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Written Testimony before The U.S. House Of Representatives Committee on Science, Space and Technology

HEARING ENTITLED:

"Beyond Coronaviruses: Understanding the Spread of Infectious Diseases and Mobilizing Innovative Solutions."

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Chairwoman Johnson, Ranking Member Lucas and distinguished members of the U.S. House of Representatives Committee on Science, Space and Technology, thank you for inviting me to speak with you today. I will be addressing the topic of "Beyond Coronaviruses: Understanding the Spread of Infectious Diseases and Mobilizing Innovative Solutions" and sharing with you how novel technologies, like Artificial Intelligence (AI), can help predict, detect and monitor emerging infectious diseases while also discussing how nontraditional data sources can supplement existing epidemiological techniques. It is my goal to share how these technologies have changed the ways we manage public health crises or potential crises and what the future can hold, with proper investments and planning.

I am a Professor at Harvard Medical School and the Chief Innovation Officer at Boston Children's Hospital. I also direct the Computational Epidemiology Lab at the Boston Children's Hospital's Computational Health Informatics Program. My research aims to have translational impact on the surveillance, control and prevention of disease. My team develops innovative infectious disease surveillance platforms that use freely available online data to provide real-time insights for both public health officials and the general public. Throughout the 2009 H1N1 influenza pandemic, H7N9 Avian Influenza, Ebola in West Africa, Zika in the Americas and now COVID-19, these platforms, and our research, have highlighted the critical role that innovative surveillance can have on outbreak detection, monitoring, and mitigation.

Our inaugural project, developed in 2006, is called HealthMap. It is a publicly available platform, which brings together disparate data sources, including online news aggregators, eyewitness reports, expert-curated discussions and validated official reports, to achieve a unified and comprehensive view of the current global state of infectious diseases. The system automates data acquisition, filtering and characterization of information, using machine learning algorithms and natural language processing. The system ingests and classifies its data independently, without human intervention. However, we choose to keep a human in the loop - having infectious disease analysts review the content to correct and refine the automated classifications. The analysts ensure that subtle signals of an outbreak are captured. For example, on March 14th 2014 the HealthMap system brought in a French alert reporting cases of "mystery hemorrhagic fever" that had killed eight in Guinea. This was the earliest signal in West Africa of what would become the largest Ebola outbreak in history. On December 30, 2019, we were alerted to an unknown viral pneumonia, which was one of the earliest signals in the current COVID-19 outbreak. The HealthMap platform has been integrated into the Epidemic Intelligence from Open Sources (EIOS) platform developed and maintained by

the World Health Organization. This system supports efforts for event-based surveillance globally, and has proven to be a valuable resource during emerging disease outbreaks.

The HealthMap platform is just one of many that highlight the utility and need for timely, sentinel outbreak signals. Artificial Intelligence (AI) can be used for public health preparedness measures to control the spread of disease, particularly during an emerging disease outbreak. Earlier disease detection provides health leaders with the tools to adequately prevent or prepare against the threat of an emerging disease.

The use of AI in modelling epidemics is one area of research that can provide vast insight into the potential burden of disease, and where it spreads. For example, machine learning models can predict where a given virus may arrive next, and inform public health organizations how to prepare in response. Predictive modelling techniques can utilize information like prior disease history, weather and travel patterns, laboratory testing, symptom surveillance and more. These forecasting tools have the power to provide insights on health outcomes and disease progression.

AI use in healthcare systems can provide novel insights on an emerging outbreak, as well. AI has been used to identify patterns in images, scans or records that emulate the disease of interest, providing earlier signs of infection. Increased use of AI for disease surveillance measures can hopefully provide a more rapid response between countries to control epidemics. AI technologies provide value in information exchange, surveillance measure, public response to emerging and seasonal outbreaks, and education on disease threats, all of which are critical needs to prevent or contain an outbreak.

It is also critical to support sentinel surveillance measures of disease. Sentinel surveillance allows public health officials an ability to identify signal trends, and impacts to disease burden in a community. One such example of this is Flu Near You[1], a crowdsourced symptom surveillance tool in the U.S. where users submit health reports weekly. The project, created in partnership with my research lab at Boston Children's Hospital, Ending Pandemics and the American Public Health Association, allows researchers, and local, state and federal public health agencies to access the submitted symptom data to understand disease patterns at the community level. This system captures individuals who may not be seeking medical attention, and is updated in real time. In response to the ongoing novel coronavirus outbreak, our team has added additional questions that may pick up early signals of this virus here in the US, including questions on diagnosis and travel history. As we collect reports in the Flu Near You system, we are able to detect spikes in symptoms over a set amount of time. We can also retroactively look back at symptom reports to learn about potential community spread after a case is confirmed. Systems like Flu Near You are extremely valuable tools to fill in gaps of information, and provide early signals of disease impacts at a community level.

With each outbreak comes its own difficulties. We experienced the lack of online local news media during the West African Ebola outbreak, we have built platforms to allow field epidemiologists on the ground confirm or deny rumored outbreaks.

We understand that each outbreak might require a slightly different approach to monitoring or response. However, there are key updates and metrics, which every outbreak could benefit from: how many new cases, is there geographical spread, are healthcare workers infected, and/or are there new testing or treatment methods available.

[1] https://flunearyou.org/#!/

The use of digital disease detection platforms is complementary to traditional surveillance - aggregating data from a variety of sources in real-time. Prioritizing sensitivity over specificity, these platforms provide stakeholders with a snapshot view of the current situation - aggregating everything that's available.

On December 31, 2019, the World Health Organization (WHO) China Country office was informed of cases of pneumonia of unknown etiology located in Wuhan City, Hubei Province of China[2]. Within 4 days, 44 cases of disease were identified, though no infectious agent or cause was known. At the time, the only link between cases was a seafood market that all cases reportedly visited. On January 7, 2020, Chinese scientists released sequencing that determined that the cause of illness was a novel coronavirus, later named COVID-19[3]. Since the first alert of COVID-19, the number of confirmed cases in China and globally expanded quickly, leading to WHO holding three emergency meetings of the International Health Regulations Emergency Committee (IHR) on January 22, 23 and 30, 2020[3]. IHR, led by WHO Director General Dr. Tedros Adhanom Ghebreyesus, determined that the COVID-19 outbreak is a Public Health Emergency of International Concern (PHEIC) on January 30, 2020 due to the threat of disease globally[3].

As of 10am CET on March 2, 2020, 78,811 confirmed cases of COVID-19 have been reported to WHO globally, including 2,462 deaths related to the disease[4]. The number of cases reported daily in China have continued to decrease, showing promising results in an effort to contain the disease within the country[5]. Based on evidence provided by the WHO-China joint mission, WHO reports that the epidemic peaked and plateaued between January 23 and February 2, 2020 in China and has been steadily declining since that time[5].

WHO currently has the global risk level for COVID-19 as very high. Outside of China, 8,774 cases have been confirmed in 64 countries[4]. In the United States, 62 cases of COVID-19 have been confirmed, including 2 deaths[4]. To date, there is evidence supporting local transmission of COVID-19 in the United States, but does not suggest sustained transmission at the community-level at this time. Additionally, the epidemiologic curve for the outbreak is showing an increase in case reports outside of China over time (fig. 3)[4]. This suggests that COVID-19 has expanded beyond imported cases associated with travel to Hubei, China and has sustained transmission in new regions. Sudden increases in cases since February 21, 2020 in Italy, the Republic of Korea and the Islamic Republic of Iran are deeply concerning for human health and signal that a continued global response is necessary[4].

Great strides have been taken to understand COVID-19 since its discovery. The public health community has united to work quickly to understand the virus and its impact. WHO has been able to determine that the fatality rate is between 2% and 4% in Wuhan, China and 0.7% outside of Wuhan[5]. In most cases of mild disease, recovery time is approximately two weeks and in cases of severe disease, recovery takes three to six weeks[5].

While COVID-19 is not currently circulating in the United States, the risk of sustained transmission is still high. The current global situation suggests that this COVID-19 outbreak has the potential to cause a pandemic, threatening the health of people in the United States and globally[6]. The continued COVID-19 response has demonstrated what can be accomplished as scientific and humanitarian disciplines unite for a common goal. In order to stay persistent in

[2] https://www.who.int/docs/default-source/coronaviruse/situation-reports/20200121-sitrep-1-2019-ncov.pdf?sfvrsn=20a99c10_4

[3] http://www.diseasedaily.org/diseasedaily/article/world-health-organization-covid-19-outbreak-public-health-emergency

[4] https://www.who.int/docs/default-source/coronaviruse/20200302-sitrep-42-covid-19.pdf?sfvrsn=d863e045_2

[5] https://www.who.int/dg/speeches/detail/who-director-general-s-opening-remarks-at-the-media-briefing-on-covid-19---24-february-2020

combating COVID-19 and future outbreaks, we need more continuous support for public health initiatives and investment in programs aiding in the detection and monitoring of infectious diseases.

Within the realm of infectious diseases, we often say, "it is not a matter 'if' the next pandemic occurs, but a matter of 'when'". Global emerging and re-emerging infectious diseases are a constant threat to human health. Infectious disease monitoring and surveillance are critical for preventing the spread of disease. We need continual support for initiatives that strive to make an impact both domestically and globally. We live in an interconnected world and it is our duty to protect human health. By investing in our neighbors and promoting health initiatives outside our borders, we are also helping reduce the threat of an outbreak within the United States.

It is critical that, as a nation, we take a stance in promoting global health and health security. We have already seen the impacts that COVID-19 has had, in two months time, on travel, trade, and economies. It highlights the need to support and empower local health departments in preparedness. Long term support for the Centers for Disease Control and Prevention and for local health departments are critical to preparedness efforts. This support should not only include funding, but also oversight and direction to ensure that systems employed utilize the most effective tracking tools, such as AI and other data driven methods and that the findings of publicly funded surveillance translate into action and tools to combat these global challenges. We need to be diligent in our continual response to infectious diseases. The CDC's Influenza surveillance systems are the backbone of flu surveillance in this country. Augmenting the current system with novel programs like HealthMap provides additional information that can help public health authorities, clinicians, researchers and decision makers learn more and react faster to seasonal and novel outbreaks.

With every outbreak, whether it is Ebola, Zika or even influenza, we have a dangerous cycle that exists. The outbreak is announced and captures the attention of politicians and media, where all the alarms are raised. The entire world becomes united with concern and amazing strides are taken, but only for a relatively short period of time. Eventually, we become complacent and as the headlines fade, so does the investment in infectious disease response, both in time and financially. But this cycle needs to change and that can start with you today. If we, the United States, are proactive instead of reactive in the investment of public health and surveillance initiatives, we can hopefully prevent the next COVID-19, or at the very least, reduce its global scale. It is time that we make a continued effort to ensure all public health systems are prepared and equipped to handle any infectious disease threat it may encounter.

Federal government investments have already shown to be successful in protecting human health. Among them, USAID has proven this success through the PREDICT project, which has prepared us for the next pandemic through its wildlife sampling. Through this work, we are able to detect potential zoonotic diseases before humans are infected. But with this achievement, we are clear that we need more support from our federal government to keep innovating and creating novel technologies for the surveillance and detection of infectious diseases globally. Amidst this crisis, we are starkly aware of the need for continual investment so that in the times of peace, we can be preparing for the next event.

In short, it is my recommendation that the United States continues to invest in the fundamental needs of disease detection and surveillance domestically and internationally. Nontraditional data sources and crowdsourcing tools have proven to give support to traditional surveillance activities and can aid in developing a clearer picture of any existing or potential infectious diseases that threaten human health. By leveraging these tools and resources, we can

identify transmission patterns of disease within a community near-real time in order to directly allocate where support is needed to prevent diseases from spreading further. Additionally, the data collected by these tools can allow us to learn about different models of transmission in order to predict the spread of disease in the future.

The COVID-19 outbreak reminds us that while we have made incredible advances in preparedness and response activities, there is still a huge amount of work to be done. Investing in novel technologies that support disease detection and existing epidemiological techniques will provide a new era for handling infectious disease outbreaks. It is only with your continued support that the momentum we have gained as a public health community is maintained.

Thank you for your thoughtful leadership on these issues. I look forward to your questions and wish to continue to be a resource in your important work.

***Please note, the COVID-19 outbreak is rapidly changing both in the United States and globally. All relevant COVID-19 case information provided in this testimony reflects the outbreak situation as of Monday, March 2, 2020.*

Charts and Figures

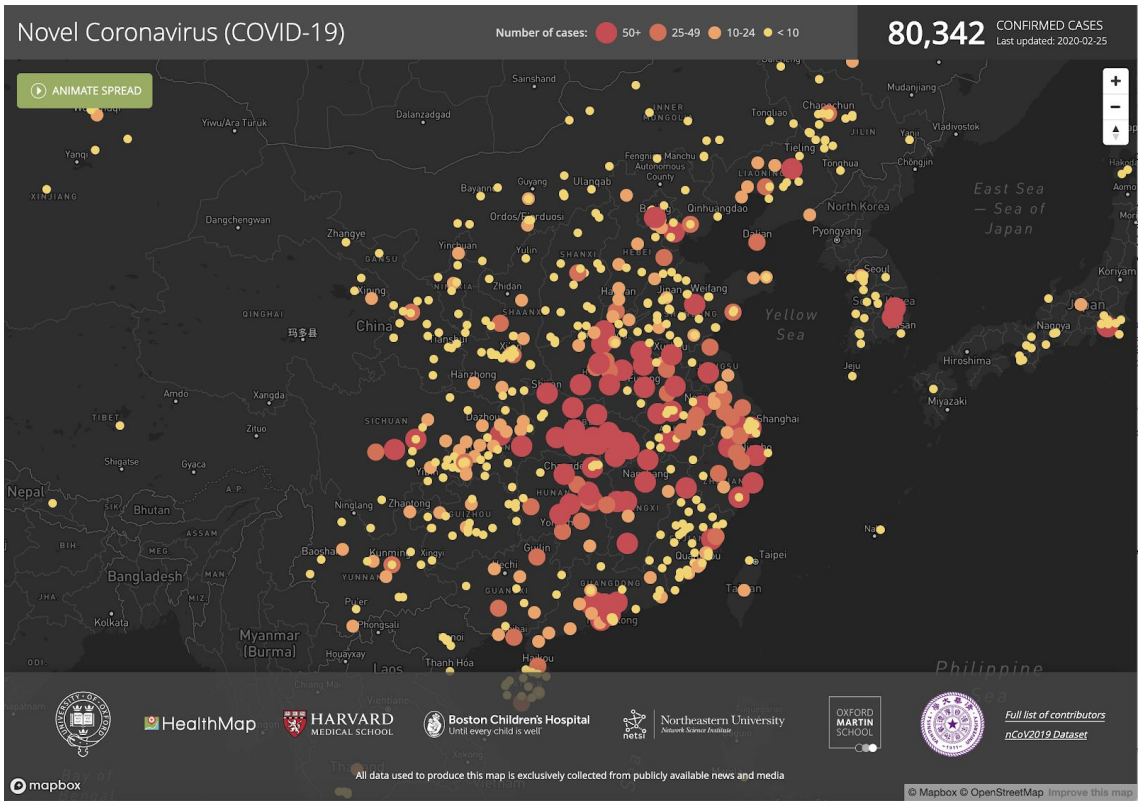

Figure 1: HealthMap COVID-19 map shows confirmed cases of coronavirus globally[6].

[6] https://www.healthmap.org/covid-19/

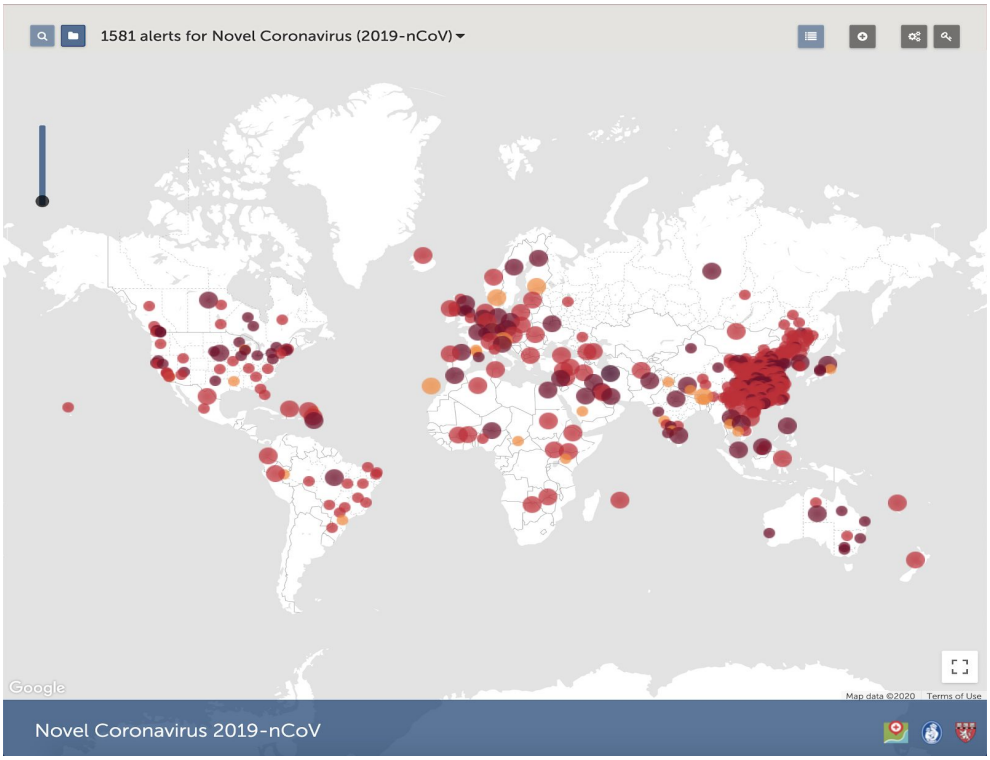

Figure 2: HealthMap shows media reports of COVID-19 globally[7].

Figure 2. Epidemic curve of confirmed COVID-19 cases reported outside of China, by date of report and WHO region with complete days of reporting through 01 March 2020

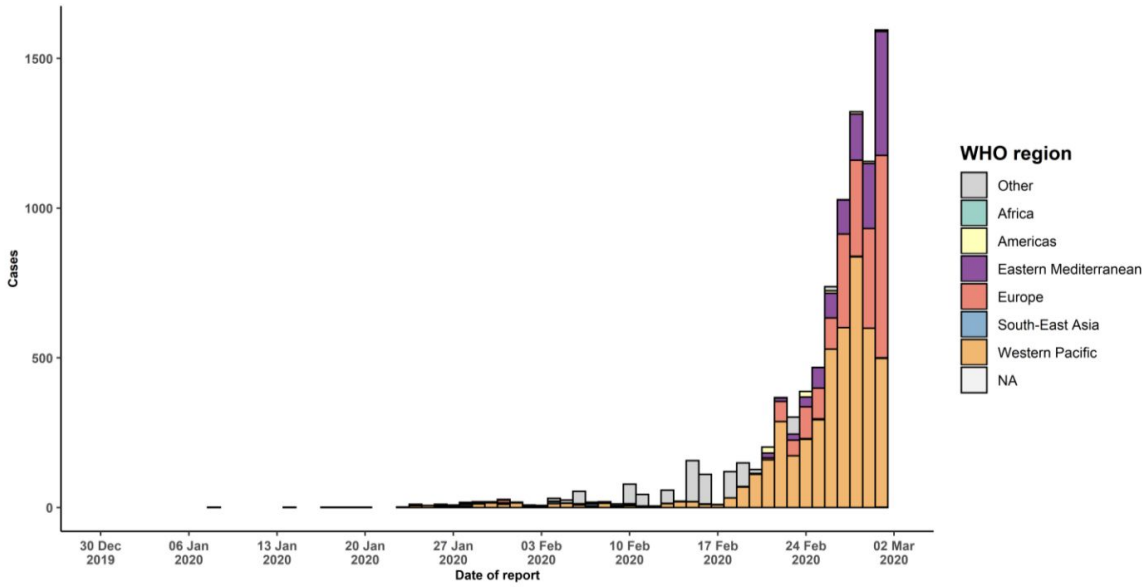

Figure 3: WHO situation report from March 2, 2020 shows epidemic curve of coronavirus cases detected outside of China as increasing over time[4].

[7] https://www.healthmap.org/wuhan/

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John Brownstein, Ph.D is Professor of Biomedical Informatics at Harvard Medical School and is the Chief Innovation Officer of Boston Children's Hospital. He also directs the Computational Epidemiology Lab and the Innovation and Digital Health Accelerator both at Boston Children's. He was trained as an epidemiologist at Yale University. Overall, his work aims to have translation impact on the surveillance, control and prevention of disease. He has been at the forefront of the development and application of data mining and citizen science to public health. His efforts are in use by millions each year including the CDC, WHO, DHS, DOD, HHS, and EU, and has been recognized by the National Library of Congress and the Smithsonian. In addition to research achievements, this translational impact comes from playing an advisory role to numerous agencies on real-time public health surveillance including HHS, DHS, CDC, IOM, WHO and the White House. He was awarded the Presidential Early Career Award for Scientists and Engineers, the highest honor bestowed by the United States government to outstanding scientists and the Lagrange Prize for international achievements in complexity sciences. Dr. Brownstein is also Uber's healthcare advisor and co-founder of digital health companies Epidemico and Circulation. He has authored over 200 peer-reviewed articles on epidemiology and public health. This work has been reported on widely including pieces in the New England Journal of Medicine, Science, Nature, New York Times, The Wall Street Journal, CNN, National Public Radio and the BBC.

Short bio

John Brownstein, PhD is Professor of Biomedical Informatics at Harvard Medical School and is the Chief Innovation Officer of Boston Children's Hospital. He directs the Computational Epidemiology Lab and the Innovation and Digital Health Accelerator both at Boston Children's. He was trained as an epidemiologist at Yale University. Dr. Brownstein is also Uber's healthcare advisor and co-founder of digital health companies Epidemico and Circulation.