reached into the states’ centralized distribution centers, but this was found to be ineffective for achieving the ultimate goal of vaccinating the greatest number of people possible as rapidly as possible. By extending the supply chains to the last tactical mile, the distribution process was streamlined.

While the distribution varied among states, the Federal Emergency Management Agency and National Guard often either augmented or even took charge of vaccine distribution (of course, in coordination with each state’s governor’s priorities). OWS also reinforced the criticality of communications between federal and local authorities in vaccine distribution. At the beginning, there were communications gaps between state and federal authorities that hindered the overall vaccination program.²²³ Once these two shortfalls were addressed, the pace of vaccinations dramatically increased.

Conclusions

Access to essential products and commodities in a pandemic-type environment requires having sufficient

accessible capacity in the domestic industrial base to allow a rapid increase in production, which may require outright subsidy by the USG. Development could be funded through the existing system of federally funded laboratories and development centers. Maintenance of manufacturing capability, however, poses a different set of complicated issues, which will take concerted research and planning efforts, enabling legislation, new organizations, and, likely, additional funding.

COVID-19 has taught us about the type of supply shortages that can arise in a public health emergency, and we need to use that information to plan for the future—to know where our supplies come from, stockpile realistic quantities when we can, and put in place the mechanisms needed to ensure access to capacity. HHS and its component elements, such as the CDC, along with the Department of Homeland Security and its Federal Emergency Management Agency component are the appropriate entities to lead these operations. The Department of Defense can also provide a ready source of support, as in the case of OWS and last tactical mile vaccine distribution. The experience of the COVID-19 pandemic underscores how many different government elements have important national security missions when faced with a public health crisis of this magnitude.

CHAPTER EIGHT

American Attitudes About Vaccine Globalism

Katherine Grace Carman and Anita Chandra



SOURCE: WHO photo, used with permission.

The United States delivered 1 million doses of the Moderna vaccine to Tunisia through the COVAX mechanism in July 2021.

The COVID-19 pandemic is a global threat, with nearly 500 million cases and 6 million reported and 18 million estimated deaths throughout the world as of the end of May 2022.²²⁴ Furthermore, despite the development of highly effective vaccines, vaccine access is not universal, with poorer countries lagging much farther behind richer countries. Health experts fear that new variants may arise and perhaps be more pernicious in countries where vaccination rates remain low. One potential strategy to help

suppress future spread of COVID-19 is for wealthier countries that already have high vaccination rates to donate vaccines to those countries in need and provide resources to ensure effective use. Thus far, the USG has donated more than 537 million vaccine doses to more than 110 countries, and President Biden has pledged to share a total of 1.2 billion doses.²²⁵ Understanding Americans' attitudes toward vaccines for themselves and others remains important for fighting any variant of COVID-19 and addressing any future infectious disease that may spread around the globe. There has been significant and warranted concern about vaccine nationalism at the national policy level, but RAND endeavored to understand whether attitudes that may underlie this concern are expressed by the American public.²²⁶

In September 2021, as the Delta variant was beginning to decline but before the emergence of the Omicron variant, RAND researchers asked a group of 1,753 Americans about their views on sharing vaccines with other countries. These questions were part of the final survey in a series of surveys of the American health mindset and COVID-19 experiences, funded by the Robert Wood Johnson Foundation and conducted at four time points between summer 2020 and fall 2021.²²⁷

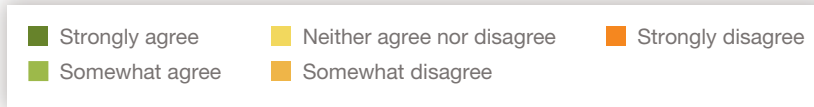
More than two-thirds of respondents strongly or somewhat agreed that the United States should send extra vaccines to other countries (Figure 8.1, top panel). While the Delta variant was still affecting Americans in September 2021, nearly 60 percent of Americans reported that they agreed that if the United States did not help to fight the spread of COVID-19 in other countries, it would put the country at greater risk (Figure 8.1, bottom panel).

FIGURE 8.1
American Views About Sharing Vaccines with Other Countries

The United States should send extra vaccines to other countries.



If the United States does not help to fight the spread of COVID-19 in other countries (e.g., sending vaccines, sending money), it will put our country at greater risk.



SOURCE: Experiences of Populations at Greater Risk Survey (Carman et al., 2021).

Support for global strategies was much higher among those who reported receiving at least one shot of any COVID-19 vaccine (Figure 8.2). For both questions, more than 70 percent of those who had received at least one shot supported a global response, while only one-quarter to one-third of those who were unvaccinated supported a global response. The difference between these two groups is striking.

We also observed strong differences by income and education, which are notable when describing the extent of public will. Those with higher incomes (Figure 8.3) and higher levels of education were generally more likely to support global strategies. Those with incomes over \$100,000 per year were more than 20 percentage points more likely to agree than those in the lowest-income groups, and those with more than a college education were

approximately 20 percentage points more likely to agree than those with less than a high school education.

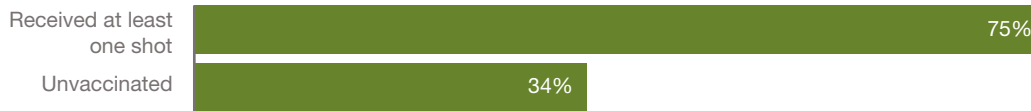
Overall, American support for sharing vaccines globally was high even before the most recent variant. This is a cause for optimism for two reasons. First, while findings about the American health mindset—including in this set of surveys—have often underscored a sense of health individualism, in this case, there appears to be a deeper understanding of the benefits of acting at a global level.²²⁸

Further, these findings may reflect an American recognition of the interdependence inherent in pandemics and the benefit from proactively addressing the issue beyond U.S. borders to truly be on the path to pandemic recovery.

These survey results suggest that policymakers may have more public support than anticipated to take measures to help other countries contend with disease out-

FIGURE 8.2
Interest in Sharing Vaccines, by Personal COVID-19 Vaccination Status

The United States should send extra vaccines to other countries.



If the United States does not help to fight the spread of COVID-19 in other countries (e.g., sending vaccines, sending money), it will put our country at greater risk.



SOURCE: Experiences of Populations at Greater Risk Survey (Carman et al., 2021).

breaks that have the potential to spread to the United States. As the COVID-19 pandemic wanes, and many countries tentatively return to normal, policymakers and health professionals have some noteworthy successes to herald amid millions of deaths attributable to the virus. Effectively communicating the value of global vaccine sharing requires deft crafting of the public message and consideration of the differences in public attitudes by sociodemographic factors, such as income and education. If policymakers make the case, with attention to subgroup differences in acceptability and understanding, that providing vaccines to other countries facing an outbreak is in the interest of preventing a health crisis in the United States, the political downsides may not be as great as many feared.

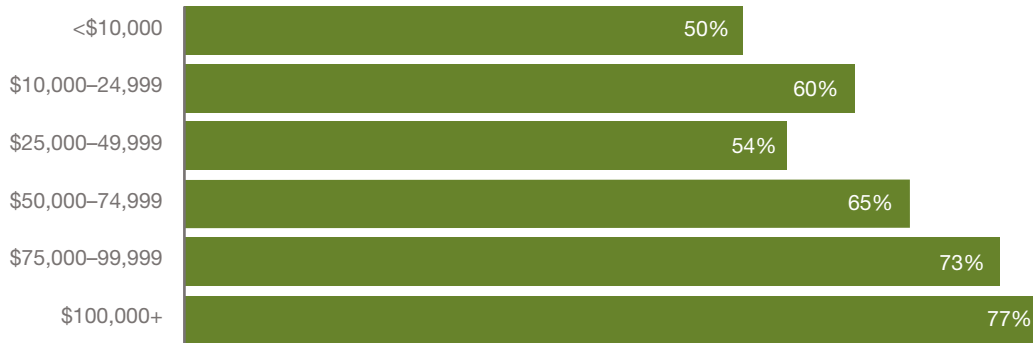
While it is unclear how durable positive attitudes towards vaccine globalism will remain among the Ameri-

can public, the enduring resistance to proven measures to stem COVID-19 in the United States among some groups via vaccinations, mask wearing, testing, and social distancing remains worrisome, particularly as we consider this in the context of waning general trust in public health.²²⁹ To further strengthen the value of global vaccine sharing as part of American discourse, policymakers might highlight the role donations of safe and effective vaccines have had in the containment of COVID-19 in foreign countries. Celebrating the end of the battle against COVID-19—won, in part, by mass vaccinations—could underscore the benefits of vaccines in future pandemics.

More study of how to effectively augment the American public's appreciation of the value of sharing vaccines globally is needed. It is conceivable that another point of national pride related to the rapid development and production of vaccines in the United States and Europe could

FIGURE 8.3
Interest in Sharing Vaccines, by Income Status

The United States should send extra vaccines to other countries.



If the United States does not help to fight the spread of COVID-19 in other countries (e.g., sending vaccines, sending money), it will put our country at greater risk.



SOURCE: Experiences of Populations at Greater Risk Survey (Carman et al., 2021).

NOTE: Percentages show respondents who indicated that they strongly agree or somewhat agree with the statement.

be leveraged to extend positive views of vaccine sharing. The dreaded wait for the development of safe and effective vaccines took much less time than feared during the early phases of the COVID-19 pandemic. The Russian

Sputnik-V and China's Sinovac vaccines have not proven to be as effective. Countries that originally accepted these vaccines promoted by Russia and China have moved to vaccines produced in the United States and European

countries.²³⁰ Moreover, the development of these vaccines has not been transparent. The WHO has never approved Sputnik-V because of the lack of transparent trial data, and the Russian national approval of the vaccine short-circuited the bulk of the usual clinical trials.²³¹

Highlighting the vaccine development and production miracle helps to set expectations for developing and producing vaccines to contend with future outbreaks of novel infectious diseases. The United States has slowly become a major supplier of vaccines to nations in need. While Russia and China heralded their vaccines early and often, the United States has a remarkable story to tell, and telling it will further bolster its leadership on global public health issues. The full story of vaccine diplomacy is still developing, but, ultimately, the United States could have a compelling one to tell based on its donation of doses to WHO and UN programs, as opposed to just bilateral sales.

We are documenting the many government missteps in responding to the COVID-19 pandemic and the missed

actions to prevent some pandemic-related deaths in the United States. But the development and production of effective vaccines in the West, and in the United States in particular, has been a success. The safety and effectiveness of U.S.-produced vaccines should positively add to American credibility as a dependable steward of global public health. Understanding the public's more globally aware attitude toward sharing vaccines with other countries suggests that there may be a path to advance public health actions even in a politically polarized environment, but only with careful consideration of public health messaging. American political and public health officials should explore ways to leverage credibility in vaccine development and support by the American public to establish a renewed leadership role in international negotiations and discussions on matters of global public health.

CHAPTER NINE

Conclusions

John V. Parachini and K. Jack Riley

As the COVID-19 pandemic continues into a third year, the picture is mixed on how it will end, what measures will be needed to manage new variants, and what to do to prevent another global outbreak. Despite the alarming transmissibility of the Omicron variant and the tragic number of resulting deaths, as of this writing, while waves of the virus continue to ebb and flow, deaths rates are declining—but new variants are likely to come in the future, and anything is possible. Development of COVID-19 vaccines exceeded expectations in terms of the speed of development and effectiveness against poor outcomes. These vaccines have saved countless lives around the globe. There is increasing evidence that the development of antiviral drugs such as Paxlovid may also prevent high-risk patients from needing hospitalization.²³² However, distributing vaccines to the populations of countries in the developing world remains a serious, unresolved challenge that now competes with other seemingly more immediate health challenges.²³³

Failure to increase vaccination uptake in nations where they are readily available and distribute vaccines to vulnerable populations around the globe that have not yet been reached prolongs the pandemic. New variants may arise, result in more preventable deaths, pose a drag on economies, and contribute to international tensions not yet foreseen. Already the Omicron and BA.2 variants have displayed new characteristics and are spreading widely even among vaccinated people. Reducing the impact of these variants thus far has not been stymied because of problems of biology. The problems are a result of human

behavior and government policy. In short, they are problems that can be significantly lessened if there is the will to act upon valid scientific evidence and sound medical guidance. Survey results indicate that most Americans support global measures, particularly when they understand the link between global health measures and their impact on local health conditions.

Capabilities for testing, amassing, and sharing data in common formats and for genetic sequencing all need to be increased to contend effectively with future outbreaks. The pandemic has stimulated new initiatives that better equip countries to detect and manage a future pandemic outbreak. For example, wastewater surveillance has proved effective in detecting COVID-19 surges. In September 2020, the CDC launched a National Wastewater Surveillance System “to coordinate and build the nation’s capacity to track the presence of SARS-CoV-2,” which has emerged as an early warning system.²³⁴ As with many of the pandemic-era data-generating initiatives, the challenge is obtaining the data quickly in forms that can be analyzed effectively and generating meaningful and actionable insights. Other countries are making noteworthy progress in this area as well.²³⁵

Although the United States was slow to ramp up its testing capability because it lacks a uniform and centralized system for collecting testing data, these capabilities are, fortunately, much improved after two years of contending with the virus. Testing wastewater has also expanded, which adds another important source of information on the spread of the virus.²³⁶ Genetic sequencing of virus test samples can provide an early warning measure for new variants. Two former DoD officials responsible for biological defense measures have argued that “Next-generation

genomic sequencing, enhanced by machine learning and AI [artificial intelligence] is now making it possible . . . to characterize a pathogen and engage in real-time monitoring of its behavior.”²³⁷

Their focus was on rapidly identifying pathogens used as weapons, but these capabilities also apply to more-likely occurrences, such as natural outbreaks. Gaining access to the genetic information of a new infectious disease can give officials and health professionals the decision advantage needed to inform the type of public health policies and practices put in place to counter COVID-19, such as mask wearing, hand washing, and social distancing. At least according to what we know about the variants thus far, these are simple actions that can limit infection.

Detecting an outbreak requires a vigilant testing system that produces results rapidly, accurately, and in a volume that can make a difference. The good news is that many countries, including the United States, have developed the capability to analyze the genetic information of viruses and have shared the findings broadly. A best practice has been established and will be valuable in the future if it is built upon and sustained.

Despite a global backdrop of many interstate tensions, there are also encouraging signs of global cooperation to address the current pandemic and prevent or better manage a future one. World Health Assembly negotiations for an international convention to prevent and better manage future pandemics are a clear sign of multilateral willingness to foster international public health cooperation. As Daniel Gerstein describes in Chapter Four, there are a number of options to improve international capabilities to address future outbreaks. Given the existing organizations and options available, the WHO seems to

be the default organizational option.²³⁸ However, the surge of proposals and the World Health Assembly negotiations also represent an acknowledgment that the WHO’s performance has been lacking and that its existing authorities and capabilities are insufficient. While these negotiations for an international convention to handle future pandemics will likely take time and may not produce bold changes in the short term, it is a constructive step for governments to collaborate on global public health matters. Whether or not fundamental change comes from these negotiations remains to be seen.

One of the tough issues to address is establishing regular practices of allowing independent international officials to investigate the origins of an outbreak. In an era of resurgent nationalism, negotiators will need to make compelling arguments that, to lessen the chance of future pandemic outbreaks, national leaderships need to allow WHO or some other multilateral group to investigate concerning infections. The negotiations have thus far outlined six “action tracks” for the accord—health care systems; zoonotic outbreaks; endemic tropical diseases; food safety; antimicrobial resistance; and protecting the environment.²³⁹ Conspicuous by their absence are tracks on international investigations, research with potential pandemic pathogens, and preventing laboratory accidents, all topics highlighted by the COVID-19 pandemic. Hopefully, these topics will be covered in the six tracks in some way. Claims of national sovereignty should not impede international investigations that can support national authorities and further global interests. One should have no illusions about the prospects of achieving this degree of cooperation with authoritarian governments that may see this level of transparency as a potential threat to their sovereignty. Trans-

parency about a public health crisis that can spill across borders needs to be a norm that all regime types embrace because it is in their societal interest to do so.

Recent sharing of information on the Omicron variant demonstrated that processes for sharing information about new variants of the COVID-19 virus are possible and, if effected rapidly, can produce valuable preventative results. Exchanging information down to the level of a virus's genetic sequence is an important advent. South Africa's discoveries of the Delta and Omicron variants stem from an effective network of its research and public health institutions to collect patient samples, conduct thorough genetic sequencing, and share the results widely with South African and international organizations; this coordination saved lives. The South African organizations that compose the national network are models of responsible transparency.²⁴⁰ Unfortunately, South Africa's good international public health stewardship was swiftly met with travel bans from a host of nations, including the United States. While it may be correct to prohibit international travel to stem the spread of an infectious disease, if the travel ban applies to only some countries and not to all, it is a poor containment measure.

Rapid sharing of information on outbreaks with international scientific and public health partners is critical to the development of effective policy measures.

Had Chinese authorities shared more information with international partners at the beginning of the COVID-19 outbreak, quantitative modeling indicates that it would have significantly lessened the outbreak in China itself and in other countries around the globe.²⁴¹ True, the confluence of events and bureaucratic layers combined to produce a perfect storm, and Chinese authorities performed better

than they did during the SARS outbreak in terms of the number of days between outbreak, national action, and international notification, but the effort was not effective at preventing what led to a global pandemic.

Chinese regional and national bureaucratic politics combined to prevent what needed to be done to avert a global health crisis. We now know that if Chinese local and national authorities had been more transparent at early stages in the outbreak and cooperated with the WHO and other international offers of help, millions of lives might have been spared in this once-in-a-century event. If initial case data had been more widely shared, public health officials might have understood sooner that human-to-human transmission of COVID-19 could occur via individuals who were asymptomatic, and important health policy measures could have been put in place much earlier.

Chinese authorities are not alone in their responsibility for the tragic results in other countries, particularly the United States. For example, in the United States, even early and sustained implementation of such simple behavior practices as social distancing and mask wearing would have saved lives. President Trump downplayed the potential severity of COVID-19 and suggested that it would fade away, which contradicted scientific evidence and led to disastrous public health outcomes. Two great nations were not well served by their national leaders.

Given how major powers have struggled to effectively address the COVID-19 pandemic, the ultimate gesture of humility would be for them to push for measures to encourage transparency for data associated with outbreaks to be adopted as an international norm. While unlikely because of political differences, imagine the impact of a coalition of the United States, China, India, Brazil, Iran,

and Italy committing to transparent cooperation at the onset of outbreaks. These states all suffered from rapid spread early in the pandemic. Their united commitment would serve as a powerful example of the importance of sharing of disease outbreak information. Unlikely partners in such a coalition would set an important standard that other nations would have great incentive to meet.

Many of the proposals for reforming the WHO call for greater sharing of outbreak information and allowing third parties to verify the information shared. Countries severely affected by the pandemic can reinforce the value of early disease information sharing in regional forums, such as annual meetings of the Organization of American States, the Organization of African Unity, the Association of Southeast Asian Nations, the European Union, the G-20, and other similar multilateral meetings. With regional political and economic forums embracing outbreak transparency and information sharing, the practice is more likely to become an accepted and practiced international norm.

Even the best mechanisms for sharing information cannot overcome policymakers who fear political backlash if they enact policy measures that require inconvenient change to save lives. Once information is provided to national leaders, it is incumbent upon them to make decisions that maximize protecting public health as opposed to minimizing political damage. The leaders of Brazil, India, and North Korea ignored early expert advice on the pandemic, and others tried to end lockdowns prematurely against scientific and medical advice that aimed to protect public health.

Further development of data analytical methods to analyze disease outbreak data will increase the warning

time and give policymakers a better foundation on which to make decisions. Another positive development is the application of data analytics to understand the course of an outbreak and provide policymakers with insight into its potential evolution. Scientists and public health officials are amassing new troves of data and developing new techniques to extract insights from it. The many independent university efforts in the United States underscored the limitations associated with the absence of a central health data system, but they demonstrated the tremendous intellectual capital that is available for a revolution in health data analytics.²⁴² Centralizing relevant data in common formats is a necessary and manageable challenge.

The CDC's new Center for Forecasting and Outbreak Analytics and the WHO's Hub for Pandemic and Epidemic Intelligence are just two examples of national and international efforts to apply the power of data analytics to warning, prevention, mitigation, and management of disease outbreaks. The challenges for these new organizations will be to collect enough of the right data, maintain sufficient funding and political support, and appear relevant as time goes by, and they will need to demonstrate the value of having a robust analytic capability for a day in the future when it is truly needed. The increasing number of outbreaks in the past 25 years from species-jumping are probably indicative of the need for developing and maintaining robust capabilities.

The controversy over the origin of the COVID-19 virus raised concern about research laboratories' safety practices and the types of research being conducted. Heretofore, the primary response has been to add regulatory measures to increase transparency and accountability on research activities with potential pandemic pathogens. Regulatory

practices have their limits. Some scientists have argued that research that pushed the envelope of known science contributed to discoveries that can help with surveillance and vaccines, while others argue that attempting to “get ahead of nature” by producing novel pathogens with potential to spark a pandemic has risks that outweigh the benefits.²⁴³ When the COVID-19 pandemic declines, it will be a good time to revisit regulations, training, and educational activities that ensure research is safe, secure, and in the public good.

Laboratory surety is essential to effectively managing the risks and benefits of research involving infectious diseases. As the number of labs proliferates, global standards for safety and security “best practices” are essential. However, **in addition to regulatory processes, there is a need to train a generation of scientists and public health officials in making good judgments about research benefits and risks, foster a culture of moral responsibility, and encourage transparency in laboratory work.**

As two former lab directors argued, “Neither regulation nor leadership alone are a 100% solution, but sound leadership [about] ‘doing the right thing’ in our labs cost[s] nothing.”²⁴⁴ David Franz, one of the lab directors, argued in another publication that “Success in applying appropriate safety procedures is not about ‘things’ as much as it is about ‘people’ and behavior. I have personally witnessed laboratory activities ongoing with high-hazard pathogens in parts of the globe where facilities and equipment were inadequate by our standards, yet careful and thoughtful people were able to accomplish their laboratory tasks safely and efficiently.”²⁴⁵ Public health decisionmakers and laboratory managers who make funding decisions, hire researchers, and approve research plans have a critical lead-

ership responsibility that cannot easily be regulated into place. A combination of education and professional mentorship is required to develop responsible research leaders who can chart the best course of action based on the available science at the time.

Finally, disease does not recognize national boundaries. Despite political divisions in the United States, it is heartening to see polling results suggest that the American people appreciate that providing vaccines to other countries and helping to reduce the spread of COVID-19 in other countries is critical to reducing the risks we face in the United States. In many respects, this finding runs counter to the views of those who have embraced an “America can go it alone” attitude in world affairs. One of the great benefits of globalization is that people can travel widely about the planet to see friends, relatives, and the wonders of the world. Where people go, diseases may go with them. Similarly, where medical remedies to disease outbreaks are discovered, they must go around the globe to be effective. Given the strength of the U.S. pharmaceutical industry and scientific and public health research communities, U.S. leadership on global public health issues is critical.

Additional Issues for Research

As stated at the outset, this collection of essays covers only a select set of the many topics worthy of examination in the wake of the coronavirus pandemic. In conclusion, we highlight three noteworthy issues that warrant consideration that this study did not examine in detail. First, practices for confronting COVID-19 varied considerably across the globe. China, for example, relied to a great extent on lockdowns and mandatory testing. Australian political leaders

reacted quickly to the discovery of the virus, sought and followed the advice of public health authorities, implemented rigorous lockdown measures, and benefited from a public history of trust in government amid a crisis.²⁴⁶ Sweden pursued a course that emphasized economic functioning and protection of elderly and vulnerable populations, but with minimal attention to physical distancing and travel restrictions.²⁴⁷ Similarly, how do we explain what seem to be so few COVID-19 cases in sub-Saharan Africa, and what are the implications for the distribution of public health resources in the region when cases of malaria, polio, measles, and meningitis are prevalent?²⁴⁸ Many other policy variants were implemented as well, yet we know comparatively little about which were the most effective.²⁴⁹ Perhaps even more important, we know little about which might be most appropriate and effective in the United States. A systematic review of lessons learned seems appropriate.

Second, in the United States, the states have considerable autonomy and control over public health policy-making. The initial cooperation with federal government guidance disintegrated over time in certain states in ways that ultimately resulted in political stances against federal public health guidance—and more preventable deaths. President Trump's disdain for the advice of government public health professionals and attacks on political opponents for embracing their counsel for his own political purposes aggravated the situation. Initially, public opinion was marked by hope and uncertainty that several weeks of isolation and improved hygiene would be sufficient.

President Trump and other senior administration officials provided guidance that devolved over time into denial, rejection of scientific advice, false optimism for

political purposes, and thinly veiled anti-Asian racism. Senior leaders in Brazil, Russia, and India articulated similar views with tragic results. These politically motivated views contributed to opposition to basic COVID-19 protection measures, such as masks and physical distancing. Eventually, pockets of strong opposition to vaccination arose. Along the way, Texas, Arkansas, and several other states opted to ban mask requirements, particularly in the school environment. Still other states sued the federal government, and challenges are reaching the Supreme Court. The result is a patchwork of approaches to pandemic control and weakened public health authorities that may leave the United States at risk of an uncoordinated and ineffective response in future public health crises.

Third, and perhaps most importantly, deliberate manipulation of news and facts made the pandemic worse than it otherwise would have been. Misinformation downplayed the severity of COVID-19, promoted the false promise of untested cures and prophylactics, and contributed to slow vaccine uptake. The strategy for the next pandemic must rely on science-based guidance, communicate it effectively, and identify effective approaches for countering spurious information. Without more-effective communication of science-based public health guidance, the nation's approach to the next pandemic risks, once again, being inchoate and fractionated.

As the shadow of the COVID-19 pandemic begins to lift, it is time to take stock. Governmental and professional bodies will likely establish commissions and panels to review different aspects of the pandemic. Several leading members of Congress have called for a 9/11-style independent commission to review the U.S. response to the pandemic as a way to improve policies, plans, and procedures

for enhancing the U.S. ability to contend with a future pandemic.²⁵⁰ The outbreak's origin, responses to it by political leaders and public health officials, scientific research on the disease, and medical procedures and remedies are just a few of the topics that will undoubtedly be examined.²⁵¹ This volume is intended to contribute in a few discrete areas to

the global effort to assess what happened and capture some of the many lessons learned and suggestions of measures to take in the future. There are many areas for improvement, and this volume examines only a few—but they are a few that seem to be easily acted upon.

Notes

¹ Marshall et al., 2021, p. A23.

² Ghebreyesus, 2021.

³ Ghebreyesus, 2021.

⁴ Carlson et al., 2022.

⁵ Tugendhat, 2021.

⁶ Ridley and Ray, 2022. See also “As the Pandemic Exploded, a Researcher Saw the Danger. China’s Leaders Kept Silent,” 2022, p. A26; Leitenberg, 2021; Ran and Jian, 2021, p. 20; and Kormann, 2021.

⁷ Diamond and Toosi, 2020, p. A5.

⁸ Amin et al., 2022.

⁹ A few of the insightful books and articles already published are Wright, 2020; Hotez, 2021; Lewis, 2021; and Offit, 2021.

¹⁰ Taylor and Suliman, 2021.

¹¹ Kahn, 2022. See also Bloom et al., 2021, p. 694; and Kormann, 2021.

¹² Ebright, 2022.

¹³ White House, 2021.

¹⁴ White House, 2021.

¹⁵ Gottlieb, 2021, p. B4.

¹⁶ Sachs, 2021.

¹⁷ National Academies of Sciences, Engineering, and Medicine, 2020, Chapter 1.

¹⁸ Rogin, 2020. See also Zheng, 2020.

¹⁹ U.S. House of Representatives, Permanent Select Committee on Intelligence, 2021.

²⁰ H.R. 5412, Sec. 712, 2021.

²¹ H.R. 5412, Sec. 712, 2021.

²² H.R. 5412, Sec. 704, 2021.

²³ Henry Kissinger, as quoted in George and Bruce, eds., 2008, p. 113.

²⁴ Parachini and Gunaratna, 2022.

²⁵ Sinclair, 2010.

²⁶ National Intelligence Council, 2004, p. 55.

²⁷ National Intelligence Council, 2004, p. 30.

²⁸ Negroponte, 2006, p. 24.

²⁹ McConnell, 2008, p. 43.

³⁰ National Intelligence Council, 2008, p. 75.

³¹ National Intelligence Council, 2008, p. 75.

³² National Intelligence Council, 2008, p. 75.

³³ National Intelligence Council, 2008, p. 75.

³⁴ Blair, 2009, p. 43.

- 35 National Intelligence Council, 2012, p. xi.
- 36 National Intelligence Council, 2012, p. xi.
- 37 National Intelligence Council, 2012, p. 13.
- 38 Clapper, 2014, p. 12.
- 39 Coats, 2017, p. 14.
- 40 National Intelligence Council, 2017, p. 51.
- 41 Bloom et al., 2021. See also Kormann, 2021.
- 42 Office of the Director of National Intelligence, 2021.
- 43 Table 2.1 shows a timeline of selected key events in pandemic planning in the United States from 1978 to 2008. See Iskander et al., 2013. There have been several pandemic response plans since 2008 (Executive Office of the President, 2016).
- 44 For discussions of two efforts, see O’Toole, Michael, and Inglesby, 2002. See also Jackson et al., 2007.
- 45 Sonnemaker, 2020.
- 46 Gates, 2015.
- 47 Gates, 2015.
- 48 Lewis, 2021, pp. 74–122.
- 49 Wright, 2020. See also Diamond and Toosi, 2020.
- 50 Lewis, 2021, p. 163.
- 51 Miller and Nakashima, 2020. See also Barnes and Goldman, 2020.
- 52 Yeung, 2022.
- 53 The CDC established a Center for Forecasting and Outbreak Analytics that may begin to address this need. However, the mission is somewhat different and will need time to demonstrate its value. See CDC, 2021.
- 54 Rivers and George, 2020.
- 55 CDC, 2021. See also Sun, 2022.
- 56 CDC, 2021.
- 57 WHO, undated-c.
- 58 WHO, 2021.
- 59 Fillion, 2022.
- 60 Franz, 2020.
- 61 WHO, 2020a.
- 62 The figures reported by the Chinese government at the early stages of the pandemic were not accurate. For a discussion of the Chinese mortality statistics, see Leitenberg, 2020b.
- 63 Pekar et al., 2021.
- 64 Government of Canada, Foreign Affairs Trade and Development Canada, 2018.
- 65 Congressional Research Service, 2020.
- 66 Congressional Research Service, 2020. See also Kynge, Yu, and Hancock, 2020.
- 67 Chinese official quoted in Wu et al., 2020.
- 68 Wu et al., 2020.
- 69 Fifield, 2020.
- 70 Wu et al., 2020.
- 71 Wu et al., 2020.
- 72 Mi Liu et al., 2020.
- 73 Li, Cui, and Zhang, 2020.
- 74 Lockdown measures included shutting down all public transport, including buses, metro lines, railways, flights, and ferries; highway exits were closed, and only one person per household was allowed to exit the home every two days.
- 75 Kuo, 2020.
- 76 Jiangmei Liu et al., 2021.
- 77 WHO, 2020b.
- 78 Ma, 2020.
- 79 Huang et al., 2020.
- 80 2019-nCoV Outbreak Joint Field Epidemiology Investigation Team and Qun Li, 2020.
- 81 Liu and Qu, 2020.

- 82 Worobey, 2021.
- 83 Worobey, 2021.
- 84 Xiang, Song, et al., 2019.
- 85 Xiang, Havers, et al., 2013.
- 86 Ran and Jian, 2021, p. 20.
- 87 Ran and Jian, 2021, p. 26.
- 88 Pekar et al., 2021.
- 89 Ran and Jian, 2021, p. 20.
- 90 Ran and Jian, 2021.
- 91 Ran and Jian, 2021.
- 92 Wu et al., 2020.
- 93 Bouey, 2020.
- 94 Ang, 2018.
- 95 Ran and Jian, 2021.
- 96 Dong and Bouey, 2020.
- 97 South Korea's outbreak alert system proceeds as follows: Level 1, "Attention": Government begins to monitor the situation; Level 2, "Caution": First case emerges and government starts to cooperate; Level 3, "Alert": Infection is spreading; and Level 4, "Severe": National response is activated.
- 98 Wang et al., 2020.
- 99 Bouey, 2020.
- 100 Ran and Jian, 2021.
- 101 Davidson, 2020.
- 102 Congressional Research Service, 2021.
- 103 WHO, undated-a.
- 104 Carvalho and Zacher, 2001.
- 105 WHO, 2005.
- 106 Congressional Research Service, 2021.
- 107 Wenham, 2017. See also O'Dowd, 2015; Kamradt-Scott, 2016.
- 108 Sifferlin, 2015.
- 109 Schnirring, 2015.
- 110 CDC, undated-a.
- 111 Chaumont, 2020.
- 112 Guzman, 2020.
- 113 Hathaway and Phillips-Robins, 2020.
- 114 Ravelo, 2020.
- 115 Independent Panel for Pandemic Preparedness and Response, undated.
- 116 Brilliant et al., 2021.
- 117 Independent Panel for Pandemic Preparedness and Response, undated.
- 118 WHO, 2021.
- 119 Dag Hammarskjold Library, 2022.
- 120 Early and Nance, 2016; Dictionary.com, undated.
- 121 European Council, 2021.
- 122 G20 Research Group, 2021.
- 123 Pandemic Mitigation Project, undated.
- 124 United Nations Office for Disarmament Affairs, undated-b.
- 125 Irene Velicer, 2021.
- 126 Zhou et al., 2020. The first publication of the genetic sequence came from an international collaboration a month earlier. See Holmes, 2020.
- 127 In the policy document on this subject, the Office of Science and Technology Policy uses the phrase *Potential Pandemic Pathogen Care and Oversight (P3CO)* to refer to the creation, transfer, or use of enhanced potential pandemic pathogens. The logic for the different phrase is that *gain-of-function research of concern* is periodically confused with the vastly broader category of *gain of function* and makes a clumsy acronym. This Perspective will use the National Science Advisory Board for Biosecurity's (NSABB's) *GOFROC* because of its usage in many of the references in this chapter.
- 128 National Science Advisory Board for Biosecurity, 2016, pp. 1–2.

- 129 Gryphon Scientific, 2016.
- 130 Herfst et al., 2012; Imai et al., 2012.
- 131 Reardon, 2014a; Reardon, 2014b.
- 132 White House, 2014.
- 133 National Academies of Sciences, Engineering, and Medicine, 2016, p. 81; National Academies of Sciences, Engineering, and Medicine, 2015.
- 134 Selgelid, 2015.
- 135 Gryphon Scientific, 2016.
- 136 See, for example, European Academies Science Advisory Council, 2015.
- 137 NSABB, 2016.
- 138 White House Office of Science and Technology Policy, 2017b.
- 139 See, for example, Andersen et al., 2020; WHO, 2021; Holmes et al., 2021; Office of the Director of National Intelligence, 2021.
- 140 Other works have commented on the level of rigor of some of those studies. See, for example, Bloom et al., 2021, p. 694; and Leitenberg, 2020a.
- 141 Menachery et al., 2015.
- 142 Menachery et al., 2015.
- 143 Menachery et al., 2015.
- 144 Jacobsen, 2021.
- 145 Tabak, 2022.
- 146 National Institutes of Health, 2022.
- 147 NSABB, 2016.
- 148 White House Office of Science and Technology Policy, 2017a; HHS, 2017.
- 149 Multiple other policies provide biosecurity and biosafety oversight for U.S. research. For examples, see Appendix B in NSABB, 2016.
- 150 NSABB, 2020.
- 151 White House Office of Science and Technology Policy, 2017a, Section 6.
- 152 Willman and Muller, 2021.
- 153 Kaiser, 2021.
- 154 Oversight Committee Republicans, 2021.
- 155 Kaiser, 2021.
- 156 Engber and Federman, 2021.
- 157 Klotz and Koblentz, 2018.
- 158 NSABB, 2016, pp. 16–19.
- 159 National Academies of Sciences, Engineering, and Medicine, 2016, p. 81.
- 160 National Academies of Sciences, Engineering, and Medicine, 2016, p. 81.
- 161 National Academies of Sciences, Engineering, and Medicine, 2016, p. 81.
- 162 Inglesby and Lipsitch, 2020.
- 163 NSABB, 2020.
- 164 Williams, Cohen, and Bertrand, 2021. For an extensive preprint review of the WIV database, see Anonymous OSINT Contributor, Bos-tickson, and Demaneuf, 2021.
- 165 Williams, Cohen, and Bertrand, 2021.
- 166 National Center for Biotechnology Information, 1995.
- 167 Inglesby and Lipsitch, 2020.
- 168 Peters, 2018.
- 169 Koblentz and Lentzos, 2021. For an interactive map that displays the location of all the BSL-4 laboratories, see Globalbiolabs.org, undated.
- 170 Yeh et al., 2021. The numbers for the BSL-3 laboratories are a summation from a listing in the appendix in Peters, 2018.
- 171 Kings College London, 2021.
- 172 Kahn, 2021.
- 173 Furmanski, 2014.
- 174 Office of the Director of National Intelligence, National Intelligence Council, 2021.

- 175 United Nations Office for Disarmament Affairs, undated-a.
- 176 There are three articles of the Convention that relate to biosafety and biosecurity: Article III (Not to transfer, or in any way assist, encourage and induce anyone else to acquire or retain biological weapons), Article IV (To take any national measures necessary to implement provisions of the BWC domestically), and Article X (To do all of the above (i.e., articles) in a way that encourages the peaceful uses of biological science and technology).
- 177 U.S. Department of State, 2012.
- 178 United Nations Office for Disarmament Affairs, undated-c.
- 179 WHO, undated-b.
- 180 World Organisation for Animal Health, 2018.
- 181 Sensi et al., 2009; Food and Agriculture Organization of the United Nations, 2007.
- 182 ISO 35001:2019, 2019.
- 183 ISO 45001:2018, 2018.
- 184 ISO 115190:2020, 2020.
- 185 Australia Group Common Control List Handbook, 2021; Peters, 2018.
- 186 Khan et al., 2016.
- 187 Peters, 2018.
- 188 GHSA, 2018.
- 189 GHSA, 2018.
- 190 Nunn-Lugar Cooperative Threat Reduction Program, undated.
- 191 CDC, 2017.
- 192 DoD-GEIS, 2001.
- 193 Kaiser, 2014; Stanway-Williams, 2022; Furmanski, 2014.
- 194 CDC, 2020, p. 3.
- 195 Sunshine Project, 2004.
- 196 Kahn, 2021. See also Steinbruner et al., 2007.
- 197 VERTIC, undated.
- 198 WHO, 2022b.
- 199 Adam, 2022.
- 200 Ebbs, 2020.
- 201 Jacobs, 2021.
- 202 Rabouin, 2020.
- 203 Rabouin, 2020.
- 204 Finkenstadt, Hanfield, and Guinto, 2020.
- 205 Miltimore, 2021.
- 206 HHS, 2021.
- 207 Sanger, Kanno-Youngs, and Kulish, 2020.
- 208 Ranney, Griffeth, and Jha, 2020.
- 209 Reynolds and McSweeney, 2020.
- 210 Brooks, 2020.
- 211 Brooks, 2020.
- 212 Kensil, 2006.
- 213 The U.S. medical system had, for example, experienced shortages of routine commodities as mundane as saline solution even without the disruption caused by COVID-19. See Mazer-Amirshahi and Fox, 2018.
- 214 RAND Corporation, undated.
- 215 “Why are Drug Prices So High in the United States?” 2019.
- 216 Gidengil et al., 2018.
- 217 Sanger, Kanno-Youngs, and Kulish, 2020.
- 218 Kliff et al., 2020.
- 219 Gerstein, 2020.
- 220 Gerstein, 2020.
- 221 Pub. L. 115-232, 2018.
- 222 HHS and U.S. Department of Defense, undated.
- 223 Segal, 2020.
- 224 Adam, 2022.

- 225 U.S. Department of State, undated.
- 226 Hafner et al., 2020.
- 227 Carman et al., 2021.
- 228 Nelson, Carman, and Chandra, 2020.
- 229 Pollard and Davis, 2021.
- 230 Stronski, 2021; Wong, 2021. See also Paun and Payne, 2021; Cohen, 2020.
- 231 Abbott, 2020. See also Nogrady, 2021.
- 232 WHO, 2022a. See also Katella, 2022.
- 233 Robbins and Nolen, 2022, p. 1.
- 234 CDC, undated-b.
- 235 Fitzpatrick, 2022. See also Draaisma, 2022.
- 236 Anthes, 2021, p. 1.
- 237 Parthemore and Weber, 2021.
- 238 For a thorough comparison calling upon the WHO or BWC member states to conduct an international disease outbreak investigation, see Himmel and Frey, 2022.
- 239 Ridley, 2022.
- 240 Cocks, 2021; Sguazzin, 2021; Adepoju, 2021.
- 241 Zhang et al., 2021.
- 242 Interlandi, 2021.
- 243 National Research Council and Institute of Medicine of the National Academies, 2015. See also Casadevall and Imperiale, 2014.
- 244 Franz and LeDuc, 2021.
- 245 Franz, 2019, p. 99.
- 246 Cave, 2022, p. A1.
- 247 Mishra et al., 2021.
- 248 Nolen, 2022, p. D1.
- 249 For a useful comparative study of how the Nordic countries responded to COVID-19 and the outcomes, see Saunes et al., 2021.
- 250 U.S. Senate, 117th Congress, S.3203, 2021.
- 251 The minority staff of the House Foreign Affairs committee prepared a report on the origins of the COVID-19 pandemic. House Foreign Affairs Committee Report Minority Staff, 2021.

References

- 2019-nCoV Outbreak Joint Field Epidemiology Investigation Team and Qun Li, “An Outbreak of NCIP (2019-nCoV) Infection in China—Wuhan, Hubei Province, 2019–2020,” *China CDC Weekly*, Vol. 2, No. 5, 2020, pp. 79–80. As of July 12, 2022: <http://weekly.chinacdc.cn/en/article/doi/10.46234/ccdcw2020.022>
- Abbott, Alison, “Researchers Highlight ‘Questionable’ Data in Russian Coronavirus Vaccine Trial Results,” *Nature*, September 15, 2020. As of May 6, 2022: <https://www.nature.com/articles/d41586-020-02619-4>
- Adam, David, “COVID’s Death Toll: Much Higher Than Official Records,” *Nature*, March 10, 2022. As of May 6, 2022: <https://www.nature.com/articles/d41586-022-00708-0>
- Adepoju, Paul, “Why South Africa Keeps Detecting COVID-19 Variants Like Omicron,” *devex*, December 6, 2021. As of July 12, 2022: <https://www.devex.com/news/why-south-africa-keeps-detecting-covid-19-variants-like-omicron-102212>
- Amin, Krutika, Jared Ortaliza, Cynthia Cox, Josh Michaud, and Jennifer Kates, “COVID-19 Preventable Mortality,” Peterson-KFF Health System Tracker, April 21, 2022. As of May 6, 2022: <https://www.kff.org/coronavirus-covid-19/issue-brief/covid-19-continues-to-be-a-leading-cause-of-death-in-the-u-s/>
- Andersen, Kristian G., Andrew Rambaut, W. Ian Lipkin, Edward C. Holmes, and Robert F. Garry, “The Proximal Origin of SARS-CoV-2,” *Nature Medicine*, Vol. 26, March 17, 2020, pp. 450–452. As of September 28, 2021: <https://doi.org/10.1038/s41591-020-0820-9>
- Ang, Yuen Yuen, “Autocracy with Chinese Characteristics: Beijing Behind-the-Scenes Reforms,” *Foreign Affairs*, May 1, 2018.
- Anonymous OSINT Contributor, Billy Bostickson, and Gilles Demaneuf, “An Investigation into the WIV Databases That Were Taken Offline,” February 2021. As of May 6, 2022: https://www.researchgate.net/publication/349073738_An_investigation_into_the_WIV_databases_that_were_taken_offline
- Anthes, Emily, “Why Omicron Wasn’t Found Earlier in the U.S.,” *New York Times*, December 3, 2021.
- “As the Pandemic Exploded, a Researcher Saw the Danger. China’s Leaders Kept Silent,” editorial, *Washington Post*, April 24, 2022.
- Australia Group Common Control List Handbook*, Vol. II: Biological Weapons Related Common Control Lists, Revision 6, Washington, D.C.: U.S. Government, January 2021. As of July 12, 2022: <https://www.dfat.gov.au/sites/default/files/australia-group-common-control-list-handbook-volume-ii.pdf>
- Barnes, Julian E., and Adam Goldman, “For Spy Agencies, Briefing Trump Is a Test of Holding His Attention,” *New York Times*, May 21, 2020. As of July 12, 2022: <https://www.nytimes.com/2020/05/21/us/politics/presidents-daily-brief-trump.html>
- Blair, Dennis C., Director of National Intelligence, “Annual Threat Assessment of the Intelligence Community for the Senate Select Committee on Intelligence,” Washington, D.C., February 12, 2009.
- Bloom, Jesse D., Yujia Alina Chan, Ralph S. Baric, Pamela J. Bjorkman, Sarah Cobey, Benjamin E. Deverman, David N. Fisman, Ravindra Gupta, Akiko Iwasaki, Marc Lipsitch, Ruslan Medzhitov, Richard A. Neher, Rasmus Nielsen, Nick Patterson, Tim Stearns, Erik van Nimwegen, Michael Worobey, and David A. Relman, “Investigate the Origins of COVID-19,” *Science*, Vol. 372, No. 6543, May 14, 2021, p. 694. As of May 6, 2022: <https://www.science.org/doi/10.1126/science.abj0016>
- Bouey, Jennifer, “From SARS to 2019-Coronavirus (nCoV): U.S. China Collaborations on Pandemic Response,” testimony to the House Foreign Affairs Subcommittee on Asia, the Pacific, and Nonproliferation, Santa Monica, Calif.: RAND Corporation, CT-523, February 5, 2020. As of July 12, 2022: <https://www.rand.org/pubs/testimonies/CT523.html>
- Bouey, Jennifer, “China’s Health System Reform and Global Health Strategy in the Context of COVID-19,” testimony presented before the U.S.-China Economic and Security Review Commission, Santa Monica, Calif.: RAND Corporation, CT-A321-1, May 7, 2020. As of July 12, 2022: <https://www.rand.org/pubs/testimonies/CTA321-1.html>
- Brilliant, Larry, Lisa Danzig, Karen Oppenheimer, Agastya Mondal, Rick Bright, and W. Ian Lipkin, “The Forever Virus: A Strategy for the Long Fight Against COVID-19,” *Foreign Affairs*, Vol. 100, No. 4, July/August 2021.
- Brooks, Kristin, “API Supply for U.S. Market,” *Contract Pharma*, March 5, 2020. As of July 12, 2022: https://www.contractpharma.com/contents/view_online-exclusives/2020-03-05/api-supply-for-us-market/

Carlson, Colin J., Gregory F. Albery, Cory Merow, Christopher H. Trisos, Casey M. Zipfel, Evan A. Eskew, Kevin J. Olival, Noam Ross, and Shweta Bansal, “Climate Change Increases Cross-species Viral Transmission Risk,” *Nature*, April 28, 2022. As of May 24, 2022: <https://doi.org/10.1038/s41586-022-04788-w>

Carman, Katherine Grace, Anita Chandra, Delia Bugliari, Christopher Nelson, and Carolyn Miller, *COVID-19 and the Experiences of Populations at Greater Risk: Description and Top-Line Summary Data—Wave 4, Fall 2021*, Santa Monica, Calif.: RAND Corporation, RR-A764-4, 2021. As of July 12, 2022: https://www.rand.org/pubs/research_reports/RR-A764-4.html

Carvalho, Simon, and Mark Zacher, “The International Health Regulations in Historical Perspective,” in A. T. Price-Smith, ed., *Plagues and Politics*, Global Issues Series, London: Palgrave Macmillan, 2001. As of July 12, 2022: https://doi.org/10.1057/9780230524248_12

Casadevall, Arturo, and Michael J. Imperiale, “Risks and Benefits of Gain-of-Function Experiments with Pandemic Potential, Such as Influenza Virus: A Call for a Science-Based Discussion,” *MBio*, Vol. 5, No. 4, July/August 2014. As of July 12, 2022: <https://pubmed.ncbi.nlm.nih.gov/25085113/>

Cave, Damien, “Why Australia’s Covid Death Rate Is Only One-Tenth of U.S. Level,” *New York Times*, May 16, 2022.

CDC—See Centers for Disease Control and Prevention.

Centers for Disease Control and Prevention, “International Health Regulations (IHR),” webpage, undated-a. As of July 12, 2022: <https://www.cdc.gov/globalhealth/healthprotection/ghs/ihr/index.html>

Centers for Disease Control and Prevention, “National Wastewater Surveillance System (NWSS),” webpage, undated-b. As of March 9, 2022: <https://www.cdc.gov/healthywater/surveillance/wastewater-surveillance/wastewater-surveillance.html>

Centers for Disease Control and Prevention, “Global Health Security: Global Disease Detection Centers,” webpage, October 13, 2017. As of March 29, 2022: <https://www.cdc.gov/globalhealth/security/gdd.htm>

Centers for Disease Control and Prevention, *Biosafety in Microbiological and Biomedical Laboratories* 6th Edition, Atlanta, Ga., June 2020. As of July 12, 2022: https://www.cdc.gov/labs/pdf/SF__19_308133-A_BMBL6_00-BOOK-WEB-final-3.pdf

Centers for Disease Control and Prevention, “CDC Stands Up New Disease Forecasting Center,” press release, August 18, 2021. As of February 14, 2022: <https://www.cdc.gov/media/releases/2021/p0818-disease-forecasting-center.html>

Chaumont, Claire, “Opinion: 5 Ways to Reform the World Health Organization,” *devox*, August 5, 2020. As of February 15, 2022: <https://www.devex.com/news/opinion-5-ways-to-reform-the-world-health-organization-97843>

Clapper, James R., Director of National Intelligence, Statement for the Record, “Worldwide Threat Assessment of the U.S. Intelligence Community,” Senate Select Committee on Intelligence, Washington, D.C., January 29, 2014.

Coats, Daniel R., Senate Select Committee on Intelligence, Statement for the Record, “Worldwide Threat Assessment of the U.S. Intelligence Community,” Washington, D.C., May 11, 2017.

Cocks, Tim, “How South African Scientists Spotted the Omicron Covid Variant,” Reuters, November 30, 2021. As of July 12, 2022: <https://www.reuters.com/business/healthcare-pharmaceuticals/how-south-african-scientists-spotted-omicron-covid-variant-2021-11-30/>

Cohen, Jon, “Russia’s Claim of a Successful COVID-19 Vaccine Doesn’t Pass the ‘Smell Test,’ Critics Say,” *Science*, November 11, 2020. As of July 12, 2022: <https://www.science.org/content/article/russia-s-claim-successful-covid-19-vaccine-doesn-t-pass-smell-test-critics-say>

Congressional Research Service, “COVID-19 and China: A Chronology of Events (December 2019–January 2020),” R46354, updated May 13, 2020. As of June 1, 2022: <https://crsreports.congress.gov/product/pdf/r/r46354>

Congressional Research Service, *Rejoining the World Health Organization (WHO): Reform and Related Issues*, Washington, D.C., February 1, 2021. As of July 12, 2022: <https://crsreports.congress.gov/product/pdf/IF/IF11750/2>

Dag Hammarskjöld Library, “Are UN Resolutions Binding?” webpage, January 17, 2022. As of July 12, 2022: <https://ask.un.org/faq/15010>

Davidson, Helen, “First Covid-19 Case Happened in November, China Government Records Show—Report,” *The Guardian*, March 13, 2020. As of May 24, 2022: <https://www.theguardian.com/world/2020/mar/13/first-covid-19-case-happened-in-november-china-government-records-show-report>

Diamond, Dan, “Trump Officials Muzzled CDC on Church Virus Guidance, Emails Show,” *Washington Post*, April 30, 2022.

Diamond, Dan, and Nahal Toosi, “Trump Team Failed to Follow NSC’s Pandemic Playbook,” *Politico*, March 25, 2020. As of July 12, 2022: <https://www.politico.com/news/2020/03/25/trump-coronavirus-national-security-council-149285>

Dictionary.com, “Nonproliferation,” webpage, undated. As of March 28, 2022: <https://www.dictionary.com/browse/nonproliferation>

DoD-GEIS—See U.S. Department of Defense Global Emerging Infections System.

Dong, Lu, and Jennifer Bouey, “Public Mental Health Crisis During COVID-19 Pandemic, China,” *Emerging Infectious Diseases*, Vol. 26, No. 7, 2020, pp. 1616–1618. As of July 12, 2022: <https://doi.org/10.3201/eid2607.200407>

Draaisma, Muriel, “Wastewater Data Shows Early Signs of ‘Resurgence’ of COVID-19 Viral Load in Ontario, Expert Says,” CBC News, February 26, 2022. As of March 9, 2022: <https://www.cbc.ca/news/canada/toronto/resurgence-covid-19-viral-load-wastewater-sur-1.6366103>

Early, Bryan R., and Mark T. Nance, “Here’s How the U.N. Is Working to Stop Terrorists from Getting Weapons of Mass Destruction,” *Washington Post*, May 3, 2016. As of July 12, 2022: <https://www.un.org/en/sc/1540/documents/WashingtonPost3May2016.pdf>

Ebbs, Stephanie, “Hospitals Nationwide Face Shortage of Medical Staff amid Spike in COVID-19 Cases,” ABC News, November 2020. As of July 12, 2022: <https://abcnews.go.com/Politics/hospitals-nationwide-face-shortage-medical-staff-amid-spike/story?id=74319020>

Ebright, Richard H., “Revisiting Gain of Function Research,” written testimony submitted for the record to the U.S. Senate Committee on Homeland Security, Subcommittee on Emerging Threats and Spending Oversight, Washington, D.C., August 3, 2022. As of August 24, 2022: <https://www.hsgac.senate.gov/imo/media/doc/Ebright%20Testimony%20Updated.pdf>

Engber, Daniel, and Adam Federman, “The Lab-Leak Debate Just Got Even Messier,” *The Atlantic*, September 26, 2021. As of May 25, 2022: <https://www.theatlantic.com/science/archive/2021/09/lab-leak-pandemic-origins-even-messier/620209/>

European Academies Science Advisory Council, *Gain of Function: Experimental Applications Relating to Potentially Pandemic Pathogens*, EASAC policy report 27, October 2015. As of July 12, 2022: https://easac.eu/fileadmin/PDF_s/reports_statements/Gain_of_Function/EASAC_GOF_Web_complete_centred.pdf

European Council, “An International Treaty on Pandemic Prevention and Preparedness,” press release, December 21, 2021. As of February 15, 2022: <https://www.consilium.europa.eu/en/policies/coronavirus/pandemic-treaty/>

Executive Office of the President, *Toward Epidemic Prediction: Federal Efforts and Opportunities in Outbreak Modeling*, Washington, D.C., December 2016. As of May 6, 2022: https://obamawhitehouse.archives.gov/sites/default/files/microsites/ostp/NSTC/towards_epidemic_prediction-federal_efforts_and_opportunities.pdf

Fifield, Anna, “China Virus: Expert Says It Can Be Spread by Human-to-Human Contact, Sparking Concerns About the Massive Holiday Travel Underway,” *Washington Post*, January 20, 2020. As of May 6, 2022: https://www.washingtonpost.com/world/asia_pacific/china-virus-surge-in-new-cases-raises-concerns-about-human-transmission-ahead-of-holiday-travel-season/2020/01/20/06d077fc-3b6a-11ea-971f4ce4f94494b4_story.html

Fillion, Stephanie, “The WHO’s New Pandemic Center Isn’t Ready for Action,” *Foreign Policy*, January 10, 2022. As of July 12, 2022: <https://foreignpolicy.com/2022/01/10/the-whos-new-pandemic-center-isnt-ready-for-action/>

Finkenstadt, Daniel, Robert Hanfield, and Peter Guinto, “Why the U.S. Still Has a Severe Shortage of Medical Supplies,” *Harvard Business Review*, September 2020. As of February 15, 2022: <https://hbr.org/2020/09/why-the-u-s-still-has-a-severe-shortage-of-medical-supplies>

Fitzpatrick, Michael, “Covid-19: NI Wastewater Tested to Detect Virus Outbreaks,” BBC News, March 9, 2022. As of March 9, 2022: <https://www.bbc.com/news/uk-northern-ireland-60680967>

Food and Agriculture Organization of the United Nations, FAO Biosecurity Toolkit, Rome, 2007. As of March 28, 2022: <https://www.fao.org/3/a1140e/a1140e.pdf>

Franz, David R., “Facilities, Equipment and Procedures: An Historic Glimpse at High-containment Lab Safety and Security,” *Journal of Biosafety and Biosecurity*, Vol. 1, No. 2, September 2019.

- Franz, David R., “Biological Security and Health in the Post-Pandemic World: The Infectious Disease Community’s ‘Mushroom Cloud?’” *CBW Magazine*, Vol. 13, No. 2, January–June 2020.
- Franz, David R., and James W. LeDuc, “Technology Advances, High-Risk Research, and a Safe Way Forward,” *mBio*, Vol. 21, No. 5, September/October 2021. As of July 13, 2022: <https://journals.asm.org/doi/full/10.1128/mBio.02373-21>
- Furmanski, Martin, “Threatened Pandemics and Laboratory Escapes: Self-fulfilling Prophecies,” *Bulletin of Atomic Scientists*, March 31, 2014. As of May 6, 2022: <https://thebulletin.org/2014/03/threatened-pandemics-and-laboratory-escapes-self-fulfilling-prophecies/>
- G20 Research Group, “G20 Rome Leaders’ Declaration,” October 31, 2021. As of May 6, 2022: <http://www.g20.utoronto.ca/2021/211031-declaration.html>
- Gates, Bill, “The Next Outbreak? We’re Not Ready,” YouTube video, March 2015. As of July 13, 2022: https://www.ted.com/talks/bill_gates_the_next_outbreak_we_re_not_ready
- Gerstein, Daniel M., *The Strategic National Stockpile and COVID-19: Rethinking the Stockpile*, testimony presented before the Senate Committee on Homeland Security and Governmental Affairs on June 24, 2020, Santa Monica, Calif.: RAND Corporation, CT-A530-1, 2020. As of March 28, 2022: <https://www.rand.org/pubs/testimonies/CTA530-1.html>
- Gerstein, Daniel M., “Could the Bioweapons Treaty Be Another Tool for Addressing Pandemics?” *Bulletin of the Atomic Scientists*, March 12, 2021. As of February 15, 2022: <https://thebulletin.org/2021/03/could-the-bioweapons-treaty-be-another-tool-for-addressing-pandemics/>
- Ghebreyesus, Tedros Adhanom, “WHO Director-General’s Closing Remarks at the Special Session of the World Health Assembly,” December 1, 2021. As of July 13, 2022: <https://www.who.int/director-general/speeches/detail/who-director-general-s-opening-remarks-at-the-special-session-of-the-world-health-assembly---01-december-2021>
- GHSA—See Global Health Security Agenda.
- Gidengil, Courtney A., Christopher Nelson, Laura J. Faherty, and Nabeel Qureshi, *Does the United States Need to Strengthen the System of Care for Infectious Diseases?* Santa Monica, Calif.: RAND Corporation, RR-2046-ASPR, 2018. As of May 6, 2022: https://www.rand.org/pubs/research_reports/RR2046.html
- Global Health Security Agenda, “2024 Framework,” November 2018. As of July 13, 2022: <https://ghsagenda.org/wp-content/uploads/2020/06/ghsa2024-framework.pdf>
- Globalbiolabs.org, “Tracking BSL-4 Labs Around the World,” homepage, undated. As of May 6, 2022: <https://www.globalbiolabs.org/>
- Gottlieb, Scott, “Intelligence Agencies Can Help Prevent Future Pandemics. Here’s How,” *Washington Post*, September 19, 2021.
- Government of Canada, Foreign Affairs Trade and Development Canada, “Focus on Wuhan, China,” webpage, archived from the original on December 17, 2018. As of July 13, 2022: <https://web.archive.org/web/20181217025408/http://www.tradecommissioner.gc.ca/china-chine/market-facts-faits-sur-le-marche/96289.aspx?lang=eng>
- Gruenberg, Justin S., “An Analysis of United Nations Security Council Resolutions: Are All Countries Treated Equally?” *Case Western Reserve Journal of International Law*, Vol. 41, No. 2, 2009, Article 12. As of August 24, 2022: <https://scholarlycommons.law.case.edu/cgi/viewcontent.cgi?article=1268&context=jil>
- Gryphon Scientific, *Risk and Benefit Analysis of Gain of Function Research*, Takoma Park, Md., April 2016. As of July 13, 2022: <http://gryphonsci.wpengine.com/wp-content/uploads/2018/12/Risk-and-Benefit-Analysis-of-Gain-of-Function-Research-Final-Report-1.pdf>
- Guzman, Joseph, “WHO Admits Error in Assessment of Deadly Coronavirus Risk,” *The Hill*, January 28, 2020. As of February 15, 2022: <https://thehill.com/changing-america/well-being/prevention-cures/480291-who-admits-error-in-assessment-of-deadly>
- Hafner, Marco, Erez Yerushalmi, Clement Fays, Eliane Dufresne, and Christian Van Stolk, *COVID-19 and the Cost of Vaccine Nationalism*, Santa Monica, Calif.: RAND Corporation, RR-A769-1, 2020. As of March 29, 2022: https://www.rand.org/pubs/research_reports/RRA769-1.html
- Hathaway, Oona, and Alasdair Phillips-Robins, “COVID-19 and International Law Series: Reforming the World Health Organization,” *Just Security*, December 11, 2020. As of July 13, 2022: <https://www.justsecurity.org/73793/covid-19-and-international-law-series-reforming-the-world-health-organization/>

Herfst, Sander, Eefje J. A. Schrauwen, Martin Linster, Salin Chutinimitkul, Emmie de Wit, Vincent J. Munster, Erin M. Sorrell, Theo M. Bestebroer, David F. Burke, Derek J. Smith, Guus F. Rimmelzwaan, Albert D. M. E. Osterhaus, and Ron A. M. Fouchier, “Airborne Transmission of Influenza A/H5N1 Virus Between Ferrets,” *Science*, Vol. 336, No. 6088, June 22, 2012, pp. 1534–1541. As of July 13, 2022:
<https://doi.org/10.1126/science.1213362>

HHS—See U.S. Department of Health and Human Services.

Himmel, Mirko, and Stefan Frey, “SARS-CoV-2: International Investigation Under the WHO or BWC,” *Frontiers in Public Health*, February 3, 2022. As of May 24, 2022:
<https://www.frontiersin.org/articles/10.3389/fpubh.2021.636679/full>

Holmes, Edward C., “Novel 2019 Coronavirus Genome,” webpage, January 2020. As of July 28, 2022:
<https://virological.org/t/novel-2019-coronavirus-genome/319>

Holmes, Edward C., Stephen A. Goldstein, Angela L. Rasmussen, David L. Robertson, Alexander Crits-Christoph, Joel O. Wertheim, Simon J. Anthony, Wendy S. Barclay, Maciej F. Boni, Peter C. Doherty, Jeremy Farrar, Jemma L. Geoghegan, Xiaowei Jiang, Julian L. Leibowitz, Stuart J. D. Neil, Tim Skern, Susan R. Weiss, Michael Worobey, Kristian G. Andersen, Robert F. Garry, and Andrew Rambaut, “The Origins of SARS-CoV-2: A Critical Review,” *Cell*, Vol. 184, No. 19, 2021, pp. 4848–4856. As of July 13, 2022:
<https://doi.org/10.1016/j.cell.2021.08.017>

Hotez, Peter J., *Preventing the Next Pandemic: Vaccine Diplomacy in a Time of Anti-Science*, Baltimore, Md.: Johns Hopkins University Press, March 2, 2021.

House Foreign Affairs Committee Report Minority Staff, *The Origins of COVID-19: An Investigation of the Wuhan Institute of Virology*, Washington, D.C., 117th Congress, August 2021. As of August 17, 2022:
<https://gop-foreignaffairs.house.gov/wp-content/uploads/2021/08/ORIGINS-OF-COVID-19-REPORT.pdf>

House Resolution 5412, Intelligence Authorization Act for Fiscal Year 2022, Sec. 704, “Biennial Reports on Foreign Biological Threats,” September 29, 2021. As of July 13, 2022:
https://intelligence.house.gov/uploadedfiles/iaa22_ans_xml.pdf

House Resolution 5412, Intelligence Authorization Act for Fiscal Year 2022, Sec 712, “Report on Potential Inclusion Within Intelligence Community of the Office of National Security of the Department of Health and Human Services,” September 29, 2021.

Huang, Chaolin, Yeming Wang, Xingwang Li, Lili Ren, Jianping Zhao, Yi Hu, Li Zhang, Guohui Fan, Jiuyang Xu, Xiaoying Gu, et al., “Clinical Features of Patients Infected with 2019 Novel Coronavirus in Wuhan, China,” *The Lancet*, Vol 395, No. 10223, February 15, 2020, pp. 497–506.

Imai, Masaki, Tokiko Watanabe, Masato Hatta, Subash C. Das, Makoto Ozawa, Kyoko Shinya, Gongxun Zhong, Anthony Hanson, Hiroaki Katsura, Shinji Watanabe, Chengjun Li, Eiryo Kawakami, Shinya Yamada, Maki Kiso, Yasuo Suzuki, Eileen A. Maher, Gabriele Neumann, and Yoshihiro Kawaoka, “Experimental Adaptation of an Influenza H5 HA Confers Respiratory Droplet Transmission to a Reassortant H5 HA/H1N1 Virus in Ferrets,” *Nature*, Vol. 486, No. 7403, May 2, 2012, pp. 420–428. As of July 13, 2022:
<https://doi.org/10.1038/nature10831>

Independent Panel for Pandemic Preparedness and Response, “COVID-19: Make It the Last Pandemic: A Summary,” undated. As of February 15, 2022:
https://theindependentpanel.org/wp-content/uploads/2021/05/Summary_COVID-19-Make-it-the-Last-Pandemic_final.pdf

Inglesby, Thomas V., and Marc Lipsitch, “Proposed Changes to U.S. Policy on Potential Pandemic Pathogen Oversight and Implementation,” *mSphere*, Vol. 5, 2020, p. e00990-19. As of July 13, 2022:
<https://doi.org/10.1128/mSphere.00990-19>

Institute of Medicine, Committee for the Study of the Future of Public Health, *The Future of Public Health*, Washington, D.C.: National Academies Press, 1988.

Interlandi, Jeneen, “Inside the C.D.C.’s Pandemic ‘Weather Service,’” *New York Times Magazine*, November 22, 2021. As of July 13, 2022:
<https://www.nytimes.com/2021/11/22/magazine/cdc-pandemic-prediction.html>

Iskander, John, R. A. Strikas, K. F. Gensheimer, N. J. Cox, and S. C. Redd, “Pandemic Influenza Planning, United States, 1978–2008,” *Emerging Infectious Diseases*, Vol. 19, No. 6, 2013, pp. 879–885. As of May 6, 2022:
<https://doi.org/10.3201/eid1906.121478>

ISO 45001:2018, “Occupational Health and Safety Management Systems—Requirements with Guidance for Use,” March 2018. As of July 13, 2022:
<https://www.iso.org/standard/63787.html>

ISO 35001:2019, “Biorisk Management for Laboratories and Other Related Organisations,” November 2019. As of July 13, 2022:
<https://www.iso.org/standard/71293.html>

ISO 15190:2020, “Medical Laboratories—Requirements for Safety,” February 2020. As of July 13, 2022: <https://www.iso.org/standard/72191.html>

Jackson, Brian A., James W. Buehler, Dana Cole, Susan Cookson, David J. Dausey, Lauren Honess-Morreale, Susan Lance, Roger C. Molander, Patrick O’Neal, and Nicole Lurie, *Bioterrorism with Zoonotic Disease: Public Health Preparedness Lessons from a Multiagency Exercise*, Santa Monica, Calif.: RAND Corporation, RB-9279, 2007. As of May 24, 2022: https://www.rand.org/pubs/research_briefs/RB9279.html

Jacobs, Andrew, “‘Nursing Is in Crisis’: Staff Shortages Put Patients at Risk,” *New York Times*, August 21, 2021. As of February 15, 2022: <https://www.nytimes.com/2021/08/21/health/covid-nursing-shortage-delta.html>

Jacobsen, Rowan, “Inside the Risky Bat-virus Engineering That Links America to Wuhan: China Emulated US Techniques to Construct Novel Coronaviruses in Unsafe Conditions,” *MIT Technology Review*, June 29, 2021. As of July 13, 2022: <https://www.technologyreview.com/2021/06/29/1027290/gain-of-function-risky-bat-virus-engineering-links-america-to-wuhan/>

Kahn, Laura H., “How to Make Biomedical Research (and Biosafety Labs) Less Dangerous and More Ethical, Post-COVID-9,” *Bulletin of Atomic Scientists*, June 8, 2021. As of May 6, 2022: <https://thebulletin.org/2021/06/how-to-make-biomedical-research-and-biosafety-labs-less-dangerous-and-more-ethical-post-covid-19/>

Kahn, Laura H., “The Origins of SARS-Cov-2: Still to Be Determined,” *Bulletin of the Atomic Scientists*, March 10, 2022. As of May 6, 2022: <https://thebulletin.org/2022/03/the-origins-of-sars-cov-2-still-to-be-determined/>

Kaiser, Jocelyn, “Lab Incidents Lead to Safety Crackdown at CDC,” *Science*, July 11, 2014. As of July 13, 2022: <https://www.science.org/content/article/lab-incidents-lead-safety-crackdown-cdc#:~:text=The%20cases%20include%20an%20accidental,from%20CDC%20to%20another%20lab>

Kaiser, Jocelyn, “NIH Says Grantee Failed to Report Experiment in Wuhan That Created a Bat Virus That Made Mice Sicker,” *Science*, October 21, 2021. As of May 24, 2022: <https://www.science.org/content/article/nih-says-grantee-failed-report-experiment-wuhan-created-bat-virus-made-mice-sicker>

Kamradt-Scott, Adam, “WHO’s to Blame? The World Health Organization and the 2014 Ebola Outbreak in West Africa,” *Third World Quarterly*, Vol. 37, No. 3, 2016, pp. 401–418. As of May 6, 2022: <https://www.tandfonline.com/doi/full/10.1080/01436597.2015.1112232>

Katella, Kathy, “12 Things to Know About Paxlovid, the Latest COVID-19 Pill,” *Yale Medicine*, April 29, 2022. As of May 6, 2022: <https://www.yalemedicine.org/news/12-things-to-know-paxlovid-covid-19>

Kensil, Charlotte Read, “Immunomodulatory Adjuvants from Quillaja Saponaria,” in Virgil E. J. C. Schijns and Derek T. O’Hagan, eds., *Immunopotentiators in Modern Vaccines*, Amsterdam: Elsevier, 2006, pp. 109–122. As of July 14, 2022: <https://www.sciencedirect.com/science/article/pii/B9780120884032500083#:~:text=Quillaja%20saponaria%20saponins%20have%20found,in%20mice%20immunized%20with%20P>

Khan, Erum, Nayla Ahmed, Khalid R. Temsamani, Atef El-Gendy, Murray Cohen, Ariba Hasan, Hillard Gastfriend, and Jennifer Cole, “Biosafety Initiatives in BMENA Region: Identification of Gaps and Advances,” *Frontiers in Public Health*, March 24, 2016. As of July 14, 2022: <https://www.frontiersin.org/articles/10.3389/fpubh.2016.00044/full>

Kings College London, “Mapping Maximum Biological Containment Labs Globally,” May 2021. As of May 6, 2022: <https://static1.squarespace.com/static/6048d7a0e9652c472e619f6f/t/60ae71cea2219b008f29d4ca/1622045135314/Mapping+BSL4+Labs+Globally+EMBARGOED+until+27+May+2021+1800+CET.pdf>

Kissinger, Henry, as quoted in Roger Z. George and James B. Bruce, eds., *Analyzing Intelligence: Origins, Obstacles, and Innovations*, Washington, D.C.: Georgetown University Press, 2008.

Kliff, Sarah, Adam Satariano, Jessica Silver-Greenberg, and Nicholas Kulish, “There Aren’t Enough Ventilators to Cope with the Coronavirus,” *New York Times*, March 18, 2020. As of February 15, 2022: <https://www.nytimes.com/2020/03/18/business/coronavirus-ventilator-shortage.html>

Klotz, Lynn C., and Gregory D. Koblentz, “New Pathogen Research Rules: Gain of Function, Loss of Clarity,” *Bulletin of the Atomic Scientists*, February 26, 2018. As of July 14, 2022: <https://thebulletin.org/2018/02/new-pathogen-research-rules-gain-of-function-loss-of-clarity/>

Koblentz, Gregory D., and Filippa Lentzos, “Whether Covid Came from a Leak or Not, It Is Time to Talk About Lab Safety,” *The Guardian*, June 15, 2021. As of May 6, 2022: <https://www.theguardian.com/commentisfree/2021/jun/15/covid-escaped-lab-or-not-biosecurity-laboratories>

- Kormann, Carolyn, “The Mysterious Case of the COVID-19 Lab-Leak Theory: Did the Virus Spring from Nature or from Human Error?” *New Yorker*, October 12, 2021. As of July 14, 2022: <https://www.newyorker.com/science/elements/the-mysterious-case-of-the-covid-19-lab-leak-theory>
- Kuo, Lily, “Coronavirus: Panic and Anger in Wuhan as China Orders City into Lockdown,” *The Guardian*, January 23, 2020. As of May 6, 2022: <https://www.theguardian.com/world/2020/jan/23/coronavirus-panic-and-anger-in-wuhan-as-china-orders-city-into-lockdown>
- Kynge, James, Sun Yu, and Tom Hancock, “Coronavirus: The Cost of China’s Public Health Cover-up,” *Financial Times*, February 6, 2020. As of June 1, 2022: <https://www.ft.com/content/fa83463a-4737-11ea-aeb3-955839e06441>
- Leitenberg, Milton, “Did the SARS-CoV-2 Virus Arise from a Bat Coronavirus Research Program in a Chinese Laboratory? Very Possibly,” *Bulletin of the Atomic Scientists*, June 4, 2020a. As of July 14, 2022: <https://thebulletin.org/2020/06/did-the-sars-cov-2-virus-arise-from-a-bat-coronavirus-research-program-in-a-chinese-laboratory-very-possibly/>
- Leitenberg, Milton, “The Question of Covid-19 Mortality in China,” *CBRNE World*, December 2020b. As of May 7, 2022: <https://spp.umd.edu/sites/default/files/2021-01/BRNe%20December%202020%20vChanges%20Milton.pdf>
- Leitenberg, Milton, “China Versus SARS,” *CBRNe World*, June 2021. As of May 6, 2022: <https://cisssm.umd.edu/sites/default/files/2021-07/China%20versus%20SARs%20extended.pdf>
- Lewis, Michael, *The Premonition: A Pandemic Story*, New York: W. W. Norton & Company, May 4, 2021.
- Li, Xixing, Weina Cui, and Fuzhen Zhang, “Who Was the First Doctor to Report the COVID-19 Outbreak in Wuhan, China?” *Journal of Nuclear Medicine*, Vol. 61, No. 6, June 2020, pp. 782–783.
- Liu, Mi, Lizong Deng, Dayan Wang, and Taijiao Jiang, “Influenza Activity During the Outbreak of Coronavirus Disease 2019 in Chinese Mainland,” *Biosafety and Health*, Vol. 2, No. 4, 2020, pp. 206–209. As of July 14, 2022: <https://doi.org/10.1016/j.bsheat.2020.08.005>
- Liu, Jiangmei, Lan Zhang, Yaqiong Yan, Yuchang Zhou, Peng Yin, Jinlei Qi, Lijun Wang, Jingju Pan, Jinling You, Jing Yang, Zhenping Zhao, Wei Wang, Yunning Liu, Lin Lin, Jing Wu, Xinhua Li, Zhengming Chen, and Maigeng Zhou, “Excess Mortality in Wuhan City and Other Parts of China During the Three Months of the COVID-19 Outbreak: Findings From Nationwide Mortality Registries,” *BMJ*, Vol. 372, No. 415, February 24, 2021. As of February 14, 2022: <https://doi.org/10.1136/bmj.n415>
- Liu, Yuhai, and Yixian Qu, “Why Was the Infectious Disease Direct Reporting System Built After SARS Not Launched in Time?” *Sina*, February 8, 2020. As of March 14, 2022: <https://news.sina.com.cn/c/2020-02-08/doc-iimxxste9715035.shtml>
- Ma, Josephine, “Coronavirus: China’s First Confirmed COVID-19 Case Traced Back to November 17,” *South China Morning Post*, March 13, 2020. As of May 6, 2022: <https://www.scmp.com/news/china/society/article/3074991/coronavirus-chinas-first-confirmed-covid-19-case-traced-back>
- Marshall, Roger, Diane Feinstein, Joni Ernst, and Kirsten Gillibrand, “Congress Must Set Up a COVID-19 Commission,” *Washington Post*, December 2, 2021.
- Mazer-Amirshahi, Maryann, and Erin Fox, “Saline Shortages—Many Causes, No Simple Solution,” *New England Journal of Medicine*, Vol. 378, April 19, 2018, pp. 1472–1474. As of May 6, 2022: <https://www.nejm.org/doi/full/10.1056/NEJMp1800347>
- McConnell, J. Michael, Director of National Intelligence, Annual Threat Assessment of the Intelligence Community for the House Permanent Select Committee on Intelligence, February 27, 2008.
- Menachery, Vineet D., Boyd L. Yount, Jr., Kari Debbink, Sudhakar Agnihothram, Lisa E. Gralinski, Jessica A. Plante, Rachel L. Graham, Trevor Scobey, Xing-Yi Ge, Eric F. Donaldson, Scott H. Randell, Antonio Lanzavecchia, Wayne A. Marasco, Zhengl-Li Shi, and Ralph S. Baric, “A SARS-like Cluster of Circulating Bat Coronaviruses Shows Potential for Human Emergence,” *Nature Medicine*, Vol. 21, No. 12, 2015, pp.1508–1513. As of July 14, 2022: <https://doi.org/10.1038/nm.3985>
- Miller, Greg, and Ellen Nakashima, “President’s Intelligence Briefing Book Repeatedly Cited Virus Threat,” *Washington Post*, April 27, 2020. As of July 14, 2022: https://www.washingtonpost.com/national-security/presidents-intelligence-briefing-book-repeatedly-cited-virus-threat/2020/04/27/ca66949a-8885-11ea-ac8a-fe9b8088e101_story.html

Miltimore, Jon, “Fauci’s Mask Flip-Flop, Explained (by Economics),” Foundation for Economic Education, June 2021. As of February 15, 2022:

<https://fee.org/articles/fauci-s-mask-flip-flop-explained-by-economics/>

Mishra, Swapnil, James A. Scott, Daniel J. Laydon, Seth Flaxman, Axel Gandy, Thomas A. Mellan, H. Juliette T. Unwin, Michaela Vollmer, Helen Coupland, Oliver Ratmann, Melodie Monod, Harrison H. Zhu, Anne Cori, Katy A. M. Gaythorpe, Lilith K. Whittles, Charles Whittaker, Christl A. Donnelly, Neil M. Ferguson, and Samir Bhatt, “Comparing the Responses of the UK, Sweden and Denmark to COVID-19 Using Counterfactual Modelling,” *Scientific Reports*, Vol. 11, No. 16342, August 11, 2021. As of May 24, 2022:

<https://doi.org/10.1038/s41598-021-95699-9>

National Academies of Sciences, Engineering, and Medicine, “Potential Risks and Benefits of Gain-of-Function Research: Summary of a Workshop,” Washington, D.C.: National Academies Press, 2015. As of July 14, 2022:

<https://doi.org/10.17226/21666>

National Academies of Sciences, Engineering, and Medicine, “Gain-of-Function Research: Summary of the Second Symposium, March 10–11, 2016,” Washington, D.C.: National Academies Press, 2016. As of July 14, 2022:

<https://doi.org/10.17226/23484>

National Academies of Sciences, Engineering, and Medicine, *A Strategic Vision for Biological Threat Reduction: The U.S. Department of Defense and Beyond*, Washington D.C.: National Academies Press, 2020. As of May 6, 2022:

<https://www.ncbi.nlm.nih.gov/books/NBK557949/>

National Academies of Sciences, Engineering, and Medicine, “Science Academies from G20 Nations Urge Their Governments to Promote Creation of Global Surveillance Network to Detect Early Signs of Potential Future Pandemics,” statement, August 6, 2021. As of February 15, 2022:

<https://www.nationalacademies.org/news/2021/08/science-academies-from-g20-nations-urge-their-governments-to-promote-creation-of-global-surveillance-network-to-detect-early-signs-of-potential-future-pandemics>

National Center for Biotechnology Information, “Variola Major Virus (strain Bangladesh-1975) Complete Genome,” 1995. As of July 14, 2022: <https://www.ncbi.nlm.nih.gov/nuccore/L22579.1>

National Institutes of Health, “Virtual Meeting and Listening Session on Oversight Framework for Research Involving Enhanced Potential Pandemic Pathogens,” media advisory, April 21, 2022. As of May 6, 2022:

<https://www.nih.gov/news-events/news-releases/virtual-meeting-listening-session-oversight-framework-research-involving-enhanced-potential-pandemic-pathogens>

National Intelligence Council, *Mapping the Global Future: Report of the National Intelligence Council’s 2020 Project*, Washington, D.C., December 2004.

National Intelligence Council, *Global Trends 2025: A Transformed World*, Washington, D.C.: Office of the Director of National Intelligence, NIC-2008-003, November 2008.

National Intelligence Council, *Global Trends 2030: Alternative Worlds*, Washington, D.C.: Office of the Director of National Intelligence, NIC-2012-001, December 2012.

National Intelligence Council, *Global Trends: Paradox of Progress*, Washington, D.C.: Office of the Director of National Intelligence, NIC2017-001, January 2017.

National Research Council and Institute of Medicine of the National Academies, *Potential Risks and Benefits of Gain-of-Function Research: Summary of Workshop*, Washington, D.C.: National Academies Press, 2015. As of May 6, 2022:

<https://nap.nationalacademies.org/catalog/21666/potential-risks-and-benefits-of-gain-of-function-research-summary>

National Science Advisory Board for Biosecurity, “Recommendations for the Evaluation and Oversight of Proposed Gain-of-Function Research,” May 2016.

National Science Advisory Board for Biosecurity, “Meeting Minutes,” Bethesda, Md., January 23–24, 2020. As of August 25, 2022: https://osp.od.nih.gov/wp-content/uploads/NSABB_January_2020_Meeting_Minutes.pdf

Negroponte, John D., “Director of National Intelligence, Annual Threat Assessment of the Director of National Intelligence,” Senate Select Committee on Intelligence, February 2, 2006.

Nelson, Christopher, Katherine Grace Carman, and Anita Chandra, “How Much Do Americans Value Their Health During the Pandemic?” *RAND Blog*, October 29, 2020. As of July 14, 2022: <https://www.rand.org/blog/2020/10/how-much-do-americans-value-their-health-during-the.html>

Nogrady, Bianca, “Mounting Evidence Suggests Sputnik COVID Vaccine Is Safe and Effective,” *Nature*, July 6, 2021. As of May 6, 2022: <https://www.nature.com/articles/d41586-021-01813-2>

Nolen, Stephanie, “Covid’s Uneven Toll,” *New York Times*, March 29, 2022.

NSABB—See National Science Advisory Board for Biosecurity.

Nunn-Lugar Cooperative Threat Reduction Program, “Securing and Safeguarding Weapons of Mass Destruction,” fact sheet, undated. As of July 14, 2022:

<https://www.americansecurityproject.org/ASP%20Reports/Ref%200068%20-%20The%20Nunn-Lugar%20Cooperative%20Threat%20Reduction%20Program.pdf>

O’Dowd, Adrian, “WHO’s Role in Ebola Crisis is Criticized by All Sides,” *BMJ*, November 25, 2015. As of May 6, 2022: <https://www.bmj.com/content/351/bmj.h6385>

Office of the Director of National Intelligence, *Unclassified Summary of Assessment on COVID-19 Origins*, Washington, D.C., August 27, 2021. As of July 14, 2022:

<https://www.dni.gov/index.php/newsroom/reports-publications/reports-publications-2021/item/2236-unclassified-summary-of-assessment-on-covid-19-origins>

Office of the Director of National Intelligence, National Intelligence Council, *Updated Assessment on COVID-19 Origins*, 2021. As of May 6, 2022:

<https://www.dni.gov/files/ODNI/documents/assessments/Declassified-Assessment-on-COVID-19-Origins.pdf>

Offit, Paul A., *You Bet Your Life: From Blood Transfusions to Mass Vaccination, the Long and Risky History of Medical Innovation*, New York: Basic Books, September 21, 2021.

O’Toole, Tara, Mair Michael, and Thomas V. Inglesby, “Shining Light on ‘Dark Winter,’” *Clinical Infectious Diseases*, Vol. 34, No. 7, April 1, 2002, pp. 972–983. As of May 24, 2022: <https://doi.org/10.1086/339909>

Oversight Committee Republicans, “NIH Confirmed Today EcoHealth and the WIV Conducted GOF Research on Bat Coronaviruses,” tweet, October 20, 2021. As of May 24, 2022: <https://twitter.com/GOPoversight/status/1450934193177903105/photo/1>

Pandemic Mitigation Project, homepage, undated. As of May 6, 2022: <https://pandemicmitigationproject.com/>

Parachini, John V., and Rohan Gunaratna, *Implications of the Pandemic for Terrorist Interest in Biological Weapons: Islamic State and al-Qaeda Pandemic Cases*, Santa Monica, Calif.: RAND Corporation, RR-A612-1, May 2022. As of July 14, 2022: https://www.rand.org/pubs/research_reports/RRA612-1.html

Parthemore, Christine, and Andy Weber, “A Deterrence by Denial Strategy for Addressing Biological Weapons,” *War on the Rocks*, September 23, 2021. As of July 14, 2022: <https://warontherocks.com/2021/09/a-deterrence-by-denial-strategy-for-addressing-biological-weapons/>

Paun, Carmen, and Daniel Payne, “Sputnik Vaccine Goes From First to . . .,” *Politico*, November 18, 2021. As of March 9, 2022: <https://www.politico.com/newsletters/global-pulse/2021/11/18/sputnik-vaccine-goes-from-first-to-495142>

Pekar, Jonathan, Michael Worobey, Niema Noshiri, Konrad Scheffler, and Joel O. Wertheim, “Timing the SARS-CoV-2 Index Case in Hubei Province,” *Science*, Vol. 372, No. 6540, March 18, 2021. As of July 18, 2022: <https://www.science.org/doi/full/10.1126/science.abf8003>

Peters, Alexandra, “The Global Proliferation of High-containment Biological Laboratories: Understand the Phenomenon and Its Implications,” *Revue Scientifique et Technique*, Vol. 37, No. 3, December 2018, pp. 857–883. As of May 6, 2022: <https://pubmed.ncbi.nlm.nih.gov/30964462/>

Pollard, Michael S., and Lois M. Davis, *Decline in Trust in the Centers for Disease Control and Prevention During the COVID-19 Pandemic*, Santa Monica, Calif.: RAND Corporation, RR-A308-12, 2021. As of May 6, 2022: https://www.rand.org/pubs/research_reports/RRA308-12.html

Public Law 115-232, The Defense Production Act of 1950, As Amended, August 13, 2018. As of July 12, 2022: https://www.fema.gov/sites/default/files/2020-03/Defense_Production_Act_2018.pdf

Rabouin, Dion, “Coronavirus Has Disrupted Supply Chains for Nearly 75% of U.S. Companies,” *Axios*, March 11, 2020. As of July 18, 2022: <https://www.axios.com/coronavirus-supply-chains-china-46d82a0f-9f52-4229-840a-936822ddef41.html>

Ran, Ran, and Yan Jian, “When Transparency Meets Accountability: How the Fight Against the COVID-19 Pandemic Became a Blame Game in Wuhan,” *China Review*, Vol. 21, No. 1, February 2021, pp. 7–36. As of May 6, 2022: muse.jhu.edu/article/784425

- RAND Corporation, “Health Economics,” webpage, undated. As of July 18, 2022: <https://www.rand.org/topics/health-economics.html>
- Ranney, Megan, Valerie Griffeth, and Ashish Jha, “Critical Supply Shortages—The Need for Ventilators and Personal Protective Equipment During the COVID-19 Pandemic,” *New England Journal of Medicine*, April 2020. As of July 18, 2022: <https://www.nejm.org/doi/full/10.1056/NEJMp2006141>
- Ravelo, Jenny Lei, “Battered with Criticisms, What’s Next for WHO?” *devex*, May 18, 2020. As of July 18, 2022: <https://www.devex.com/news/battered-with-criticism-what-s-next-for-who-97257>
- Reardon, Sara, “Researcher Reassigned in Wake of Disease Centre’s Anthrax Scare,” blog post, *Nature*, June 23, 2014a. As of July 18, 2022: <http://blogs.nature.com/news/2014/06/researcher-reassigned-in-wake-of-disease-centres-anthrax-scare.html>
- Reardon, Sara, “NIH Finds Forgotten Smallpox Store,” blog post, *Nature*, July 9, 2014b. As of July 18, 2021: <https://www.nature.com/articles/nature.2014.15526>
- Reynolds, Emma, and Eoin McSweeney, “‘Desperate’ Shortage of Ventilators for Coronavirus Patients Puts Manufacturers on Wartime Footing,” CNN, March 2020. As of July 18, 2022: <https://www.cnn.com/2020/03/19/business/coronavirus-ventilators-manufacture-intl/index.html>
- Ridley, Matt, “A WHO Pandemic Pact Would Leave the World at China’s Mercy,” *The Telegraph*, May 14, 2022. As of May 24, 2022: <https://www.telegraph.co.uk/news/2022/05/14/pandemic-pact-would-leave-world-chinas-mercy/>
- Ridley, Matt, and Prasenjit Ray, “Did Virus Hunters Cover Up a Lab Leak?” *UnHerd*, April 22, 2022. As of July 18, 2022: <https://unherd.com/2022/04/did-virus-hunters-cover-up-a-lab-leak/>
- Rivers, Caitlin, and Dylan George, “How to Forecast Outbreaks and Pandemics,” *Foreign Affairs*, June 29, 2020. As of July 18, 2022: <https://www.foreignaffairs.com/articles/united-states/2020-06-29/how-forecast-outbreaks-and-pandemics>
- Robbins, Rebecca, and Stephanie Nolen, “Race to Vaccinate the World Loses Momentum,” *New York Times*, April 23, 2022.
- Rogin, Josh, “State Department Cables Warned of Safety Issues at Wuhan Lab Studying Bat Coronaviruses,” *Washington Post*, April 14, 2020. As of May 6, 2022: <https://www.washingtonpost.com/opinions/2020/04/14/state-department-cables-warned-safety-issues-wuhan-lab-studying-bat-coronaviruses/>
- Sachs, Jeffrey D., “Finding the Origins of COVID-19 and Preventing Future Pandemics,” *Project Syndicate*, June 21, 2021. As of July 18, 2022: <https://www.project-syndicate.org/onpoint/finding-the-origins-of-covid19-by-jeffrey-d-sachs-2021-06>
- Sanger, David, Zolan Kanno-Youngs, and Nicholas Kulish, “A Ventilator Stockpile, with One Hitch: Thousands Do Not Work,” *New York Times*, April 1, 2020. As of July 18, 2022: <https://www.nytimes.com/2020/04/01/us/politics/coronavirus-ventilators.html>
- Saunes, Ingrid Sperre, Karsten Vrangbæk, Haldor Byrkjeflot, Signe Smith Jervelund, Hans Okkels Birk, Liina-Kaisa Tynkkynen, Ilmo Keskimäki, Sigurbjörg Sigurgeirsdóttir, Nils Janlöv, Joakim Ramsberg, Cristina Hernández-Quevedo, Sherry Merkur, Anna Sagan, and Marina Karanikolos, “Nordic Responses to Covid-19: Governance and Policy Measures in the Early Phases of the Pandemic,” *Health Policy*, September 2021. As of May 6, 2022: <https://www.sciencedirect.com/science/article/pii/S0168851021002220>
- Schnirring, Lisa, “Ebola Review Calls for Reforms to Boost Global Outbreak Response,” *CIDRAP News*, November 23, 2015. As of July 18, 2022: <https://www.cidrap.umn.edu/news-perspective/2015/11/ebola-review-calls-reforms-boost-global-outbreak-response>
- Segal, Edward, “First Communication Problem Surfaces in Covid-19 Vaccination Campaign; General Takes Responsibility for Snafu,” *Forbes*, December 19, 2020. As of May 6, 2022: <https://www.forbes.com/sites/edwardsegal/2020/12/19/first-communication-problem-surfaces-in-recently-launched-covid-19-vaccination-campaign/?sh=390dd63d51f9>
- Selgelid, Michael J., “White Paper: Gain-of-Function Research: Ethical Analysis,” Monash University, Melbourne, Australia, 2015. As of July 18, 2022: https://osp.od.nih.gov/wp-content/uploads/2013/06/Gain-of-Function_Research_Ethical_Analysis.pdf
- Sensi, Alessandra, Kakoli Ghosh, Masami T. Takeuchi, and Andrea Sonnino, *Building Biosafety Capacities: FAO’s Experience and Outlook*, Rome: Food and Agriculture Organization of the United Nations, 2009. As of March 28, 2022: <https://www.fao.org/3/i1033e/i1033e.pdf>

Sguazzin, Anthony, “How a Missing Gene Led South African Scientists to Find Omicron,” *Bloomberg*, November 30, 2021. As of February 14, 2022:

<https://www.bloomberg.com/news/articles/2021-11-30/how-south-african-scientists-found-the-troubling-omicron-strain>

Sifferlin, Alexandra, “WHO Vows Reform After Ebola Outbreak Mistakes,” *Time*, May 18, 2015. As of July 18, 2022:

<https://time.com/3882556/who-reform-ebola-outbreak-mistakes/>

Sinclair, Robert S., *Thinking and Writing: Cognitive Science and Intelligence Analysis*, Langley, Va.: Center for the Study of Intelligence, February 2010, revised edition of a monograph originally published in January 1984. As of July 18, 2022:

<https://www.cia.gov/resources/csi/books-monographs/thinking-and-writing/>

Sonnemaker, Tyler, “Bill Gates Said He Warned Trump About the Dangers of a Pandemic in December 2016 Before He Took Office,” *Business Insider*, May 11, 2020.

Stanway-Williams, Caitlin, “Common Sources of Error in Biology Lab Experiments,” *Automata*, March 4, 2022. As of July 18, 2022:

<https://automata.tech/blog/common-sources-of-error-in-biology-lab-experiments/>

Steinbruner, John, Elisa Harris, Nancy Gallagher, and Stacy M. Okutani, “Pathogens: A Prototype Protective Oversight System,” College Park, Md.: The Center for International and Security Studies, March 2007. As of May 6, 2022:

https://cisss.umd.edu/sites/default/files/2019-07/pathogens_project_monograph.pdf

Stroski, Paul, “What Went Wrong with Russia’s Sputnik V Vaccine Rollout?” *Carnegie Endowment for International Peace*, November 15, 2021. As of July 18, 2022:

<https://carnegieendowment.org/2021/11/15/what-went-wrong-with-russia-s-sputnik-v-vaccine-rollout-pub-85783>

Sun, Lena H., “New Team at CDC: A ‘Weather Service’ to Forecast What’s Next in Pandemic,” *Washington Post*, April 20, 2022.

Sunshine Project, “Mandate for Failure: The State of Institutional Biosafety Committees in an Age of Biological Weapons Research,” Austin, Texas, October 4, 2004. As of May 6, 2022:

https://bkofsecrets.files.wordpress.com/2015/06/sunshine_mandate-for-failure.pdf

Tabak, Lawrence A., Acting Director, National Institutes of Health, “Statement on Charge to the National Science Advisory Board for Biosecurity to Review Scope and Effectiveness of Two U.S. Government Biosecurity Policy Frameworks,” February 28, 2022. As of July 18, 2022: <https://www.nih.gov/about-nih/who-we-are/nih-director/statements/statement-charge-national-science-advisory-board-biosecurity-review-scope-effectiveness-two-us-government-biosecurity-policies>

Taylor, Adam, and Adela Suliman, “World Agrees to Negotiate a Global ‘Pandemic Treaty’ to Fight the Next Outbreak,” *Washington Post*, December 1, 2021. As of May 24, 2022:

<https://www.washingtonpost.com/world/2021/12/01/who-coronavirus-pandemic-agreement-treaty/>

Tugendhat, Tom, “Treating Viruses Like Atomic Bombs Would Help Prevent Pandemics,” *Financial Times*, November 21, 2021. As of May 24, 2022:

<https://www.ft.com/content/318c0cf6-5b34-4482-bfa3-26c4825b866e>

UN—See United Nations.

United Nations Office for Disarmament Affairs, “Biological Weapons Convention,” webpage, undated-a. As of February 15, 2022:

<https://www.un.org/disarmament/biological-weapons/>

United Nations Office for Disarmament Affairs, “Secretary-General’s Mechanism for Investigation of Alleged Use of Chemical and Biological Weapons (UNSGM),” undated-b. As of July 18, 2022:

<https://www.un.org/disarmament/wmd/secretary-general-mechanism>

United Nations Office for Disarmament Affairs, “UN Security Council Resolution 1540 (2004),” webpage, undated-c. As of February 15, 2022: <https://www.un.org/disarmament/wmd/sc1540/>

U.S. Department of Defense, *Global Emerging Infections System, Annual Report Fiscal Year 2001*, Silver Spring, Md., 2001. As of July 18, 2022:

https://pdf.usaid.gov/pdf_docs/PCAAB062.pdf

U.S. Department of Health and Human Services, “Framework for Guiding Funding Decisions About Proposed Research Involving Enhanced Potential Pandemic Pathogens,” 2017.

U.S. Department of Health and Human Services, “Strategic National Stockpile,” webpage, August 9, 2021. As of March 29, 2022:

<https://www.phe.gov/about/sns/Pages/default.aspx>

U.S. Department of Health and Human Services and U.S. Department of Defense, “Explaining Operation Warp Speed,” fact sheet, undated. As of July 18, 2022:

<https://www.nihb.org/covid-19/wp-content/uploads/2020/08/Fact-sheet-operation-warp-speed.pdf>

U.S. Department of State, “COVID-19 Vaccine Donations,” webpage, undated. As of March 28, 2022:
<https://www.state.gov/covid-19-recovery/vaccine-deliveries/>

U.S. Department of State, *United Nations Security Council Resolution 1540*, Washington, D.C.: Bureau of International Security and Nonproliferation, December 2012. As of July 18, 2022:
<https://www.state.gov/wp-content/uploads/2018/11/UNSCR-1540.pdf>

U.S. House of Representatives, Permanent Select Committee on Intelligence, “Chairman Schiff Applauds Passage of 2022 Intelligence Authorization Act,” press release, September 30, 2021. As of July 18, 2022:
<https://intelligence.house.gov/news/documentsingle.aspx?DocumentID=1161>

U.S. Senate, 117th Congress, S.3203, National Commission on the COVID-19 Pandemic Act, November 04, 2021. As of May 6, 2022:
<https://www.congress.gov/bill/117th-congress/senate-bill/3203>

Velicer, Irene, “Covid Heats Up Debate Over Biological Weapons Convention,” Geneva Solutions, updated on September 18, 2021. As of July 18, 2022:
<https://genesolutions.news/science-tech/covid-heats-up-debate-over-biological-weapons-convention>

Verification Research, Training and Information Center, “BWC Legislation Database,” webpage, undated. As of March 28, 2022:
<https://www.vertic.org/programmes/nim/biological-weapons-and-materials/bwc-legislation-database/u/>

VERTIC—*See* Verification Research, Training and Information Center.

Wang, Yuxi, Adriana Castelli, Qi Cao, and Dan Liu, “Assessing the Design of China’s Complex Health System—Concerns on Equity and Efficiency,” *Health Policy*, Vol. 1, November 21, 2020. As of May 6, 2022:
<https://www.sciencedirect.com/science/article/pii/S2590229620300198>

Wenham, Clare, “What We Have Learnt About the World Health Organization from the Ebola Outbreak,” *Philosophical Transactions of the Royal Society of London. Series B, Biological Sciences*, Vol. 372, No. 1721, 2017.

White House, “Doing Diligence to Assess the Risks and Benefits of Life Sciences Gain-of-Function Research,” blog post, October 17, 2014. As of July 18, 2022:
<https://obamawhitehouse.archives.gov/blog/2014/10/17/doing-diligence-assess-risks-and-benefits-life-sciences-gain-function-research>

White House, “Remarks by President Biden at the Office of the Director of National Intelligence,” July 27, 2021. As of July 18, 2022:
<https://www.whitehouse.gov/briefing-room/speeches-remarks/2021/07/27/remarks-by-president-biden-at-the-office-of-the-director-of-national-intelligence/>

White House Office of Science and Technology Policy, “Recommended Policy Guidance for Departmental Development of Review Mechanisms for Potential Pandemic Pathogen Care and Oversight (P3CO),” Washington, D.C., January 9, 2017a. As of May 6, 2022:
<https://www.phe.gov/s3/dualuse/documents/p3co-finalguidancestatement.pdf>

White House Office of Science and Technology Policy, “Recommended Policy Guidance for Potential Pandemic Pathogen Care and Oversight,” Washington, D.C., January 9, 2017b. As of May 6, 2022:
<https://obamawhitehouse.archives.gov/blog/2017/01/09/recommended-policy-guidance-potential-pandemic-pathogen-care-and-oversight>

WHO—*See* World Health Organization.

“Why Are Drug Prices So High in the United States?” *RAND Review*, May 2019. As of July 18, 2022:
<https://www.rand.org/blog/rand-review/2019/05/why-are-drug-prices-so-high-in-the-united-states.html>

Williams, Katie Bo, Zachary Cohen, and Natasha Bertrand, “Intel Agencies Scour Reams of Genetic Data for Wuhan Lab in COVID Origins Hunt,” CNN, August 5, 2021. As of July 18, 2022:
<https://www.cnn.com/2021/08/05/politics/covid-origins-genetic-data-wuhan-lab/index.html?form=MY01SV&OCID=MY01SV>

Willman, David, and Madison Muller, “A Science in the Shadows: Controls on ‘Gain of Function’ Experiments with Supercharged Pathogens Have Been Undercut Despite Concerns About Lab Leaks,” *Washington Post*, August 26, 2021.

Wong, Tessa, “Covid: Is China’s Vaccine Success Waning in Asia?” BBC News, July 19, 2021. As of March 9, 2022:
<https://www.bbc.com/news/world-asia-57845644>

World Health Organization, “About WHO,” webpage, undated-a. As of July 18, 2022:
<https://www.who.int/about>

World Health Organization, homepage, undated-b. As of March 28, 2022:
<https://www.who.int>

- World Health Organization, “WHO Hub for Pandemic and Epidemic Intelligence: Better Data. Better Analytics. Better Decisions,” webpage, undated-c. As of July 18, 2022: https://cdn.who.int/media/docs/default-source/2021-dha-docs/who_hub.pdf?sfvrsn=8dc28ab6_5
- World Health Organization, *International Health Regulations*, Third Ed., Geneva, 2005.
- World Health Organization, “WHO Director-General’s Opening Remarks at the Media Briefing on COVID-19,” March 11, 2020a. As of May 6, 2022: <https://www.who.int/director-general/speeches/detail/who-director-general-s-opening-remarks-at-the-media-briefing-on-covid-19---11-march-2020>
- World Health Organization, “Situation Report,” webpage, April 20, 2020b. As of July 18, 2022: https://www.who.int/docs/default-source/coronaviruse/situation-reports/20200420-sitrep-91-covid-19.pdf?sfvrsn=fcf0670b_10
- World Health Organization, *WHO-Convended Global Study of Origins of SARS-CoV-2: China Part*, Joint WHO-China Study January 14–February 10, 2021, March 30, 2021.
- World Health Organization, 74th World Health Assembly, Agenda Item 17.3, May 25, 2021. As of February 15, 2022: https://apps.who.int/gb/ebwha/pdf_files/WHA74/A74_ACONF7-en.pdf
- World Health Organization, “WHO, Germany Open Hub for Pandemic and Epidemic Intelligence in Berlin,” news release, September 1, 2021. As of July 18, 2022: <https://www.who.int/news/item/01-09-2021-who-germany-open-hub-for-pandemic-and-epidemic-intelligence-in-berlin>
- World Health Organization, “WHO Recommends Highly Successful COVID-19 Therapy and Calls for Wide Geographical Distribution and Transparency from Originator,” news release, April 22, 2022a. As of July 18, 2022: <https://www.who.int/news/item/22-04-2022-who-recommends-highly-successful-covid-19-therapy-and-calls-for-wide-geographical-distribution-and-transparency-from-originator>
- World Health Organization, “WHO Coronavirus (COVID-19) Dashboard,” webpage, updated May 19, 2022b. As of May 19, 2022: <https://covid19.who.int/>
- World Organisation for Animal Health, “Managing Biorisk: Examples of Aligning Risk Management Strategies with Assessed Biorisks,” Chapter 2.1.3 in *OIE Terrestrial Manual*, Paris, 2018. As of February 15, 2022: https://www.oie.int/fileadmin/Home/eng/Health_standards/tahm/2.01.03_BIOL_AGENT_SPECIF_RA.pdf
- Worobey, Michael, “Dissecting the Early COVID-19 Cases in Wuhan,” *Science*, Vol. 374, No. 6572, November 18, 2021. As of July 18, 2022: <https://www.science.org/doi/10.1126/science.abm4454>
- Wright, Lawrence, “The Plague Year. The Mistakes and the Struggles Behind America’s Coronavirus Tragedy,” *New Yorker*, December 28, 2020. As of July 18, 2022: <https://www.newyorker.com/magazine/2021/01/04/the-plague-year>
- Wu, Jin, Welyi Cai, Derek Watkins, and James Glanz, “How the Virus Got Out,” *New York Times*, March 22, 2020. As of May 6, 2022: <https://www.nytimes.com/interactive/2020/03/22/world/coronavirus-spread.html>
- Xiang, N., F. Havers, T. Chen, Y. Song, W. Tu, L. Li, Y. Cao, B. Liu, L. Zhou, L. Meng, et al., “Use of National Pneumonia Surveillance to Describe Influenza A(H7N9) Virus Epidemiology, China, 2004–2013,” *Emerging Infectious Diseases*, Vol. 19, 2013, pp. 1784–1790.
- Xiang, Nijuan, Ying Song, Yu Wang, Jiabing Wu, Alexander J. Millman, Carolyn M. Greene, Zhentao Ding, Jie Sun, Wei Yang, Guoxia Guo, et al., “Lessons from an Active Surveillance Pilot to Assess the Pneumonia of Unknown Etiology Surveillance System in China, 2016: The Need to Increase Clinician Participation in the Detection and Reporting of Emerging Respiratory Infectious Diseases,” *BMC Infectious Disease*, Vol. 19, No. 770, 2019. As of July 18, 2022: <https://doi.org/10.1186/s12879-019-4345-0>
- Yeh, Kenneth B., Kairat Tabynov, Falgunee K. Parekh, Illich Mombo, Kyle Parker, Kaissar Tabynov, Shelton S. Bradrick, Ashley S. Tseng, Ji-Rong Yang, Lolly Gardiner, Gene Olinger, and Bradley Setser, “Significance of High-Containment Biological Laboratories Performing Work During the COVID-19 Pandemic: Biosafety Level-3 and -4 Labs,” *Frontiers in Bioengineering and Biotechnology*, Vol. 9, August 13, 2021. As of July 18, 2022: www.frontiersin.org/article/10.3389/fbioe.2021.720315
- Yeung, Douglas, “National Sewage Tracking Could Keep Us a Step Ahead of COVID. But Congress Just Cut the Funds,” *San Francisco Chronicle*, March 24, 2022. As of March 29, 2022: <https://www.sfchronicle.com/opinion/openforum/article/National-wastewater-tracking-could-help-us-stay-17023568.php>

Zhang Xu-Sheng, Emilia Vynnycky, Andre Charlett, Daniela De Angelis, Zhengji Chen, and Wei Liu, “Transmission Dynamics and Control Measures of COVID-19 Outbreak in China: A Modelling Study,” *Scientific Reports*, Vol. 11, January 29, 2021. As of May 6, 2022: <https://www.nature.com/articles/s41598-021-81985-z#citeas>

Zheng, Sarah, “Coronavirus: US State Department Cables Show Concerns over Rules and Training at Wuhan Lab,” *South China Morning Post*, July 20, 2020. As of May 6, 2022: <https://www.scmp.com/news/china/science/article/3093961/coronavirus-us-state-department-cables-show-concerns-over-rules>

Zhou, Peng, Xing-Lou Yang, Xian-Guang Wang, Ben Hu, Lei Zhang, Wei Zhang, Hao-Rui Si, Yan Zhu, Bei Li, Chao-Lin Huang, Hui-Dong Chen, Jing Chen, Yun Luo, Hua Guo, Ren-Di Jiang, Mei-Qin Liu, Ying Chen, Xu-Rui Shen, Xi Wang, Xiao-Shuang Zheng, Kai Zhao, Quan-Jiao Chen, Fei Deng, Lin-Lin Liu, Bing Yan, Fa-Xian Zhan, Yan-Yi Wang, Geng-Fu Xiao, and Zheng-Li Shi, “A Pneumonia Outbreak Associated with a New Coronavirus of Probable Bat Origin,” *Nature*, No. 579, 2000, pp. 270–273. As of July 18, 2022: <https://doi.org/10.1038/s41586-020-2012-7>

| Abbreviations | | IC | U.S. Intelligence Community |
|---------------|---|--------|--|
| API | active pharmaceutical ingredient | IHR | International Health Regulations |
| BMBL | Biosafety in Microbiological and Bio-medical Laboratories | ISO | International Organization for Standardization |
| BSL-3 | Biosafety Level 3 | MERS | Middle East respiratory syndrome |
| BSL-4 | Biosafety Level 4 | NIH | National Institutes of Health |
| BWC | Biological and Toxin Weapons Convention | NSABB | National Science Advisory Board for Biosecurity |
| CDC | Centers for Disease Control and Prevention | OSTP | Office of Science and Technology Policy |
| CET | Central Expert Team | OWS | Operation Warp Speed |
| COVID-19 | coronavirus disease 2019 | PPE | personal protective equipment |
| DNI | Director of National Intelligence | PRC | People’s Republic of China |
| DoD-GEIS | Department of Defense Global Emerging Infections System | PUE | Pneumonia of Unexplained Etiology |
| DPA | Defense Production Act | SARS | Severe Acute Respiratory Syndrome |
| GDP | Gross Domestic Product | SNS | Strategic National Stockpile |
| GHSA | Global Health Security Agenda | UN | United Nations |
| GOFROC | gain-of-function research of concern | UNSCR | United Nations Security Council Resolution |
| H5N1 | highly pathogenic Asian avian influenza | USG | U.S. government |
| HHS | U.S. Department of Health and Human Services | VERTIC | Verification Research, Training and Information Center |
| IAA | Intelligence Authorization Action | WHO | World Health Organization |
| | | WIV | Wuhan Institute of Virology |

About the Authors

John V. Parachini is a senior international and defense researcher, former director of the RAND Intelligence Policy Center, and a member of the Pardee RAND Graduate School faculty.

Dr. **Jennifer Bouey** is a senior policy researcher, Tang Chair for China Policy Studies, and an epidemiologist at the RAND Corporation.

Senior policy researcher **Daniel M. Gerstein** served as Under Secretary (Acting) and Deputy Under Secretary in the Science and Technology Directorate and as Senior Counselor to the Deputy Secretary at the Department of Homeland Security.

Senior engineer **Alison K. Hottes** has co-led RAND projects on defense acquisition data, biocontainment laboratories, chemical security, and international basic research.

Senior policy researcher **Bradley Martin** is the director of the RAND National Security Supply Chain Institute.

Trupti Brahmhatt is a senior policy researcher and infectious disease expert who spent 28 years in the Navy as an enlisted service member and Medical Service Corps officer.

Senior economist **Katherine Grace Carman** is director of RAND's Center for Financial and Economic Decision Making and a professor at the Pardee RAND Graduate School.

Senior policy researcher **Anita Chandra** is vice president and director of RAND Social and Economic Well-Being.

K. Jack Riley is vice president and director of RAND's Homeland Security Research Division.

Barbara Bicksler is a research communications analyst who works across RAND's federally funded research and development centers.

About This Perspective

The coronavirus pandemic that began in late 2019 and continues as of the writing of this Perspective in early 2022 has been the cause of both tremendous tragedy—in lives lost and economic hardship—and great triumph in the rapid development of effective vaccines. Along this journey, nations around the world have scrambled to respond to a once-in-a-century event that has exposed many weaknesses in response planning and capabilities, including those of the United States. Even as the pandemic continues, it is not too early to reflect on the missteps that have been made and lessons that can be learned so that the United States and nations worldwide can be better prepared for the future. This volume contains a collection of essays that explores topics of critical importance toward that aim and identifies actions that can be taken to not only improve pandemic preparedness but also help prevent the occurrence of future pandemics. The essays center on U.S. challenges and experiences, but the solutions, in many cases, require collaborative efforts that reach across national boundaries.

The research described here was completed in May 2022 and underwent security review with the sponsor and the Defense Office of Pre-publication and Security Review before public release.

RAND National Security Research Division

This research was sponsored by the U.S. Department of Defense and conducted within the International Security and Defense Policy Center of the RAND National Security Research Division (NSRD), which operates the National Defense Research Institute (NDRI), a federally funded research and development center sponsored by the Office of the Secretary of Defense, the Joint Staff, the Unified Combatant Commands, the Navy, the Marine Corps, the defense agencies, and the defense intelligence enterprise.

For more information on the RAND International Security and Defense Policy Center, see www.rand.org/nsrd/isdp or contact the director (contact information is provided on the webpage).

