The Role of AI Technology in Pandemic Response and Preparedness: Recommended Investments and Initiatives

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NATIONAL SECURITY COMMISSION ON ARTIFICIAL INTELLIGENCE

Disclaimer: This white paper only reflects the views of the contributing Commissioner and staff and does not reflect official views or recommendations of the full Commission.

Contents

Letter from the Executive Director

The COVID-19 pandemic stands as a vivid reminder that health security is national security. The virus threatens the U.S. economy, the health of our citizens, the readiness of our armed forces, and America's role in the world. It takes no leap of imagination to envision a similar, or even more catastrophic biothreat emerging from a pathogen engineered for lethality and deployed as a weapon. While Americans have long understood that confronting biothreats—-including pandemics—are important to national security, any future strategies must integrate biohealth and pandemic planning and preparations even more deeply.

I believe the National Security Commission on Artificial Intelligence (NSCAI) has a responsibility to offer recommendations that will leave the nation in a healthier position after this crisis and prepare it for the next generation of national security threats. A successful strategy for confronting the current pandemic depends in large part on harnessing and applying new technologies—many of which are underpinned by artificial intelligence (AI). The Commission mandate is to consider how the United States should advance the development of artificial intelligence, machine learning, and associated technologies to comprehensively address its national security and defense needs. Harnessing AI and associated technologies now to confront the pandemic will help to protect our nation's health and preserve our global leadership going forward.

The Commission has initiated temporary special projects to issue white papers that address AI-related aspects of pandemic response and implications of the crisis for America's security and strategic competitiveness. Each paper is a collaboration of participating Commissioners and select staff, and only reflects the views of the Commissioners and staff who have contributed to the special project. It does not reflect official action, deliberation, or decision by the NSCAI, all 15 Commissioners, a majority of Commissioners, or any Commissioner who was not part of the special project that produced the paper. These special projects are separate and distinct from the Commission's current lines of effort.

The first white paper, "Privacy and Ethics Recommendations for Computing Applications Developed to Mitigate COVID-19," analyzed how computing applications can supplement the United States' manual contact tracing efforts and recommends privacy and ethics considerations in developing and fielding these applications. The second white paper, "Mitigating Economic Impacts of the COVID-19 Pandemic and Preserving U.S. Strategic Competitiveness in AI," offered recommendations for using

AI to mitigate the economic impact of COVID-19, and protecting AI and other emerging technologies as strategic assets and sources of U.S. and allied economic strength.

This white paper, "The Role of AI Technology in Pandemic Response and Preparedness," outlines a series of investments and initiatives that the United States must undertake to realize the full potential of AI to secure our nation against pandemics.

As always, we welcome your comments and feedback submitted via congress@nscai.gov.

Yll Bajraktari
Executive Director

The Role of AI Technology in Pandemic Response and Preparedness: Recommended Investments and Initiatives[1]

National Security Commission on Artificial Intelligence Commissioner Jason Matheny and Directors of Research & Analysis Olivia Zetter, Tess deBlanc-Knowles, and Michael Garris[2]

The COVID-19 pandemic confirms that health security is national security. No facet of American life has been spared. The nation's economic prosperity, the well-being of its citizens, the readiness of its armed forces, and its role in the world are all threatened by the virus. United States strategy and planning has long recognized the potential danger that biothreats pose to national security, be they natural or manmade.[3] Undoubtedly, future conceptions of national security will have to integrate pandemics and broader biothreats into national security even more tightly, elevating the threat and expanding

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[1] This white paper reflects the views of the commissioner and staff who have participated in this special project on the role of AI and technology in pandemic response and preparedness. It does not reflect official action, deliberation, or decision by the NSCAI, all 15 commissioners, a majority of commissioners, or any commissioner who was not part of this special project.

[2] NSCAI staff Raina Davis provided key contributions to this white paper.

[3] The U.S. actively engaged in biodefense programs during WWII and the Cold War. In more recent decades, protecting against natural and manmade biological threats have been included in U.S. National Security Strategies since 1995, and national biodefense presidential directives and strategies have been released by every administration since the Clinton Administration. See *National Security Strategy of the United States of America*, The White House at 9 (Dec. 2017), https://www.whitehouse.gov/wp-content/uploads/2017/12/NSS-Final-12-18-2017-0905.pdf. For additional history, see *A National Blueprint for Biodefense: Leadership and Major Reform Needed to Optimize Efforts*, Bipartisan Commission on Biodefense (Oct. 2015), https://biodefensecommission.org/wp-content/uploads/2015/10/NationalBluePrintNov2018-03.pdf; *National Security Strategy*, Historical Office, Office of the Secretary of Defense, Department of Defense (last visited June 16, 2020), https://history.defense.gov/Historical-Sources/National-Security-Strategy/; *Evolution of U.S. Biodefense Policy*, *Biodefense Summit Transcript*, U.S. Department of Health & Human Services (last reviewed June 21, 2019), https://www.phe.gov/Preparedness/biodefense-strategy/Pages/kadlec-transcript.aspx.

the ways and means for responding to pandemics to protect the American people and United States interests.

The early months of the pandemic response suggest that technology—some of it underpinned by artificial intelligence—offers powerful potential for detecting and containing the virus, driving biomedical innovation—including for vaccines and therapeutics—and improving response and recovery.[4] While it's unclear whether AI will significantly affect the course of the COVID-19 pandemic, these initial investigations illustrate how AI could be used to enhance pandemic preparedness and response in the future. With the right investments, over the next decade AI could revolutionize how scientists understand data, carry out research, and design new pharmaceuticals; how doctors diagnose certain diseases and interact with their patients; and how public health officials manage information and make decisions.[5]

We recognize that AI is not a panacea and some of the technological promise is, today, more theoretical than practical.[6] Algorithms can perform differently in the field than they do in the lab. Bias can creep into underlying data and model design. Many applications remain brittle, with little transferability or efficacy outside their narrow and discrete use cases. And it takes education and training to teach doctors and scientists to use new tools and integrate them into their workflow. Care must be taken to ensure that applied systems and tools are safe, trustworthy, unbiased, and understood by users.[7]

Yet, the promise of AI-enabled technology is real and builds on the long-standing strengths of the American technology ecosystem. The Commission's interim report highlighted the enduring power of the United States innovation model. The

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[4] Promising efforts currently underway detailed in Part I of this paper.

[5] Claudia Wallis, *How Artificial Intelligence Will Change Medicine*, nature (Dec. 18, 2019), https://www.nature.com/articles/d41586-019-03845-1.

[6] The following resources outline the types of concerns that must be taken into consideration in order to safely and effectively apply AI solutions. Alex Engler, *A Guide to Healthy Skepticism of Artificial Intelligence and Coronavirus*, Brookings (Apr. 2, 2020), https://www.brookings.edu/research/a-guide-to-healthy-skepticism-of-artificial-intelligence-and-coronavirus/; Myura Nagendran, et al., *Artificial Intelligence Versus Clinicians: Systematic Review of Design, Reporting Standards, and Claims of Deep Learning Studies*, BMJ (Mar. 25, 2020), https://www.bmj.com/content/368/bmj.m689; Will Douglas Heaven, *Google's Medical AI was Super Accurate in a Lab. Real Life was a Different Story.*, MIT Technology Review (Apr. 27, 2020), https://www.technologyreview.com/2020/04/27/1000658/google-medical-ai-accurate-lab-real-life-clinic-covid-diabetes-retina-disease/; https://www.wired.com/story/artificial-intelligence-wont-save-us-from-coronavirus/.

[7] Christine M. Cutillo, et al., *Machine Intelligence in Healthcare——Perspectives on Trustworthiness, Explainability, Usability, and Transparency*, npj Digital Medicine (Mar. 26, 2020), https://www.nature.com/articles/s41746-020-0254-2.

United States Government, universities, and private companies have long served as the reinforcing pillars of our technological leadership and economy.[8] They have tackled America's toughest societal and national security challenges together. Once again this "triangular alliance" is mobilizing for action to research, develop, and field new technologies to protect the American people and lead the world in next-generation solutions to biological threats, whether natural or engineered.

Part I of this White Paper identifies ways that AI is showing promise now and could help in the future. Part II outlines a series of investments and initiatives that the United States must undertake to realize the full potential of AI to secure our nation against pandemics.

Part I. Promising Uses of AI for Pandemic Response — Now and in the Future

Below we summarize several ways in which AI can be applied to advance healthcare, biomedicine, and biosecurity. These are broken down across four primary areas: 1) situational awareness and disease surveillance; 2) diagnostics; 3) production of vaccines, therapeutics, and medical equipment; and, 4) ongoing healthcare - protecting the healthy and treating the sick. AI is continually evolving. Investing in these areas will improve existing applications, lead to novel use cases, and offer even greater opportunities to keep our citizens safe. While it's unclear whether AI will significantly affect the course of COVID-19, these initial investigations suggest how AI can be used to enhance pandemic preparedness and response in the future.

A. Situational Awareness and Disease Surveillance

Understand the threat through disease modeling. AI is being employed to better understand how diseases, including COVID-19, spread and ways to fight them. AI models are predicting the structure of proteins associated with the virus[9] and mapping

[8] *Interim Report*, National Security Commission on Artificial Intelligence at 24 (Nov. 2019), https://www.nscai.gov/reports/.

[9] *Computational Predictions of Protein Structures Associated with COVID-19*, DeepMind (Apr. 8, 2020), https://deepmind.com/research/open-source/computational-predictions-of-protein-structures-associated-with-COVID-19; http://www.rcsb.org/news?year=2020&article=5e3c4bcba5007a04a313edcc.

the spread of infection,[10] enabling researchers to determine the mechanisms the virus employs to infect humans and how they can be inhibited.[11] Natural Language Processing helps researchers gain faster understanding of COVID-19 by combing through vast amounts of medical research literature to find answers and build on the work of other experts.[12] In the future, the application of AI to virology could dramatically expedite our ability to understand and combat emerging viral threats.

Enable early outbreak detection and real-time disease surveillance. AI is currently being used to ingest and fuse near real-time data from varied sources—including news feeds, social media, public health data, clinical health data, and digital health tools—to monitor for outbreaks, gauge new hot spots, and measure the progress and severity of the virus.[13] Canadian company BlueDot used an AI-driven tool to detect the COVID-19 outbreak in Wuhan, China, doing so before widespread recognition of the disease's emergence.[14] Boston-based enterprise AI provider DataRobot has built

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[10] For example, scientists at Lawrence Berkeley National Laboratory are applying "machine-learning methods to . . . health and environmental datasets, combined with high-resolution climate models and seasonal forecasts," to determine the environmental factors influencing transmission. Emily Henderson, *Scientists Use Machine Learning Methods to Estimate COVID-19's Seasonal Cycle*, News-Medical.Net (May 20, 2020), https://www.news-medical.net/news/20200520/Scientists-use-machine-learning-methods-to-estimate-COVID-19s-seasonal-cycle.aspx.

[11] Karina Mazhukhina, *How AI is Helping Scientists in the Fight Against COVID-19, from Robots to Predicting the Future*, GeekWire (Apr. 8, 2020), https://www.geekwire.com/2020/ai-helping-scientists-fight-covid-19-robots-predicting-future/.

[12] Allen Institute for AI, *COVID-19 Open Research Dataset Challenge*, kaggle (updated June 9, 2020), https://www.kaggle.com/allen-institute-for-ai/CORD-19-research-challenge. For example, a team at Northwestern University has developed a tool to rate the promise of scientific papers on COVID-19 vaccines and treatments by estimating reproducibility, aiming to help researchers focus on efforts with a higher chance of tangible results. Vinod Sreeharsha, *Northwestern University Team Develops Tool to Rate COVID-19 Research*, Wall Street Journal (May 12, 2020), https://www.wsj.com/articles/northwestern-university-team-develops-tool-to-rate-covid-19-research-11589275800; Another team at the Allen Institute for AI developed a system to fact check scientific claims around COVID-19. Karen Hao, *AI Could Help Scientists Fact-check COVID Claims Amid a Deluge of Research*, MIT Technology Review (May 29, 2020), https://www.technologyreview.com/2020/05/29/1002349/ai-coronavirus-scientific-fact-checking/.

[13] For example, the long-standing disease surveillance program, HealthMap, uses machine learning to scan open source information in real time and visually map disease outbreak and spread. HealthMap, https://www.healthmap.org/en/; John McCormick, *Online Map Tracks Coronavirus Outbreak in Real Time*, Wall Street Journal (Mar. 5, 2020), https://www.wsj.com/articles/online-map-tracks-coronavirus-outbreak-in-real-time-11583354911. The Army has augmented its AI-powered Joint Analytic Real-time Virtual Information Sharing System (JARVISS) to track the pandemic and provide a COVID-19 specific dashboard to commanders. Jackson Barnett, *New Job for JARVISS: Coronavirus Tracking for the Army*, FedScoop (Apr. 28, 2020), https://www.fedscoop.com/coronavirus-tracking-army-jarviss/.

[14] Bill Whitaker, *The Computer Algorithm that was Among the First to Detect the Coronavirus Outbreak*, CBS 60 Minutes (Apr. 27, 2020), https://www.cbsnews.com/news/coronavirus-outbreak-computer-algorithm-artificial-intelligence/.

AI-based models that predict COVID-19 spread down to the county level, creating a tool that can help inform local policy decisions.[15] AI-driven platforms will be increasingly capable of universal data ingestion of unstructured multi-domain data sources. These platforms will provide leaders and public health officials with tailored alerts and real-time situational awareness of emerging threats.

Monitor and prevent zoonotic spillovers. AI-enabled predictive tools can help monitor for zoonotic spillovers,[16] identify at-risk environmental areas and inform where, when, and what data to collect; thereby contributing to both research and critical early warning systems.[17] AI has been used to identify new species of virus, as well as animal species that may carry pathogens that could jump to humans.[18] Today's AI capabilities can already be used to sift through molecular, epidemiological, ecological, and climate data to identify vulnerabilities for such zoonotic spillovers.[19] As more data is generated through this work and as the technology progresses for merging multi-source data and models, zoonotic warning systems could combine with the outbreak detection platforms described above for earlier and more accurate disease detection.

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[15] Sergey Yurgenson, et al., *Predicting COVID-19 on the U.S. County Level*, DataRobot (Mar. 17, 2020), https://www.datarobot.com/blog/predicting-the-covid-19-on-the-u-s-county-level/.

[16] Zoonotic spillover is "pathogen transmission from a vertebrate animal to a human." Alfonso J. Rodriguez-Morales, et al., *History is Repeating Itself: Probably Zoonotic Spillover as the Cause of the 2019 Novel Coronavirus Epidemic*, InfezMed (Mar. 1, 2020), https://pubmed.ncbi.nlm.nih.gov/32009128/.

[17] Amy Maxmen, *Machine Learning Spots Treasure Trove of Elusive Viruses*, nature (Mar. 19, 2020), https://www.nature.com/articles/d41586-018-03358-3. The Global Public Health Intelligence Network (GPHIN) is an AI-enabled monitoring system for ongoing infectious disease surveillance and detection. Run by Health Canada and WHO, GPHIN provided early alerts of SARS and MERS-CoV and played a significant role in the monitoring of the Ebola outbreak in West Africa. M. Dion, et al., *Big Data and the Global Public Health Intelligence Network*, CCDR (Sept. 3, 2015), https://www.canada.ca/content/dam/phac-aspc/migration/phac-aspc/publicat/ccdr-rmtc/15vol41/dr-rm41-09/assets/pdf/ccdrv41i09a02-eng.pdf.

[18] Amy Maxmen, *Machine Learning Spots Treasure Trove of Elusive Viruses*, nature (Mar. 19, 2020), https://www.nature.com/articles/d41586-018-03358-3; Boer Deng, *Artificial Intelligence Joins Hunt for Human-Animal Diseases*, Nature (May 18, 2015), https://www.nature.com/news/artificial-intelligence-joins-hunt-for-human-animal-diseases-1.17568.

[19] Michael C. Lu, *Future Pandemics can be Prevented, but That'll Rely on Unprecedented Global Cooperation*, Washington Post (Apr. 17, 2020), https://www.washingtonpost.com/health/future-pandemics-can-be-prevented-but-thatll-rely-on-unprecedented-global-cooperation/2020/04/16/0caca7b8-7e6d-11ea-8013-1b6da0e4a2b7_story.html; *UNEP Frontiers 2016 Report: Emerging Issues of Environmental Concern*, United Nations Environment Programme (2016), https://wedocs.unep.org/bitstream/handle/20.500.11822/7664/Frontiers_2016.pdf?sequence=1&isAllowed=y; Toph Allen, et al., *Global Hotspots and Correlates of Emerging Zoonotic Diseases*, Nature Communications (Oct. 24, 2017), https://www.nature.com/articles/s41467-017-00923-8.

Advance bioforensics for threat analysis. When an outbreak occurs, bioforensic analysis plays a key role in determining the cause as natural, intentional, or accidental.[20] COVID-19 has highlighted the inherent complexity in identifying the origin of a disease outbreak. Bioforensic capabilities seek to detect high-consequence biothreats and profile pathogen samples during an incident for unique signatures that can aid attribution.[21] AI is enabling advances in key sciences for next generation bioforensics—including genomics, proteomics, and metabolomics[22]—that seek to answer both agent-specific and threat-agnostic questions.[23] AI will further progress bioforensics by enabling inferential and predictive methods for interpreting data and identifying key indicators.[24]

Detect pathogens with advanced sensing. New intelligent sensor technologies could compile data on new pathogens (including instances of weaponized pathogens), trace exhaled droplets dispersed through the air and deposited on surfaces,[25] detect early onset of infection through wearable sensors,[26] and encourage social distancing through mobile proximity detection. Going forward, AI will likely play an increasing role in identifying novel sensing materials and ways to build new capabilities, as well as serve a functional role within certain sensors.

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[20] The field of microbial and bioforensics evolved following the 2001 anthrax attacks in the United States and subsequent U.S. government investment in biothreat detection capabilities. Ali S. Khan, et al., *Microbial Forensics: Chapter 8 - Forensic Public Health: Epidemiological and Microbiological Investigations for Biosecurity*, ScienceDirect (2020), https://www.sciencedirect.com/science/article/pii/B9780128153796000088; http://bnbi.org/about-us-2/history/.

[21] James Burans, et al., *The National Bioforensic Analysis Center*, Elsevier Public Health Emergency Collection (Dec. 6, 2019), https://www.ncbi.nlm.nih.gov/pmc/articles/PMC7153312/.

[22] Davide Chicco, et al., *Editorial: Artificial Intelligence Bioinformatics: Development and Application of Tools for Omics and Inter-Omics Studies*, Frontiers (Apr. 9, 2020), https://www.frontiersin.org/articles/10.3389/fgene.2020.00309/full; Nikolaos Perakakis, et al., *Omics, Big Data and Machine Learning as Tools to Propel Understanding of Biological Mechanisms and to Discover Novel Diagnostics and Therapeutics,* Metabolism (Aug. 8, 2018), https://www.metabolismjournal.com/article/S0026-0495(18)30170-7/fulltext#%20.

[23] James Burans, et al., *The National Bioforensic Analysis Center*, Elsevier Public Health Emergency Collection (Dec. 6, 2019), https://www.ncbi.nlm.nih.gov/pmc/articles/PMC7153312/.

[24] *Id.*

[25] Claudia Ibacache-Quiroga, et al., *Detection and Control of Indoor Airborne Pathogenic Bacteria by Biosensors Based on Quorum Sensing Chemical Language*, IntechOpen (Dec. 22, 2017), https://www.intechopen.com/books/biosensing-technologies-for-the-detection-of-pathogens-a-prospective-way-for-rapid-analysis/detection-and-control-of-indoor-airborne-pathogenic-bacteria-by-biosensors-based-on-quorum-sensing-c; *Dinner Plate Detectives: AI Sensors will Detect Foodborne Pathogens at Home*, IBM Research (last visited June 16, 2020), https://www.research.ibm.com/5-in-5/plate/.

[26] Matt Hamblen, *Northwestern Creates Wearable Sensor for Detecting COVID-19 Symptoms*, Fierce Electronics (May 21, 2020), https://www.fierceelectronics.com/electronics/northwestern-creates-wearable-sensor-for-detecting-covid-19-symptoms.

B. Diagnostics

Diagnose patients and triage care. AI is helping scientists develop more effective tests for COVID-19 by allowing them to more rapidly and comprehensively infer biological insights that contribute to test design,[27] as well as model and design the antibodies and enzymes that are the components of immunoassay diagnostic tests.[28] AI-enabled tools are also being directly used in diagnostics to assist and inform expert assessments. Tools that analyze chest scans have assisted radiologists in detecting diseases like breast cancer and tuberculosis.[29] Some hospitals have applied similar technology to detect COVID-19 and to assess disease severity and care needs.[30] Others have built novel AI-based tools that aid diagnosis based on clinical symptoms and routine laboratory tests.[31] However, the success of these tools is highly dependent on large amounts of disease-specific training data, making it difficult to rapidly transition AI tools designed for other diseases to help healthcare professionals detect and assess

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[27] DARPA's Epigenetic Characterization Observation (ECHO) program's novel COVID-19 diagnostic test used AI tools to rapidly develop the test. In particular, the program relied on Icahn School of Medicine's pathway-level information extractor (PLIER) to automatically identify specific pathways that regulate gene expression. Melissa Harris, *DARPA's COVID-19 Test Detects Virus Before People Become Infectious*, GovernmentCIO (May 6, 2020), https://www.governmentciomedia.com/darpas-covid-19-test-detects-virus-people-become-infectious; Weiguang Mao, et al., *Pathway-level Information Extractor (PLIER) for Gene Expression Data*, Nature Methods (June 27, 2019), https://www.nature.com/articles/s41592-019-0456-1.

[28] Cormac Sheridan, *Fast, Portable Tests Come Online to Curb Coronavirus Pandemic*, Nature Biotechnology (June 3, 2020), https://www.nature.com/articles/d41587-020-00010-2.

[29] Marla Paul, *Artificial Intelligence Improves Breast Cancer Detection on Mammograms in Early Research*, Northwestern University (Jan. 1, 2020), https://news.northwestern.edu/stories/2020/01/ai-breast-cancer/; Sagar Kulkarni & Saurabh Jha, *Artificial Intelligence, Radiology, and Tuberculosis: A Review*, PubMed.gov (Jan. 2020), https://pubmed.ncbi.nlm.nih.gov/31759796/.

[30] Xueyan Mei, et al., *Artificial Intelligence-Enabled Rapid Diagnosis of Patients with COVID-19*, Nat Med (May 19, 2020), https://spectrum.ieee.org/the-human-os/biomedical/imaging/hospitals-deploy-ai-tools-detect-covid19-chest-scans; https://pubmed.ncbi.nlm.nih.gov/32427924/. For example, the Mayo clinic is trialing AI software to analyze echocardiograms to predict if a Covid-19 patient is at high risk of suffering a cardiac arrest or developing other heart problems as well as an AI algorithm to analyze an EKG to assess the risk that a Covid-19 patient has a weakened heart pump. Brian Gormley, *Startups Seek to Unravel Cardiovascular-Disease Mysteries in COVID-19*, Wall Street Journal (May 27, 2020), https://www.wsj.com/articles/startups-seek-to-unravel-cardiovascular-disease-mysteries-in-covid-19-11590571800.

[31] Cong Feng, et al., *A Novel Triage Tool of Artificial Intelligence Assisted Diagnosis Aid System for Suspected COVID-19 Pneumonia in Fever Clinics*, medRxiv (Mar. 20, 2020), https://www.medrxiv.org/content/10.1101/2020.03.19.20039099v1.

COVID-19.[32] As more data and clinical training enhance diagnostic algorithms, AI will be able to contribute in additional ways to diagnostic test development, and will more reliably support radiologists and emergency care teams in rapidly identifying disease indicators and informing patient care.[33]

C. Development of Vaccines, Therapeutics, and Medical Equipment

Rapidly discover and design vaccines and therapeutics. Researchers are leveraging AI to create simulations of how the coronavirus might interact with different therapeutics and vaccines, vastly accelerating the discovery process by exploring a great number of possibilities and narrowing the field of viable candidates.[34] Others are using AI-driven simulations to assess feasibility of repurposing existing drugs as a first step toward treating COVID-19.[35] Additionally, AI can help speed drug and vaccine production by enabling continuous manufacturing processes and digital twins to

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32 Alex Engler, *Artificial Intelligence Won't Save US from Coronavirus*, Wired (Apr. 26, 2020), https://www.wired.com/story/artificial-intelligence-wont-save-us-from-coronavirus/. However, progress is being made, including through a recent NIH and NVIDIA system built on scans from confirmed COVID-19 patients with around 90 percent accuracy rates. Jared Council, *NIH, Nvidia Use COVID-19 Patient Data to Build Diagnostic System*, Wall Street Journal (May 14, 2020), https://www.wsj.com/articles/nih-nvidia-use-covid-19-patient-data-to-build-diagnostic-system-11589448600. And researchers at Mount Sinai built an AI system to detect COVID-19 based on CT scans of the chest, in combination with patient information, with 84% accuracy. *COVID-19 Accurately Diagnosed by AI Model*, Genetic Engineering & Biotechnology News (May 26, 2020), https://www.genengnews.com/news/covid-19-accurately-diagnosed-by-ai-model/.

33 Charlotte R. Blease, et al., *US Primary Care in 2029: A Delphi Survey on the Impact of Machine Learning*, medRxiv (May 11, 2020), https://www.medrxiv.org/content/10.1101/2020.05.08.20095224v1.

34 This approach is being used at the University of Washington Institute for Protein Design. The Baker Lab, University of Washington Institute for Protein Design, https://www.bakerlab.org/. See also David Wright Kuano, *Combined Virtual Screening and Machine Learning Approach to Finding Novel SARS-CoV-2 Protease Inhibitors*, COVID-19 HPC Consortium (last visited June 16, 2020), https://covid19-hpc-consortium.org/projects/5ea0c62656238c007c05b6b0.

35 See e.g., Jennifer Klein, *A Dynamic Structural Model of the SARS-CoV-2 MAin Protease to Guide Drug Design and Repurposing*, COVID-19 HPC Consortium (last visited June 16, 2020), https://covid19-hpc-consortium.org/projects/5ea0c58556238c007c05b6ad; and Rafael Gomez-Bombarelli, *Drug-Repurposing for COVID-19 with 3D-Aware Machine Learning*, COVID-19 HPC Consortium (last visited June 16, 2020), https://covid19-hpc-consortium.org/projects/5ea0c5f856238c007c05b6af. The Wyss Institute's Predictive Biodiscovery Initiative is also applying new machine learning-enabled computational tools to confront the repurposing challenge, working to rapidly identify existing FDA approved drugs and drug combinations that may be used as COVID-19 therapeutics, or as prophylactic therapies for healthcare workers or patients who are particularly vulnerable. Benjamin Boettner, *The Wyss Institute's Response to COVID-19: Beating Back the Coronavirus*, Wyss Institute (Apr. 6, 2020), https://wyss.harvard.edu/news/news-the-wyss-institutes-response-to-covid-19-beating-back-the-coronavirus/.

support clinical trials.[36] As the technology develops, AI has the potential to support automated pipelines for building models that simulate possibilities, and synthesize and validate solutions, allowing researchers to respond to emerging viral threats more rapidly with efficiently designed therapeutics and vaccines.[37]

Manage supply chains. Today's supply chains are complex, and in the private sector, AI is being used to create self-correcting, smart supply chains.[38] AI can predict disruptions and vulnerabilities, monitor and prioritize inventory, prompt on-demand manufacturing, order orchestration and fulfillment, and recommend corrective actions. We foresee a future in which AI enables intelligent workflows to manage complex and global supply chains for pandemic response, dynamically managing surges and failures.[39]

Drive advanced manufacturing. AI has enabled the manufacturing industry to speed production and enable innovative manufacturing techniques for medical equipment, including ventilator components, face shields, and personal protective equipment. AI advances manufacturing capabilities, productivity, and quality by helping manage supply chains for raw materials, predict the need for maintenance (thereby reducing production downtime), facilitate human-machine collaboration, and enable generative design.[40] AI further optimizes 3D-printing, which proves useful in adapting to demands for pandemic-related supplies.[41] In the near future, we believe AI-powered advanced manufacturing can provide the agility needed to manage surges in demand for critical items needed during pandemics. In this new era, AI could be used to optimize

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[36] *Innovations in Artificial Intelligence, Deep Learning, Predictive Analytics, and Digital Twins*, Alliance of Advanced Biomedical Engineering (2018), https://aabme.asme.org/posts/innovations-in-artificial-intelligence-deep-learning-predictive-analytics-and-digital-twins; Charles K. Fisher, *'Digital Twin' Advances Poised to Expand Clinical Trial Reach*, ACRP (Nov. 25, 2019), https://acrpnet.org/2019/11/25/digital-twin-advances-poised-to-expand-clinical-trial-reach/.

[37] Petra Schneider, et al., *Rethinking Drug Design in the Artificial Intelligence Era*, Nature Reviews (Dec. 4, 2019), https://www.nature.com/articles/s41573-019-0050-3.

[38] For example, DoD's Joint Artificial Intelligence Center has created an AI-driven dashboard for Northern Command to understand where critical supplies are in short supply. Jackson Barnett, *JAIC's New Project Salus Links Up Supply-Chain Data in Fight Against Coronavirus*, FedScoop (Apr. 15, 2020), https://www.fedscoop.com/supply-chain-jaic-project-salus-coronavirus/.

[39] Jim Lee & Jonathan Wright, *COVID-19 and Shattered Supply Chains*, IBM (Mar. 2020), https://www.ibm.com/downloads/cas/OVZ3GZRG.

[40] Phillip Kushmaro, *5 Ways Industrial AI is Revolutionizing Manufacturing*, CIO (Sept. 27, 2018), https://www.cio.com/article/3309058/5-ways-industrial-ai-is-revolutionizing-manufacturing.html.

[41] *It's a Match! How Artificial Intelligence and 3D Printing Can Work Together*, drupa (June 25, 2019), https://blog.drupa.com/en/its-a-match-how-artificial-intelligence-and-3d-printing-can-work-together/.

manufacturing, optimize logistics and supply chains, drive autonomous equipment and vehicles, empower intelligent robots, and direct next-generation 3D-printing and on-demand manufacturing.[42]

D. Ongoing Healthcare - Protecting the Healthy and Treating the Sick

Manage patient risk and mortality. An existing tool in use in 20 hospitals around the United States predicts which patients will experience cardiac arrest and require intensive care, helping physicians determine which patients to admit to the hospital.[43] AI-driven models are being developed that can help predict a patient's severity of illness and risk of mortality.[44] Such a capability can inform crucial triage decisions when hospitals become overcrowded, providing decision support tools to inform allocation of limited resources.[45] The reliability of these tools will increase as AI design and engineering principles improve, allowing independent testing with comparable performance metrics.

Reduce transmission rates through use of autonomous robots. AI is being used to limit human interaction by enabling new autonomous robotic capabilities and services. These include assisting clinicians in hospitals, monitoring re-opened public spaces,

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[42] Bernard Marr, *What is Industry 4.0? Here's a Super Easy Explanation for Anyone*, Forbes (Sept. 2, 2018), https://www.forbes.com/sites/bernardmarr/2018/09/02/what-is-industry-4-0-heres-a-super-easy-explanation-for-anyone/#54959c09788a.

[43] Eliza Strickland, *AI Can Help Hospitals Triage COVID-19 Patients*, IEEE Spectrum (Apr. 17, 2020), https://spectrum.ieee.org/the-human-os/artificial-intelligence/medical-ai/ai-can-help-hospitals-triage-covid19-patients.

[44] Israel's largest healthcare service is using AI to determine which of the people it covers are most at risk of severe COVID-19 complications, and to fast track high risk patients. Will Douglas Heaven, *Israel is Using AI to Flag High-Risk COVID-19 Patients*, MIT Technology Review (Apr. 24, 2020), https://www.technologyreview.com/2020/04/24/1000543/israel-ai-prediction-medical-testing-data-high-risk-covid-19-patients/.

[45] Mohammad Pourhomayoun & Mahdi Shakibi, *Predicting Mortality Risk in Patients with COVID-19 Using Artificial Intelligence to Help Medical Decision-Making,* medRxiv (Apr. 1, 2020), https://www.medrxiv.org/content/10.1101/2020.03.30.20047308v1.full.pdf.

enabling telehealth services, and processing test samples.[46] A Danish company has developed a line of ultraviolet light emitting robots that can travel through hallways and rooms disinfecting areas with no human intervention.[47] Hospitals in Boston have used AI-enabled robots to diagnose COVID-19 patients remotely, enabling informed allocation of in-person care, minimization of exposure, and preservation of protective equipment.[48] Today's robots are employed in a limited capacity to carry out a small set of specialized tasks such as relaying communications, delivering supplies and meals, monitoring patients, and disinfecting. In the future, a robot may be able to oversee and complete complex, multi-phased tasks such as laboratory testing pipelines that involve teams of robots conducting sample collection, preparation, test administration, error recovery, results interpretation, and results delivery.

Remotely monitor patients. With appropriate sensor data, AI is being developed to help physicians remotely monitor patients, both severe cases in intensive care units and moderately ill patients from their homes, as well as conduct remote medical trials.[49] A hospital in Houston has created a "clinical command center" using high-resolution cameras and an analytics platform that uses machine learning algorithms to assess the state of critical patients based on real-time ingested data feeds from ventilators, electrocardiogram machines and oxygen pumps as well as a patient's electronic medical record and vital signs.[50] A clinical team in Boston is testing an AI-driven device developed by Massachusetts Institute of Technology's Computer Science and Artificial

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[46] Karina Mazhukhina, *How AI is Helping Scientists in the Fight Against COVID-19, from Robots to Predicting the Future*, GeekWire (Apr. 8, 2020), https://www.geekwire.com/2020/ai-helping-scientists-fight-covid-19-robots-predicting-future/. A robot in use in South Korea developed by SK Telecom and Omron Electronics Korea checks temperatures of employees, disinfects entryways, and detects proximity of groups of people and compliance with mask wearing, advising on proper social distancing and face covering. Hyonhee Shin, *Armed with Disinfectant and Admonishments, South Korean Robot Fights Coronavirus Spread*, Reuters (June 1, 2020), https://www.reuters.com/article/us-health-coronavirus-southkorea-robots/armed-with-disinfectant-and-admonishments-south-korean-robot-fights-coronavirus-spread-idUSKBN23816M.

[47] Evan Ackerman, *Autonomous Robots are Helping Kill Coronavirus in Hospitals*, IEEE Spectrum (Mar 11, 2020), https://spectrum.ieee.org/automaton/robotics/medical-robots/autonomous-robots-are-helping-kill-coronavirus-in-hospitals.

[48] Sara Castellanos & John McCormick, *Hospitals Deploy Technology to Reduce ICU Staff Exposure to COVID-19*, Wall Street Journal (May 7, 2020), https://www.wsj.com/articles/hospitals-deploy-technology-to-reduce-icu-staff-exposure-to-covid-19-11588843801.

[49] Karen Taylor, et al., *Intelligent Clinical Trials: Transforming through AI-enabled Engagement*, Deloitte Insights (Feb. 10, 2020), https://www2.deloitte.com/content/dam/insights/us/articles/ 22934_intelligent-clinical-trials/DI_Intelligent-clinical-trials.pdf; and *The Future Of Clinical Trials: How AI & Big Tech Could Make Drug Development Cheaper, Faster, & More Effective*, CB Insights (Aug. 7, 2018), https://www.cbinsights.com/research/clinical-trials-ai-tech-disruption/#find.

[50] *Id.*

Intelligence Laboratory that remotely monitors a COVID-19 patient's breathing, movement, and sleep patterns using wireless signals.[51] Meanwhile, the Department of Defense (DoD) is working with company PhysIQ to monitor COVID-19 patients and those at high risk using clinical-grade biosensors that share data with a Food and Drug Administration approved, AI-enabled platform.[52] Remote monitoring capabilities will likely become increasingly integrated into treatment programs and medical trials as the technology develops, reducing the risk of disease transmission and the burden on hospitals, as well as accelerating robust clinical testing of new medicines.

Part II. Recommended AI Focused Investments and Initiatives

The following recommendations outline a path forward for the United States to capitalize on AI capabilities for pandemic response. The recommendations fall into two categories: 1) advancing science; and 2) building the foundation for smart response.

A. Leverage AI to Advance the Science

Recommendation 1: Increase Federal Funding for AI Research and Development to Accelerate Advancement of AI Technology.

The Commission's First Quarter Recommendations recommended that the Congress double federal funding for non-Defense AI Research and Development (R&D) in Fiscal Year 2021 to roughly $2 Billion. The need for better data science tools and

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[51] Kyle Wiggers, *A Clinical Team Used MIT CSAIL's AI to Remotely Monitor a COVID-19 Patient*, Venture Beat (Apr. 14, 2020), https://venturebeat.com/2020/04/14/a-clinical-team-used-mit-csails-ai-to-remotely-monitor-a-covid-19-patient/.

[52] *AI-Powered physIQ Ink DOD Contract to Support COVID-19 Research*, Polsky Center for Entrepreneurship and Innovation, University of Chicago (May 14, 2020), https://polsky.uchicago.edu/2020/05/14/ai-powered-physiq-inks-dod-contract-to-support-covid-19-research/. Another platform developed by Bright.md uses AI to serve as a virtual physician assistant that gathers information interactively from a patient, then alerts a physician when a suggested treatment may be needed. Karina Mazhukhina, *Bright.md Raises $8M for Virtual Healthcare Service that can Help with COVID-19 Related Care*, GeekWire (Mar. 27, 2020), https://www.geekwire.com/2020/bright-md-raises-8m-virtual-healthcare-service-can-help-covid-19-related-care/.

technology-based approaches to respond to the current pandemic underscores the necessity of this investment. Within that initial recommendation, the Commission recommended **$400 million to the National Science Foundation (NSF), $300 million to the Department of Energy (DOE), $150 million to the National Institutes of Health (NIH), and $50 million to the National Institute for Standards and Technology (NIST) for AI-focused initiatives**.

The Commission advised that priority research areas for application of these funds should be: novel machine learning directions; testing, evaluation, verification, and validation (TEVV) of AI systems; robust machine learning; complex multi-agent scenarios; AI for modeling, simulation, and design; and advanced scene understanding.[53] If advanced, each of these broad research areas would expand our nation's ability to leverage AI for future pandemic response.

Within these research priorities, investments in the following areas would be especially helpful to improve the country's ability to apply AI for pandemic response: AI for biomedicine and biosecurity; human-AI teaming; AI-driven discovery; scalable, multi-source, multi-type data aggregation for advanced analytics; AI-driven signal processing; privacy-preserving methods to support data anonymization and aggregation; and the core AI research areas of prediction, reasoning, planning, control, and autonomy.

Recommendation 2: Create an NSF-led AI Institute for Health and Biomedicine.

This year, NSF, in conjunction with other departments and agencies, launched the National AI Research Institutes Program with the intention to fund six multi-institution, university-based research institutes at $4 million per year for five years.[54] Organized

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53 See *First Quarter Recommendations*, NSCAI (Mar. 2020), https://drive.google.com/file/d/1wkPh8Gb5drBrKBg6OhGu5oNaTEERbKss/view.

54 *Program Solicitation, NSF 20-503, National Artificial Intelligence Research Institutes*, NSF (last visited June 16, 2020), https://www.nsf.gov/pubs/2020/nsf20503/nsf20503.htm?org=NSF. The first round of six institutes will be organized around the research areas of: Trustworthy AI; Foundations of Machine Learning; AI-Driven Innovation in Agriculture and the Food System; AI-Augmented Learning; AI for Accelerating Molecular Synthesis and Manufacturing; and AI for Discovery in Physics. The National AI Research Institutes initiative is a joint effort of the NSF, U.S. Department of Agriculture National Institute of Food and Agriculture, U.S. Department of Homeland Security Science & Technology Directorate, U.S. Department of Transportation (DOT) Federal Highway Administration, and U.S. Department of Veterans Affairs.

around general cross-cutting themes or the use of AI in specific sectors, the program's objective is to develop "transformational technologies" that can spur foundational research advances and field AI-powered innovations.[55]

The Congress should fund NSF to create additional institutes focused on AI for Health and Biomedicine, in partnership with the Department of Health and Human Services (HHS), including NIH and the Centers for Disease Control and Prevention (CDC).[56] The nexus of AI and biomedicine holds the potential to not only foster methods to address public health emergencies, but also to develop precision medicine for critical care, advanced therapeutics to treat a range of diseases, diagnostic tools to inform human decision-making, and capabilities to optimize patient monitoring and care. NSF should also explore opportunities for future institutes and targeted funding to advance the critical research areas highlighted above, including human-AI teaming, autonomy, privacy-preserving data aggregation, signal processing and reasoning. Expanding the National AI Research Institutes Program would not only accelerate research and development of technology that underpins future AI-driven responses to pandemics, but it would also serve as an immediate action to fund research, create jobs, and support the training of the next generation of AI researchers and practitioners, at a time when universities are feeling the impacts of the economic uncertainty caused by the pandemic.

Recommendation 3: Launch a prize challenge administered by NSF to advance next-generation technical solutions for data integration and modeling.

AI can fuel a game-changing ability to predict risk of outbreak, identify early warnings, monitor infectious disease spread, and model the effectiveness of policy interventions to slow or stop the spread of a pathogen. Advances in AI reasoning could help expand

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[55] *Id.*

[56] An institute on AI for Health and Biomedicine aligns with multiple themes under the program's institute track requirement, including AI for Accelerating Molecular Synthesis and Manufacturing. The institute could accelerate research targeting the key challenges illuminated by COVID-19, including those in disease surveillance, drug discovery, and vaccine development. *Id.*

current SIR modeling techniques[57] to represent the complex interrelationships that drive human reactions to events, news, and policies; as well as the sources of data that can be fed into models, helping policymakers forecast the effectiveness of different policies.[58] Many of the relevant technical challenges involve combining models and data across multiple domains[59]—problems that are well suited to a prize challenge.[60] Given existing investments in AI, computing, and big data, NSF houses the expertise and established relationships to administer this effort. Furthermore, should Congress advance the recently-introduced Endless Frontiers Act,[61] the technology directorate within a restructured National Science and Technology Foundation would be well positioned to support the challenge. The proposed legislation would solidify United States technological leadership, now and into the future.[62]

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[57] SIR is a traditional epidemiological model, first used in 1927, that compartments the population into susceptible, infected, and recovered, and strives to predict how and how quickly people move between the stages. See discussion of current models for COVID-19 response: David Adam, *Special Report: The simulations driving the world's response to COVID-19*, Nature (April 2, 2020), https://www.nature.com/articles/d41586-020-01003-6.

[58] For example, advancements are necessary to allow for integration and efficient use of datasets with differing or diverging types of data, such as text, image, time series, geospatial, etc.

[59] Brenda Leong & Dr. Sara Jordan, *Artificial Intelligence and the COVID-19 Pandemic*, FPF (May 7, 2020), https://fpf.org/2020/05/07/artificial-intelligence-and-the-covid-19-pandemic/.

[60] Early studies have illustrated the promise of machine learning (ML) models for outbreak detection, noting additional research needed to integrate ML and traditional models. See Sina Ardabili, et al., *COVID-19 Outbreak Prediction with Machine Learning*, Preprints (Apr. 19, 2020), https://www.preprints.org/manuscript/202004.0311/v1.

[61] Endless Frontiers Act, S. 3832, 116th Congress (2020), https://www.congress.gov/bill/116th-congress/senate-bill/3832/text.

[62] The Endless Frontiers Act proposes a restructuring of NSF to include a technology directorate, and an almost quadrupling of the Foundation's budget over the course of 5 years. It places emphasis on enabling the transition of technology research into the commercial sector, and provides an ability for the Foundation to adopt a DARPA-like approach to manage the technology directorate's research portfolio. See Jeffrey Mervis, *U.S. Lawmakers Unveil Bold $100 Billion Plan to Remake NSF*, Science Magazine (May 26, 2020), https://www.sciencemag.org/news/2020/05/us-lawmakers-unveil-bold-100-billion-plan-remake-nsf.

Recommendation 4: Continue the Defense Advanced Research Projects Agency's (DARPA) work to create the infrastructure and protocols for collaboration in drug discovery, and mirror efforts at NIH.

Sharing experimental data in real time lays the foundation for AI-enabled research on vaccines and therapeutics. Efforts like DARPA's Synergistic Discovery and Design (SD2) program can connect laboratories through shared infrastructure and standard protocols to enable data sharing at the point of experimentation.[63] Similar initiatives should be fostered at NIH, bringing together laboratory networks the agency already funds. Such infrastructure can support collaboration and AI-driven analytics for more rapid drug discovery.

Recommendation 5: Make the COVID-19 High Performance Computing Consortium permanent.

In March, the White House Office of Science and Technology Policy (OSTP) launched the COVID-19 High Performance Computing Consortium, bringing together federal agencies, laboratories, academia, and private sector partners to provide computing resources for COVID-19 research. Since its inauguration, the Consortium has grown to include 40 partners and supported 66 projects (many leveraging AI), including molecular structure prediction for potential inhibitors, gene sequencing to assess risk of morbidity, and data-driven strategies for allocation of scarce resources.[64] The Congress should make this consortium permanent, situated under the Department of Energy. A permanent consortium would create a standing capability to apply AI to pandemic-related research, and would continue to build predictive capabilities and fine-tune response measures.[65] Furthermore, this successful model could be leveraged to create a broader national AI research infrastructure rooted in public-private partnerships that would support democratization of AI research resources through provision of low-cost compute resources and AI-ready data sets to AI researchers and

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[63] Dr. Joshua Elliott, *Synergistic Discovery and Design (SD2)*, DARPA (last visited June 16, 2020), https://www.darpa.mil/program/synergistic-discovery-and-design.

[64] *The COVID-19 High Performance Computing Consortium*, COVID-19 HPC Consortium, (last visited June 16, 2020), https://covid19-hpc-consortium.org/.

[65] Making the Consortium permanent is currently proposed in legislation introduced in the U.S. House of Representatives. See The Covid Research Act of 2020, H.R. 6599, 116th Congress (2020), https://www.congress.gov/bill/116th-congress/house-bill/6599.

students across the country. One approach to do this would be to create a study and pilot program for such a resource, as the Commission recommended in its First Quarter Recommendations.[66]

B. Build an AI-Enabled Foundation for Smart Response[67]

Data is the foundation for most AI systems[68] but the data needed for effective pandemic prevention and response is currently stovepiped.[69] The nation needs to build the data infrastructure on which future AI-driven pandemic response will be based. This infrastructure includes the physical capacity to store and transfer data, as well as approaches to data collection, data standards, shared computing resources, and associated modeling and simulation. Here, we outline recommendations to bring such an infrastructure to fruition.

Recommendation 1: Identify critical questions and create a federal "Pandemic Preparedness Dataset."

A first step towards developing a national public health data infrastructure is to assess the critical questions that must be answered to build more robust preparedness and response. This grounding will inform the evidence needed to answer those questions, the analytics necessary to support that evidence, and the data inputs that enable analytics. Multiple efforts are underway to collate the data

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[66] See *First Quarter Recommendations*, NSCAI (Mar. 2020), https://drive.google.com/file/d/1wkPh8Gb5drBrKBg6OhGu5oNaTEERbKss/view.

[67] For all efforts, the best practices and standards outlined in the white paper issued by NSCAI Commissioners Dr. Eric Horvitz, The Honorable Mignon Clyburn, Dr. Jose-Marie Griffiths, and Dr. Jason Matheny and select staff titled, "Privacy and Ethics Recommendations for Computing Applications Developed to Mitigate COVID-19," should be upheld and should ensure there is adequate transparency around data collection, protection, and use. The white paper is available for download here: https://www.nscai.gov/reports.

[68] We also note the potential approaches to AI modeling and reasoning not based on data, which would be advanced by research investments outlined in Section A.

[69] Aaron Miri & Daniel P. O'Neill, *Accelerating Data Infrastructure for COVID-19 Surveillance and Management,* Health Affairs (Apr. 14, 2020), https://www.healthaffairs.org/do/10.1377/hblog20200413.644614/full/; Christina Farr, *These 'Disease Hunters' Developed a Novel Technique for Tracking Pandemics After 9/11, But Lost Funding Right Before COVID-19*, CNBC (Apr. 4, 2020), https://www.cnbc.com/2020/04/04/syndromic-surveillance-useful-to-track-pandemics-like-covid-19.html.

that could support this initiative. The White House and a coalition of leading research groups prepared a dataset under the COVID-19 Open Research Dataset Challenge (CORD-19) that brings together over 29,000 scholarly articles for data and text mining—representing the most extensive machine-readable coronavirus literature collection available. The coalition called for the nation's artificial intelligence experts to develop new text and data mining techniques that can help the science community answer high-priority scientific questions related to COVID-19.[70] Additionally, the NIH has launched the National COVID Cohort Collaborative (N3C) to help connect the research community to clinical data. N3C seeks to build a centralized national data enclave of clinical, laboratory, and diagnostic data from hospitals and health care plans.[71] Within private industry, C3.ai built a COVID-19 Data Lake that integrates multiple data sources into an analysis ready unified data model open to the research community.[72]

The United States Government should build off of current momentum to create a "Pandemic Preparedness Dataset"—a static, anonymized, multi-source and multi-type legacy dataset—structured around the identified critical questions. The dataset should capture the evidence, analysis, and data inputs needed for effective pandemic prevention, detection, and response. The dataset should be widely accessible for future research. In addition to scholarly articles, developers of this dataset should consider correlated timelines of health statistics, clinical health data, anonymized contact tracing data, social media, flight and other travel statistics, economic indicators, and other relevant data types. This dataset could be hosted for public access and could be used to support a new series of challenge tasks. Such tasks could include, among other things, applying AI to develop robust models for outbreak detection and disease surveillance, predicting the impact of interventions, and assessing the disparate impact a pandemic may have on different ethnic and socio-economic groups.[73] As with CORD-19, these tasks should be chosen and defined by the National Academies of Science, Engineering, and Medicine's Standing Committee on Emerging

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[70] *Call to Action to the Tech Community on New Machine Readable COVID-19 Dataset*, The White House (Mar. 16, 2020), https://www.whitehouse.gov/briefings-statements/call-action-tech-community-new-machine-readable-covid-19-dataset/.

[71] *About the National COVID Cohort Collaborative,* National Center for Advancing Translational Science (last visited June 22, 2020), https://ncats.nih.gov/n3c/about.

[72] The C3.ai COVID-19 Data Lake is accessible here: https://c3.ai/products/c3-ai-covid-19-data-lake/.

[73] For recommended actions to ensure that federally funded computing tools created and fielded to mitigate the COVID-19 pandemic are developed with a sensitivity to and account for potential bias and, at a minimum, do not introduce additional unfairness into healthcare delivery and outcomes, see *Privacy and Ethics Recommendations for Computing Applications Developed to Mitigate COVID-19*, NSCAI (May 2020), https://drive.google.com/file/d/1m0AT21dS2XJ6JIGMgo7SuLSLveWIO8WK/view.

Infectious Diseases and 21st Century Health Threats, and by the World Health Organization (WHO), along with leading bioinformatics scientists and modeling experts.[74]

Recommendation 2: Invest in the digital modernization of state and local health infrastructure required for effective disease surveillance.

The government must be able to collect and use data for disease surveillance and pandemic management in real time.[75] Collection of public health indicators is critical to informed policymaking and effective response. Gaps in COVID-19 data collection expose the weaknesses of the current system and reinforce the need for a strong national public health surveillance system to detect and track emerging disease threats.[76]

The CDC coordinates data collection across federal, state, territorial, and local (jurisdictional) governments. While pharmacies and laboratories communicate seamlessly and 96 percent of medical claims transfer electronically between hospitals and insurers, public health reporting continues to falter, lacking market-driven and regulatory incentives and sufficient digital infrastructure.[77] Local healthcare departments and agencies leading the COVID-19 response rely on antiquated methods, including paper records, phone calls, and fax machines, to share information across a fragmented system.[78] Health information originates from disparate public and private organizations,

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[74] *COVID-19 Open Research Dataset Challenge*, kaggle (updated June 9, 2020), https://www.kaggle.com/allen-institute-for-ai/CORD-19-research-challenge.

[75] Three NSCAI Commissioners and select staff released a white paper titled, "Mitigating Economic Impacts of the COVID-19 Pandemic and Preserving U.S. Strategic Competitiveness in AI", which outlined the important role effective disease surveillance plays in re-opening the economy and recommended state and federal data driven support tools. These tools will not be possible without dedicated investment in electronic infrastructure for public health indicator collection. The white paper is available for download here: https://www.nscai.gov/reports.

[76] Robinson Meyer and Alexis C. Madrigal, *State and Federal Data on COVID-19 Testing Don't Match Up*, The Atlantic (May 17, 2020), https://www.theatlantic.com/health/archive/2020/05/cdc-publishing-covid-19-test-data/611764/.

[77] Aaron Miri & Daniel P. ONeill, *Accelerating Data Infrastructure for COVID-19 Surveillance and Management*, Health Affairs (Apr. 14, 2020), https://www.healthaffairs.org/do/10.1377/hblog20200413.644614/full/.

[78] Electronic Health Records implementation across hospitals and outpatient clinics improved recordkeeping and efficiency within individual health care organizations, but made less progress in connecting systems and data across providers and jurisdictions due to varying standards and technological requirements. *Id.* EHR tools have been shown to support health system management of COVID-19 response. J. Jeffery Reeves, et al., *Rapid Response to COVID-19: Health Informatics Support for Outbreak Management in an Academic Health System*, Journal of the American Medical Informatics Association (June 2020), https://academic.oup.com/jamia/article/27/6/853/5811358.

including laboratories, hospitals, and outpatient facilities. Collection and sharing practices vary across jurisdictions according to state law, and reporting to the CDC is generally voluntary.[79] As COVID-19 cases surge, the lack of seamless, electronic reporting between health care providers and public health departments inhibits timely identification of cases and rapid-response.[80]

The CDC recently released a new tool for electronic case reporting (eCR) called "eCR Now" that enables automatic and real-time reporting of COVID-19 relevant data—including case data, demographic information, race and ethnicity, and clinical diagnoses—to local, state, and federal public health agencies.[81] The tool builds on two new HHS health data rules that significantly aid increased interoperability by allowing broader sharing of health information through third party applications and application programming interfaces (APIs).[82] Importantly, the rules establish secure, standards-based API requirements using the Fast Healthcare Interoperability Resources (FHIR) standard.[83] eCR Now can integrate with existing electronic health records (EHR) reporting systems, and it has a FHIR-based app for health systems that do not have existing EHR capabilities.[84] **However, sufficient digital infrastructure is essential to facilitate the use of the CDC's new tool and implementation of the HHS interoperability rules.[85]**

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[79] Kavya Sekar, *COVID-19: U.S. Public Health Data and Reporting*, Congressional Research Service (June 4, 2020), https://crsreports.congress.gov/product/pdf/IN/IN11361.

[80] Darius Tahir, *Virus Hunters Rely on Faxes, Paper Records as More States Reopen*, Politico (May 10, 2020), https://www.politico.com/news/2020/05/10/coronavirus-health-records-245483.

[81] *eCR for COVID-19 Reporting*, Association of Public Health Laboratories (last visited June 16, 2020), https://ecr.aimsplatform.org/ecr-for-covid-19-reporting/.

[82] *HHS Finalizes Historic Rules to Provide Patients More Control of Their Health Data*, HHS (Mar. 9, 2020), https://www.hhs.gov/about/news/2020/03/09/hhs-finalizes-historic-rules-to-provide-patients-more-control-of-their-health-data.html.

[83] *CMS Interoperability and Patient Access Final Rule*, Centers for Medicare & Medicaid Services (last modified Apr. 21, 2020), https://www.cms.gov/Regulations-and-Guidance/Guidance/Interoperability/index.

[84] *eCR for COVID-19 Reporting*, Association of Public Health Laboratories (last visited June 16, 2020), https://ecr.aimsplatform.org/ecr-for-covid-19-reporting/.

[85] In addition to the best practices outlined in NSCAI White Paper, *Privacy and Ethics Recommendations for Computing Applications Developed to Mitigate COVID-19*, mentioned above, we also want to call attention to the cybersecurity, privacy, and insurability needs outlined in *Data Citizenship under the 21st Century Cures Act*. See Kenneth D. Mandl, M.D., M.P.H., & Isaac S. Kohane, M.D., Ph.D, *Data Citizenship Under the 21st Century Cures Act*, New England Journal of Medicine (May 7, 2020), https://www.nejm.org/doi/full/10.1056/NEJMp1917640.

Public health experts cite the need for $1 billion in public investment in CDC data modernization over the next decade.[86] The crisis shows we don't have a decade to wait. The CDC is awarding $637 million in CARES Act funding to public health departments, with part of that funding going towards expanded disease surveillance capabilities.[87] But additional investment dedicated to digital infrastructure modernization is required. **The Congress needs to invest in, and should consider mandating, the digital modernization of state and local health infrastructure.** This infrastructure is a basic requirement for effective disease surveillance and enhanced contact tracing. It is the linchpin of widespread eCR Now use, a necessary step for HHS rule compliance, and lays the data foundation for AI systems and tools that enable next generation response.

Recommendation 3: Bolster U.S. national syndromic surveillance capabilities.

Enabling electronic data sharing will also enhance national syndromic surveillance systems for COVID-19 and future infectious disease outbreaks. Syndromic surveillance was developed as part of bioterrorism preparedness efforts following the 2001 terrorist attacks and subsequent anthrax attacks.[88] Syndromic surveillance methods traditionally rely on emergency department, urgent care and ambulatory care, inpatient healthcare, and pharmacy and laboratory data to detect unusual levels of illness and serve as an early warning system for public health response.[89] Yet, syndromic surveillance systems could provide better support to

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[86] Kavya Sekar, *COVID-19: U.S. Public Health Data and Reporting*, Congressional Research Service (June 4, 2020), https://crsreports.congress.gov/product/pdf/IN/IN11361.

[87] *HHS Announces CARES Act Funding Distribution to States and Localities in Support of COVID-19 Response*, HHS (Apr. 23, 2020), https://www.hhs.gov/about/news/2020/04/23/hhs-announces-cares-act-funding-distribution-to-states-and-localities-in-support-of-covid-19-response.html.

[88] Kenneth D. Mandl, et al., *Implementing Syndromic Surveillance: A Practical Guide Informed by the Early Experience*, Journal of Informatics in Health and Biomedicine (Mar. 2004), https://academic.oup.com/jamia/article/11/2/141/883007; Christina Farr, *These 'Disease Hunters' Developed a Novel Technique for Tracking Pandemics After 9/11, But Lost Funding Right Before COVID-19*, CNBC (Apr. 4, 2020), https://www.cnbc.com/2020/04/04/syndromic-surveillance-useful-to-track-pandemics-like-covid-19.html.

[89] The National Syndromic Surveillance Program (NSSP) is a collaboration among CDC, federal partners, local and state health departments which combines timely electronic patient encounter data and statistical tools to detect, characterize, and respond to public health events. Other national health surveillance systems include: the U.S. Influenza Surveillance System, National Vital Statistics System, National Healthcare Safety Network, and National Notifiable Diseases Surveillance System. *National Syndromic Surveillance Program*, CDC (last reviewed May 27, 2020), https://www.cdc.gov/nssp/index.html; https://www.cdc.gov/nssp/documents/NSSP-overview.pdf.

decision-makers if that data was easier to share[90] and if they included more comprehensive data inputs, such as testing and tracing data and data on hospital admissions, discharges, and transfers.[91] **Syndromic surveillance also offers a prime opportunity to apply AI-enabled data management and analysis tools that can combine disparate data sets, rapidly identify trends, and offer innovative analysis.[92]** This capability is particularly important when timely diagnostic testing is not possible.[93] Surveillance systems and analysis tools can help inform re-opening (and future micro-closings when case clusters arise) and support early detection and management of future pandemics.

Syndromic surveillance can be even more effective when paired with non-health data.[94] For example, high-quality geospatial data and airline ticketing data can inform models for setting-specific indicators of disease transmission, risk factors, and predicting pathogen prevalence.[95] However, the government's ability to pool public and non-public data sources on COVID-19 has been limited by a lack of standing policies, procedures, and technical mechanisms for public-private data sharing during emergencies. Promising

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90 NSSP only captures approximately 73% of Emergency Department visits due to lack of reporting and data from only six commercial labs. *NSSP Update*, CDC (May 2020), https://www.cdc.gov/nssp/news/2020/05-may/NSSP-Update-2020-05.pdf.

91 Mark McClellan, et al., *A National COVID-19 Surveillance System: Achieving Containment*, Duke University Margolis Center for Health Policy (Apr. 7, 2020), https://healthpolicy.duke.edu/sites/default/files/atoms/files/covid-19_surveillance_roadmap_final_0.pdf.

92 The CDC is currently upgrading it's Electronic Surveillance System for the Early Notification of Community-based Epidemics (ESSENCE) tool, which processes and analyzes data for NSSP's cloud-based BioSense platform. The upgrades include exploring machine learning and natural language processing improvements that facilitate data tagging and develop new connections and search methods. *Electronic Surveillance System for the Early Notification of Community-based Epidemics (ESSENCE) Operations and Maintenance Support*, CDC (2020), https://beta.sam.gov/opp/7951d04b4cc747bcad0a94dd92f83135/view?index=opp&naics=541&page=3; Aaron Boyd, *Mid-Pandemic, CDC Looks to Upgrade its Biosurveillance Database*, NextGov (Apr. 6, 2020), https://www.nextgov.com/it-modernization/2020/04/mid-pandemic-cdc-looks-upgrade-its-biosurveillance-database/164397/.

93 Mark McClellan, et al., *A National COVID-19 Surveillance System: Achieving Containment*, Duke University Margolis Center for Health Policy (Apr. 7, 2020), https://healthpolicy.duke.edu/sites/default/files/atoms/files/covid-19_surveillance_roadmap_final_0.pdf.

94 Christina Farr, *These 'Disease Hunters' Developed a Novel Technique for Tracking Pandemics After 9/11, But Lost Funding Right Before COVID-19*, CNBC (Apr. 4, 2020), https://www.cnbc.com/2020/04/04/syndromic-surveillance-useful-to-track-pandemics-like-covid-19.html; Arash Shaban-Nejad, et al., *Health Intelligence: How Artificial Intelligence Transforms Population and Personalized Health*, npj Digital Medicine (2018), https://www.nature.com/articles/s41746-018-0058-9.

95 Andrew Zolli, *How Satellite Data Can Help with COVID-19 and Beyond*, Planet (Apr. 14, 2020), https://www.planet.com/pulse/how-satellite-data-can-help-with-covid-19-and-beyond/; Michael C. Lu, *Future Pandemics can be Prevented, But That'll Rely on Unprecedented Global Cooperation*, Washington Post (Apr. 17, 2020), https://www.washingtonpost.com/health/future-pandemics-can-be-prevented-but-thatll-rely-on-unprecedented-global-cooperation/2020/04/16/0caca7b8-7e6d-11ea-8013-1b6da0e4a2b7_story.html.

AI tools that could help with pandemic response depend on rich datasets. It is imperative to find ways to combine diverse data from the commercial and academic sectors with data held by government organizations in a secure and responsible manner.

The United States Government's COVID-19 after-action efforts should assess and establish: 1) clear data-sharing policies and procedures for times of national emergency; and 2) a standing digital infrastructure that can facilitate better systems and a more rapid, coordinated, whole-of-society response. New capabilities should include a standing data pipeline that can feed future models in real time during public health emergencies. Agreements with relevant data providers should be established now, with clear conditions for when and how data will be shared and used. A standing data pipeline would both bolster and complement the recommendations presented above to advance the government's ability to effectively manage future health crises.

Recommendation 4: Enhance global cooperation on smart disease surveillance and international health data norms and standards.

The first level of protection from pandemic diseases at home are early warning indicators abroad and strong global data sharing that enables rapid response. Global data on zoonotic spillovers and viral transmission can inform AI platforms and models that provide early warning systems, including the disease surveillance systems described above.[96] Yet for early warning programs to be successful, they require an important

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[96] The Global Public Health Intelligence Network (GPHIN) is an AI-enabled monitoring system for ongoing infectious disease surveillance and detection. Run by Health Canada and WHO, GPHIN provided early alerts of SARS and MERS-CoV and played a significant role in the monitoring of the Ebola outbreak in West Africa. M. Dion, et al., *Big Data and the Global Public Health Intelligence Network*, CCDR (Sept. 3, 2015), https://www.canada.ca/content/dam/phac-aspc/migration/phac-aspc/publicat/ccdr-rmtc/15vol41/dr-rm41-09/assets/pdf/ccdrv41i09a02-eng.pdf; Amy Maxmen, *Machine Learning Spots Treasure Trove of Elusive Viruses*, nature (Mar. 19, 2020), https://www.nature.com/articles/d41586-018-03358-3; Michael C. Lu, *Future Pandemics can be Prevented, But That'll Rely on Unprecedented Global Cooperation*, Washington Post (Apr. 17, 2020), https://www.washingtonpost.com/health/future-pandemics-can-be-prevented-but-thatll-rely-on-unprecedented-global-cooperation/2020/04/16/0caca7b8-7e6d-11ea-8013-1b6da0e4a2b7_story.html; *UNEP Frontiers 2016 Report: Emerging Issues of Environmental Concern*, United Nations Environment Programme (2016), https://wedocs.unep.org/bitstream/handle/20.500.11822/7664/Frontiers_2016.pdf?sequence=1&isAllowed=y; Toph Allen, et al., *Global Hotspots and Correlates of Emerging Zoonotic Diseases*, Nature Communications (Oct. 24, 2017), https://www.nature.com/articles/s41467-017-00923-8.

human component—epidemiologists on the ground who can collect and corroborate data. Since 2009, the United States Agency for International Development's Emerging Pandemic Threats PREDICT program has detected 1,200 different viruses with the potential to become pandemics, 160 of them novel coronaviruses, and supported pandemic threat preparedness in over 30 countries.[97] All for only approximately $207 million over ten years.[98] **The Congress should ensure enduring and protected funding for programs like PREDICT that provide critical data to a broad array of infectious disease prevention platforms and systems.**

As data becomes increasingly essential to our health ecosystem—playing an integral role in everything from disease surveillance to the creation of vaccines and therapeutics—**the international community must come together to ensure international norms and standards protect privacy while making data accessible to those who need it in a timely manner.** This approach stands in stark contrast to those that aim to be secretive and standalone, such as China's effort to establish a biosafety-level 4 biological experiment laboratory in Zimbabwe run by the Zimbabwe Defense Forces.[99] **The United States should lead in bringing together like-minded allies and partners to set values-based norms and standards for health data.** Privacy standards for genomic datasets offer one place to start. More than 800 terabytes of genomic data are already available to researchers around the world as part of a project by the International Cancer Genome Consortium.[100] The project's cloud-based datasets span countries and research groups, yet there are no clear international guidelines that help such projects navigate issues like identifiability, consent, and withdrawal across nations.[101] An effort by like-minded nations to establish norms and standards for

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[97] *Predict: Pandemic Preparedness for Global Health Security*, U.S. Agency for International Development (last visited June 17, 2020), https://ohi.vetmed.ucdavis.edu/sites/g/files/dgvnsk5251/files/inline-files/PREDICT_4pager_COVID.pdf; Donald G. McNeil Jr., *Scientists were Hunting for the Next Ebola. Now the U.S. Has Cut Off Their Funding*, New York Times (Oct. 25, 2019), https://www.nytimes.com/2019/10/25/health/predict-usaid-viruses.html. PREDICT was initiated in 2009 to strengthen global capacity for detection of viruses with pandemic potential that can move between animals and people. PREDICT has made significant contributions to strengthening global surveillance and laboratory diagnostic capabilities for both known and newly discovered viruses within several important virus groups, such as filoviruses (including ebolaviruses), influenza viruses, paramyxoviruses, and coronaviruses.

[98] Donald G. McNeil Jr., *Scientists Were Hunting for the Next Ebola. Now the U.S. Has Cut Off Their Funding*, New York Times (Oct. 25, 2019), https://www.nytimes.com/2019/10/25/health/predict-usaid-viruses.html.

[99] Mary-Kate Kahari, *China to Establish Maximum-Security Biolab in Zimbabwe*, Spotlight Zimbabwe (May 8, 2020), http://spotlight-z.com/news/china-establish-maximum-security-biolab-zimbabwe/.

[100] Mark Phillips, et al., *Genomics: Data Sharing Needs an International Code of Conduct*, nature (Feb. 5, 2020), https://www.nature.com/articles/d41586-020-00082-9?proof=true.

[101] *Id.*

genomic data could chart a path forward for values-based data sharing that both protects citizens and promotes global health innovation.

Recommendation 5: Invest in AI-driven capabilities to maintain military readiness.

Just as we need to equip our emergency management and public health systems with the infrastructure and tools to harness AI for effective and efficient pandemic response, we must also ensure military preparedness through similar investments.

Our military needs access to the most nimble and cutting edge tools to mitigate the effect of future pandemics on force readiness. The DoD has a number of initiatives looking towards these tools. For example, the Army has augmented its AI-powered Joint Analytic Real-time Virtual Information Sharing System (JARVISS), which was designed to manage threats and ensure readiness by keeping personnel safe, to track the pandemic and provide a COVID-19 specific dashboard to commanders.[102] DoD's Global Biosurveillance Portal (GBSP) is an existing program now being leveraged to provide DoD, interagency counterparts, and allies situational awareness on pandemic response.[103] However, reporting of the United States military's own cases is primarily done through email forms and collected and assessed at the level of individual installation, rather than systematically across the force. This prevents DoD from having a full real-time assessment of force readiness. **DoD and the Services should examine how best to leverage AI-enabled platforms for managing force readiness and to ensure development of agile and persistent capabilities.**

Such platforms can also enhance United States military readiness to support domestic and global pandemic response. The Joint Artificial Intelligence Center's Project SALUS created a new multi-functional platform to support the United States Northern

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[102] Jackson Barnett, *New Job for JARVISS: Coronavirus Tracking for the Army*, FedScoop (Apr. 28, 2020), https://www.fedscoop.com/coronavirus-tracking-army-jarviss/; Lydia Dishman, *Here's How AI is Helping Reduce the Threat of Active Shooters at Work*, Fast Company (Mar. 15, 2019), https://www.fastcompany.com/90319704/heres-how-ai-is-helping-reduce-the-threat-of-active-shooters-at-work.

[103] *JPL CBRN IM/IT Global Biosurveillance Portal*, DoD (last visited June 17, 2020), https://www.jpeocbrnd.osd.mil/docs/default-source/default-document-library/fact-sheet---jpl-imit-global-biosurveillance-portal.pdf?sfvrsn=3ccb2dd7_0.

Command and the National Guard in COVID-19 response.[104] The platform provides data aggregation and fusion along with AI-enabled predictive analytics capabilities to enhance resource allocation for supply chain decision support.[105] The greatest hurdles in deploying this technology were not the algorithms themselves, but rather navigating the complex policy landscape and legal processes that govern federal agencies' and departments' abilities to directly support interagency, state, local, or tribal partners during federal emergencies or disasters. In the case of Project SALUS, critical time was lost due to these complexities, during which the data and predictive analytics could have provided critical support. Preemptive software capabilities play an important role in preventing much larger and more costly DoD interventions in terms of both lives and dollars, but only if they can be safely and quickly delivered to or deployed by those operational components that need them most. **The DoD should comprehensively assess and look to streamline or update its policies for assisting during national security crises, like a pandemic, that impact American lives and security both at home and abroad.** Particular attention should be paid to how DoD can better posture itself to rapidly apply AI-enabled capabilities for a pandemic response.

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[104] U.S. Northern Command (USNORTHCOM) is also using smart applications developed with support from Silicon Valley that can inform decisions on personnel deployments across the country and enable direct communications between USNORTHCOM leadership and those deployed. Jackson Barnett, *Northern Command Calls Upon Palantir, Apple and Others to Bring New Tech to Coronavirus Fight*, WorkScoop (May 13, 2020), https://workscoop.com/2020/05/13/northern-command-apps-palntir-apple-covid19.

[105] Patrick Tucker, *The Pentagon Will Use AI to Predict Panic Buying, COVID-19 Hotspots*, Defense One (Apr. 22, 2020), https://www.defenseone.com/technology/2020/04/pentagon-will-use-ai-predict-panic-buying-covid-19-hotspots/164820/.

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