CRITICAL STEPS IN PREVENTING FUTURE PANDEMICS

EARLY LESSONS FROM THE COVID-19 CRISIS FOR ADDRESSING NATURAL AND DELIBERATE BIOLOGICAL THREATS

A WORKSHOP REPORT BY
THE COUNCIL ON STRATEGIC RISKS AND SANDIA NATIONAL LABORATORIES

VIRTUAL WORKSHOP: AUGUST 17, 2020
REPORT ISSUED: FEBRUARY 22, 2021

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Cover Photo:
U.S. Sailors assigned to the aircraft carrier USS Theodore Roosevelt depart the ship after a COVID-19 outbreak.
Petty Officer 1st Class Christopher Liaghat / U.S. Department of Defense
EXECUTIVE SUMMARY

This report summarizes a virtual workshop on early lessons from the COVID-19 pandemic as they pertain to proactively addressing future biological threats. Co-hosted by Sandia National Laboratories (Sandia) and the Council on Strategic Risks (CSR) in August 2020, the discussion involved experts who at that time were leading innovative efforts in various U.S. government agencies, industry, and academia sharing observations from their ongoing pandemic response efforts. Based on the input by these expert participants, it is clear that even though the pandemic response is ongoing, the following recommendations will be important to consider for more successfully addressing biological threats in the future:

Continue building on the cross-sector collaboration and agility shown in the COVID-19 response. Work to address the COVID-19 pandemic has involved significant collaboration and innovation among academia, companies, and government. Many businesses, universities, government laboratories, and others quickly pivoted their work to help ramp up testing, manufacturing products related to the response, and more. The public-private collaboration that has occurred during this pandemic must continue and be expanded upon in the future---including in ways that continue to foster the agility seen in response to the COVID-19 pandemic.

Expand capabilities for detecting biological threats early. This must include improving U.S. capabilities for rapid and scalable testing and contact tracing. An important national and international vision would be for using the wide-ranging data that can contribute to early pathogen detection akin to today’s ubiquitous development and use of weather maps.

Prioritize ways to create and disseminate medical countermeasures even faster. Rapid development of vaccine candidates for COVID-19 has been a pivotal success, yet the time taken for approvals for widespread use and distribution have delayed their effective use in curtailing death and hardship. This shows that even faster development and testing of therapeutics and vaccines, and reducing bureaucratic burdens for approvals for medical countermeasures, must take high priority.

Create the U.S. bio industrial base needed for rapid response to biological threats, and keep it healthy. The U.S. economy showcased the importance of expertise and physical facilities in enabling surge capacity to respond to emerging biological threats, for example for manufacturing of critical reagents and equipment. This showed the need to foster an even stronger bio industrial base.

Major government reorganization may not be needed if there is effective work to form coalitions, improve coordination, and expand steady-state and surge capacities. If past crises are precedent, the pandemic will likely bring rise to calls for a significant reorganizing of the federal government. However, this pandemic has shown that many of the elements needed for early detection and rapid response to biological threats are already on hand---but they do need to be empowered by persistent public-private engagement and significantly improved coordination across actors. Priority should be given to ideas for fully leveraging the incredible assets the United States has, including incentivizing academia and the private sector to consistently engage regarding biological threats and solutions.

COVID-19 is not the last biological threat we will face---and it may not be the worst. These steps will help the United States (and other countries) prevent future emerging infectious diseases from growing into pandemics and bringing mass-scale devastation, whether they emerge naturally, deliberately, or by accident.
Arresting the COVID-19 pandemic is one of the most important tasks facing President Joe Biden and his administration in its early months. With well over 400,000 American lives lost already and millions affected, bringing this pandemic to an end is of paramount importance.

The task of protecting the nation from infectious disease threats will not end there. The U.S. Executive Branch and Congress---and private sector and international counterparts---must also begin work to prevent future emerging biological threats from ever again reaching pandemic scale.

In August 2019, Sandia National Laboratories and the Council on Strategic Risks (CSR) convened a workshop of government and nongovernmental experts and leaders to discuss an ambitious vision: developing a system of greater preparedness and rapid-enough response capabilities that an emerging biological threat would be detected and addressed quickly enough to prevent mass deaths. In essence, the group explored how biological weapons could be rendered ineffective as weapons of mass effect by robbing them of their potential for devastation.1

Attendees knew this wasn’t something that would be done overnight, but we came away with the sense that this national vision was possible---and indeed, many of the technologies required for such systemic change are already on hand.

Moreover, the current pandemic has proven that there is a false dichotomy between natural vs. man-made biological threats. The SARS-CoV-2 virus emerged from nature but has desirable attributes nefarious actors might want in a man-made pathogen: it is highly contagious; hard to detect, including because people spreading it may have no symptoms; it can spread quickly in a population and while a large fraction of infected population will recover, thousands will become severely ill, overpowering our health system; and efforts to contain it will require shutting down of social and economic activities, adversely affecting economic and sociopolitical wellbeing. Hence, many of the recommendations resulting from our 2019 workshop carry the same benefits for the current pandemic---and for stopping future outbreaks from reaching pandemic scale. The ongoing responses to COVID-19 therefore shaped the follow-on, virtual workshop that Sandia and CSR held in August 2020.

The discussion aimed at distilling lessons and ideas from the ongoing pandemic response, with perspectives shared from those leading innovative efforts from within various U.S. government agencies, industry, and academia.

This report summarizes these ideas, though because the conversation was held under the Chatham House Rule, the specifics captured in this report should not be considered attributable to any specific participant. It begins with brief notes from the discussion regarding the pandemic and response, then focuses on lessons that we can take from the COVID-19 pandemic for both preventing future pandemics at this scale as well as for meeting the vision of deterring and rendering ineffective any potential future deliberate biological attacks.
COVID-19 AND THE EARLY RESPONSE

By August 2020, several things were clear about COVID-19, even if many mysteries endured. For one, it was recognized early (but perhaps not early enough) that the United States needed to focus on mitigating the spread of the virus as containment was already too late. Responses were also confused by the unique characteristics of the disease itself, with its now well-known range of severity or lack of symptoms in different people, as well as misinformation and mixed messages about the disease from political leaders in the United States, both at federal and state levels.

Within weeks of the reporting on the outbreak in China, U.S. officials recognized that there was a problem and sent a small team to investigate. Significant responses were being stood up by the U.S. federal government by January and February 2020. However, the basic models of the disease’s spread made clear that if the outbreak actually began in December or earlier—and if early disease statistics from China were underreported, including because of early confusion and changes in how cases were being counted—many actions were coming too late for a strategy of prevention and containment to work. COVID-19 would surely already be spreading across the nation. Officials had to assume the virus was already almost everywhere.

By spring 2020 many specific problems were becoming both clear and urgent. The United States was too slow to develop tests and even slower to make the tests readily available throughout the country. Supply chains were heavily impacted by high demand and cut-off trade, leaving the nation in short supply of critical equipment such as ventilators, personal protective equipment including masks, and consumables such as test reagents and tubes. Early promotion of mask wearing could have paid significant dividends in slowing the virus’s spread. Mixed messaging became a significant impediment and reduced public trust. Messages about COVID-19 and what to do about it conflicted across international organizations such as the WHO, White House and U.S. federal agency leaders and state officials, and between different medical and public health officials and experts.
Of course, this virus and disease themselves confound responses in some ways. Testing remains a problem, and as time has passed experts have seen the challenges to effective testing based on elapsed time since a victim is exposed and other factors. This continues to confuse the public as guidance evolves, though with good planning this can be much better accounted for in preparedness and public communications for future biological threats.

Moreover, many deficiencies in responses stemmed from a general failure of imagination. The reasons for this can be varied and one can ask critical questions. Were we too focused on bioterrorism in the two decades after the 2001 mailing of anthrax letters in the United States? Past SARS, Ebola, and Zika outbreaks did not cause significant damage in the United States. Did that make U.S. officials complacent? The persistence of influenza has made us focus heavily on influenza viruses. Did we pay inadequate attention to coronaviruses (despite SARS and MERS)? Incidentally, the National Biodefense Strategy released in late 2018 expanded the focus of our biodefense efforts to include natural outbreaks but unfortunately, many of the recommendations were not implemented during the current pandemic. The issues of the U.S. response are all well-documented, and shaped participants’ views on the lessons offered later in this report.

Given that COVID-19 was not contained during our August 2020 discussion and continues to reach horrific milestones in its spread even today, there has been less public attention to date to things that have gone well. Yet capturing successes in the types of innovation, collaboration, and pivoting of national assets that have occurred is just as important as documenting and learning from deficiencies if we are to succeed in addressing future biological threats well before they reach this scale.

PIVOTING, COLLABORATING, AND INNOVATING

Work to address the COVID-19 pandemic has involved significant collaboration and innovation among academia, companies, and government. It has also triggered a wave of innovation, in particular in such entities applying existing assets to contribute to pandemic responses. A few examples of successes were highlighted during the workshop and are discussed in brief here.

Universities and other entities developed clinical testing capabilities: Many cases of things that went well in the COVID-19 response have involved entities pivoting to apply their capabilities toward pandemic response. This was the case for many U.S. universities (such as the Doudna Lab at University of California Berkeley), national laboratories (Sandia, Los Alamos, Pacific Northwest, et al.), and others. For the Doudna Lab, its region’s diagnostic testing deficit stood as a clear problem that the lab could contribute early to addressing, though it had skilled workers but not infrastructure in place to do so. As it stood up testing capabilities, it began with manual processes that allowed them to do about 200 tests per day and expanded into automated processes that allowed them to ramp up to more than 1,000 tests processed per day.

Moreover, the Doudna Lab and others have promoted open sharing to facilitate others replicating this work. For example, the lab’s team created a blueprint for pop-up testing labs so other academic institutions could take the same steps they did to pivot laboratory assets toward testing, and openly published information on this.²

Industry pivoted, including to manufacture equipment and reagents to address supply-chain issues: To contribute to COVID-19 response, many U.S. companies pivoted the use of their personnel and facilities
to making and increasing production of much-needed equipment like ventilators and masks, and critical consumable goods like reagents for tests. For example, Ginkgo Bioworks, a biotech and organism manufacturing company, made its facilities (otherwise used for a range of purposes, from developing enzymes to making fragrances) available to enable widespread, routine testing. This involved building the end-to-end logistics and scale needed to deploy rapid antigen tests and pooled surveillance testing. The company is supporting Moderna and other vaccine manufacturers with process optimization for key raw materials used in the manufacturing of nucleic acid vaccines.

BARDA’s Operation Warp Speed showed the possibilities for rapid vaccine development: Another important shift was in the dramatic increase in resources flowing to the Biomedical Advanced Research and Development Authority (BARDA) of the Department of Health and Human Services (HHS), which was established by pandemic and all-hazards preparedness legislation in 2006 to more quickly get medical countermeasures to the population in particular in times of national crises. BARDA is credited with acting quickly to ramp up in response to the billions of dollars Congress appropriated to it for COVID-19 responses and innovating to meet the unprecedented needs of the pandemic. Specifically, it set up Operation Warp Speed to fund and assist companies in developing and testing vaccines within months—processes that normally take years.
Vaccine candidates for SARS-COV-2 were developed within days of the virus’s genetic sequence being publicly released, and several are now in distribution. Building upon this successful rapid development of medical countermeasures will be key to addressing future biological threats. Courtesy of the U.S. Department of Health and Human Services

Still, not all went smoothly for those working to pivot their assets to pandemic response. Supply chain and regulatory hurdles affected them. Some organizations contributing new testing capacities faced mistrust from hospitals, and health insurance reimbursement issues impeded some efforts to focus more resources on testing low-income populations that were disproportionately affected.

There was also variance in how fast different types of entities could pivot. The advanced development and manufacturing facilities that U.S. health and defense departments invested in over the past decade showed progress but also deficiencies early in the pandemic which points to the need for considering future improvements in organization, infrastructure, and resources. This was in part simply because the nation lacked blueprints for the mass-scale vaccine production required, as such plans are normally designed to increase production to thousands of doses for clinical trials in a short timespan—not surging to produce millions of doses (and perhaps billions over the longer haul). Many academic labs and private sector organizations switched their assets to work on COVID-19 diagnostics, therapeutics, and vaccines much more quickly.
LESSEONSS FOR ADDRESSEENNG 
FUTURE BIOLOGICAL THREATS

Extensive work is already ongoing to assess lessons from the COVID-19 crisis, even as it is far from over at the time of this writing. Crisis responses are always imperfect, often colored by hubris and infighting, though they vary widely in what works and what doesn’t. This brief report does not seek to summarize or repeat lessons developed through other review efforts, but instead focuses on major lessons identified by participants in the August 2020 Sandia-CSR workshop.

DETECT BIO THREATS EARLY

Many workshop participants showed surprise that SARS-COV-2 and its spread were not detected earlier in the United States. The need for dramatic improvements in pathogen early warning is already one of the most widely-recognized lessons of this pandemic, and experts in government civil services roles, nongovernmental organizations, and appointees to the Biden administration are already considering solutions.

Pathogen early warning systems will require both monumental data collection and analysis, though many of the needed capabilities have advanced greatly in recent years, and many are in use today. For the United States and globally, early warning will require a steady state of persistent detection. Sequencing (including next-generation sequencing, NGS, and metagenomic NGS) will be an increasingly important element, with great promise for improving early detection if used on a regular basis. One area where NGS can play a significant role is surveillance of infectious diseases in humans, animals, insects, and plants on a continual, persistent basis. This provides a database of pathogens and strains present as a function of location and time and makes it faster to detect a new outbreak and its spread.

Improvements in diagnostics and widespread testing will play a key role in pathogen early warning as well. More types of testing to be used in a wider variety of settings will help with early disease detection and tracking, especially with tools to enable information to be easily or automatically reported. Many entities such as universities quickly developed clinical testing facilities, and they should be used as “surge capacity” for testing during future outbreaks. However, this requires planning and availability of funding to support networks of public and private universities.

What one participant called “point of person” diagnostics should also be advanced, and ready for common use before the next significant outbreak, which will require getting through regulatory and societal changes. More frequent medical testing is common for athletes and other sub-populations, for example, but public education and acceptance and costs will need to align in order for diagnostics to meet their fuller potential for contributing to disease early warning. Rapid containment of disease spread requires aggressive contact tracing following positive tests. This is another area where the United States fared poorly compared to other nations despite being leaders in smartphone and related technologies. Americans are often suspicious of the government or companies collecting their data, and that was a big impediment in implementation of automated and rapid contact tracing apps. Instead, the nation relied heavily on slow and manual interviews with people to trace and isolate close contacts. It will take work to develop creative ideas for how to do better during the next pandemic while paying attention to privacy concerns people have.
While detecting emerging infectious diseases as early as possible is critical for preventing future pandemics, this must also be accompanied by well-supported systems that can surge to then respond.

CREATE THE BIO INDUSTRIAL BASE AND KEEP IT HEALTHY

The COVID-19 pandemic shows the need for significant changes in U.S. public health systems broadly. Yet even ideal systems also need to be supported by an industrial base. Increasingly, this support base can stem from a broader bio economy in which assets are pivoted to help quash outbreaks more quickly and effectively.

In the United States and around the world, the significant innovation in vaccine development and manufacturing must be expanded upon even after this pandemic is over. Next generation platforms in which vaccines can be customized more rapidly to new viruses based on their genetic sequence should become the standard for more rapidly making vaccines. The potential of mRNA vaccines, cell-free production, and other technologies that have been known for some time but advanced in recent years can be fostered more for future pandemic prevention. These changes need to be sustained and built upon, including with more investment in optimizing production of various vaccine materials and components, in addition to vaccines themselves.

Academic and private organizations that are contributing to COVID-19 testing, medical countermeasure development, and supply chains, transitioned assets that were being used for experimental and commercial purposes before the pandemic. Indeed, the United States and other nations have growing synthetic biology industrial bases that represent a latent capability that can serve other purposes in normal times and surge for biological threat response when needed.

Many companies pivoted physical and intellectual assets to COVID-19 response, including for production of reagents, equipment, and more. This is an initial example of why the United States must foster and maintain an industrial base that can surge to help address future biological threats when they arise. COURTESY OF GINKGO BIOWORKS
Such latent capabilities can also be highly flexible at moving quickly and in coordinated fashion. For example, one company’s assets could help in analysis and production to optimize vaccines or produce materials and supplies for testing to support other entities that have extensive pharmaceutical expertise and production equipment. If COVID-19 fosters a shift to greater openness and collaboration, it will make it easier for entities in this bio industrial base to complement one another in how experimentation is conducted and made more rapid when needed. The untapped potential for leveraging assets in the United States is massive.

However, this will only work if such a bio industrial base continues to expand in sustainable ways and is maintained. Many of the successful efforts to collaborate and pivot assets to the COVID-19 pandemic response were funded by the federal government or philanthropies. Some such assets can support themselves and be sustained when they divert back to their prior work streams, but the personal leadership required to pivot to stopping disease threats again in the future cannot be taken for granted.

From the federal government perspective, it should seek to map the ecosystem of this latent industrial base, and collaborate across public and private experts on strategies for keeping it sustainable and ready to surge in times of need.

**FORM A COALITION**

Regular, open discussion needs to become common among government and nongovernmental actors. While there are countless examples of strong public-private cooperation and dialogue on biological threats, many participants don’t interact commonly across these lines outside of interactions specific to government funding and procurement processes. Even many of the nation’s top innovators don’t understand well the workings of the federal government or know how to connect with champions with whom they share a common vision of supercharging national capabilities to prevent future pandemics.

Such public-private coordination, dialogue, and partnership will be critical in shifting from reacting to pandemic threats to a more proactive posture.³

**FOCUS ON COORDINATION & CAPACITY**

Many discussion participants fear that the sheer scale of the COVID-19 crisis will trigger propositions for expensive and potentially ineffective solutions, at least for the federal government. One particular concern is that bureaucratic restructuring will take a more prominent focus than is warranted, and that this will paper over the real need for changes in resources, coordination, and political will. Focus should be on seeking optimal alignment of roles and responsibilities across the Departments of Health and Human Services, Defense, and Energy, the Federal Emergency Management Administration, the White House, and others before jumping to establish a new agency. Many discussants believe that at the federal government level, the right structures and many elements of the needed tools and workforce are largely in place if they are supported well and charged with a common national vision for how to apply those assets.
Coordination is critical—and likely more important than significant bureaucratic changes, according to many nongovernmental and former government officials, as well as many experts across the interagency who personally witnessed challenges in the COVID-19 response. Addressing biological threats requires collaboration across incredibly diverse disciplines, from all the commonly-known health and biological sciences fields, to information sciences, high-scale computing, use of precision instrumentation, supply chain and acquisition specialties, and much more. Managing across such complexity will always be challenging, but coordination, training, and resources are key.

No single individual or position can make this work. Having a lead position on biological threats and solutions in the National Security Council is important, for example, but in itself is not a metric that demonstrates the government is ready to prevent the next pandemic. Experts and officials will need to coordinate to ensure that specific improvements like this do not detract from systemic change and the dedication of adequate resources on a persistent basis that it will require. Narrowly-focused solutions are also often less resilient to political change, whereas stopping future biological threats from becoming pandemics will require effective coordination and policy responses even if specific positions change or move.

The COVID-19 pandemic proved that you cannot pull off a complex, major disaster response with ad hoc organizations that are not staffed and practiced in what needs to occur in the case of a pandemic. Many with direct knowledge of the federal government response believe that the Vice President leading a newly-established task force for the COVID-19 response was a mistake—regardless of who held that role at the time—even though many nongovernmental and former-government experts had promoted this model. Such structure can also induce micromanagement of more minor decisions that should be well-coordinated but more distributed.

Of course, surging to address an emerging biological threat also requires bandwidth, in particular a trained and resourced workforce. For COVID-19 response, the federal government pushed significant funding through HHS quickly, though evaluating where to invest those funds, what technologies were likely to work, and overseeing investments takes time and skill. Agencies like HHS need to have the capability to broaden the funnel through which response investments flow in times of crisis, and this will take a steady state of training and investment in between major outbreaks.
FULLY LEVERAGE ASSETS ALREADY AT HAND

For diseases and other threats, it is common for policy solutions to focus heavily on the federal government funding early stage research and development, given that structurally much later-stage development and innovation comes from private sector investments. Yet in the case of work to prevent future pandemics and stop biological weapons threats in their tracks, many experts believe much of the technology, tools, and knowledge needed already exist.

Several challenges remain, however. These span from inadequate funding to the difficulty of widely deploying existing tech, to engineering improvements necessary for some tools to become more economical, to the aforementioned supply chain and logistical impediments. Public-private coordination efforts should include efforts to map what assets are already on the table that can contribute to the bio industrial base that will help address future infectious disease threats---if they are fostered and advanced.

TAKE EVERY OPPORTUNITY TO IMPROVE

Another key lesson is the need for constant reexamination of normal government processes and practices that can be improved, and that may need to be significantly enhanced or altered to halt significant emerging biological threats. This should be a steady-state process, rather than something that surges only in times of crises.
Operation Warp Speed, the special initiative to accelerate development of vaccines and therapies, was a case in point. For the future, further analysis should focus on what worked well with this effort, and where a portfolio investment approach is better than traditional acquisition processes that focus often on slower down-selection to a smaller number of investments. One important feature was that key government agencies sent highly-skilled individuals with complementary backgrounds to collaborate for this effort, such as defense experts with unique experiences in speeding acquisition processes and managing significant financial resources.

Many positive stories of innovation and American ingenuity will emerge from the COVID-19 crisis, even as it has been devastating for the nation. However, this is not a reliable replacement for strong, persistent preparedness and standing up a robust steady-state system for detecting and rapidly addressing biological threats. For example, while many academic and private sector labs adjusted around major supply chain impediments, minimizing these hindrances in the first place is a far more reliable approach.

Additionally, relatively small investments in research and development could lead to exponential improvements, for example in aspects of vaccine production like plasmid development and enzyme production. During the COVID-19 crisis, many companies and labs made such investments with their own resources, or were able to conduct significant work with government support. There is concern that this could, however, lead to a market failure in which major advancements that could help prevent the next novel disease from spreading to pandemic scale are left by the wayside instead.

**ADDRESS DELIBERATE BIOLOGICAL THREATS**

Much attention will be paid to naturally occurring infectious diseases as a result of the COVID-19 crisis---and rightfully so. Yet it must serve as a persistent warning of the devastating potential of all biological threats.

This must include the national security community taking serious ownership of its important roles in biological threats writ large. Today, many in defense agencies in particular view disease threats as worries to be addressed by other parts of the government unless they are intentionally introduced by an adversary. COVID-19 sidelined an aircraft carrier and infected the Commander in Chief, among more than 200,000 other defense community workers to date. This shows the harm of drawing an artificial line between natural and deliberate biological threats, whereas they have distinct elements but largely overlap.

Additionally, Operation Warp Speed and National Guard units assisting with vaccine distribution are just a few examples of the critical role defense experts and assets play in protecting the nation from disease threats. Preventing pandemics and rendering biological weapons ineffective at inflicting mass casualties are both “all hands on deck” national security imperatives.

Some meeting participants also noted that those wishing to do harm to the United States will not miss how sweepingly the pandemic has affected the nation, and are likely very interested in exploiting our weaknesses in biodefense in the future. The COVID-19 crisis must be continually examined for lessons on what future biological weapons could entail---and be applied aggressively to addressing that threat. Public education on how deliberate and natural biological threats overlap, and where they differ, is also needed, especially in light of continual misinformation and disinformation campaigns.
The COVID-19 pandemic will be assessed thoroughly for lessons to apply to future infectious disease outbreaks. What went both well and poorly in its responses must inform future preparedness. This is true not just for natural outbreaks but also for man-made bioweapons. We must assume that our poor response to the pandemic has provided adversaries with an incentive to consider bioweapons as a credible threat against the United States.

Hence, this pandemic should be used as a launching point for envisioning even-worse biological threats—and for significantly enhancing preparedness, detection, and response capacities. Future natural or manmade infectious diseases could, for example, be even more transmissible than SARS-COV-2, cause even more-severe neurological problems in victims, inflict a significantly higher mortality rate, and carry even-worse other effects. We must therefore avoid viewing COVID-19 as a worst case scenario, even while we work toward the goal of systemic, enhanced preparedness and rapid responses that aim to make sure no future infectious disease threats rise to its scale of devastation.

Work toward solutions must remain one of the highest priorities through the full Biden Administration and those that come after. This work will require significant and sustained support and public-private collaboration, and it is urgent. As one participant in our workshop stated succinctly, we will not have another fifteen years before we have to do this again. Yet this nation and others have significant resources that can be tapped for systemic, enduring change.
# Making BioWeapons Obsolete and Preventing Future Pandemics

**Workshop #2 (Via Zoom)**  
August 17, 2020, 11:00AM to 1:00PM Eastern

## Participants

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NOTES


3 Based on this workshop lesson and insights from other private discussions, in 2020 CSR formed the Alliance to End Biological Threats, which brings together public and private leaders in a neutral space to discuss issues and collaborate on solutions. See more at https://councilonstrategicrisks.org/bioalliance/.


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