Innovation Lessons From the COVID-19 Pandemic

Gianrico Farrugia, MD, and Roshelle W. Plutowski, BA

From the Mayo Clinic Administration (G.F.), and the Mayo Clinic Executive Office (R.W.P.), Mayo Clinic, Rochester, MN.

On December 31, 2019, Chinese authorities reported the first case of what would become known as coronavirus disease 2019 (COVID-19) to the World Health Organization, which declared a Public Health Emergency of International Concern 1 month later.[1] At the time of this publication, the virus has spread to all 6 World Health Organization regions, infecting several million people and killing more than 280,000 worldwide, with numbers that continue to grow.[2] To stem pandemic-related deaths and prevent health care systems from being overwhelmed with sick patients, governments responded by limiting travel, closing schools, issuing stay-at-home orders, making emergency investments in health care, scaling testing, and using data and technology to trace contacts.[3] In the interim, health care organizations ramped up molecular and serological testing, initiated triage systems to reduce exposure, and prepared facilities and staff for a surge of COVID-19 cases.[4] To identify effective tools to fight the disease, biotechnology, pharmaceutical, and information technology industry and academia quickly turned their attention and resources to research vaccines, antiviral agents, and immune response to the virus.

INNOVATION DURING CRISIS

Now, a few months into the pandemic, people worldwide continue to suffer from both the health and the economic fallout of COVID-19. As the crisis wears on and experts predict additional waves of infection,[5] we must strongly resist the natural urge to retreat to our safe zones to ride out the storm. Instead, we must seize the opportunity for cross-sector partnerships in science and technology to fight the disease while simultaneously deploying new digital health care solutions that our world greatly needs. With science guiding every step, we must adopt an urgent short-term strategy to save lives, but always with an eye on the long term.

COLLABORATING WITH GOVERNMENT

A public-private partnership facilitates innovation, and we have seen considerable collaboration from many levels of the US government over the past months. We and other organizations have advocated for many years for more flexibility in licensing and telehealth regulations to enable virtual care. The pandemic catalyzed these changes. The Federal Communications Commission[6] facilitated expanding access with the COVID-19 Telehealth Program, fast-tracking application processes and funding to help health care providers quickly establish telehealth services for remote patients. To date, the Centers for Medicare & Medicaid Services[7] has agreed to pay in-person visit rates for virtual visits for several office and hospital telehealth appointments with various providers, including physicians, nurse practitioners, and psychologists. To meet the demand for virtual services, Mayo Clinic has expanded video appointments from about 200 to 35,000 virtual visits per week. Many, if not close to all, other medical centers are also ramping up quickly.[8] Mayo Clinic patients' response to virtual care has been positive, and we intend to build on this model in the future—not to replace face-to-face visits, but rather to increase patient convenience and make in-person care more efficient when needed. We also must ensure that the regulatory changes that have made virtual services scalable are refined but not rolled back.

CROSS-SECTOR SOLUTIONS FOR PREVENTION, TESTING, AND TREATMENT

The response to the pandemic has produced partnerships that are impressive in scale and that reimagine traditional organizational boundaries. One initiative, the COVID-19 Healthcare Coalition,[9] has garnered the expertise and resources from large health care organizations, private industries, academic institutions, and startups. Coordinating the use of data and advanced analytics, the collaboration, which includes Mayo Clinic, the University of California health care system, Amazon Web Services, Microsoft, and Epic, aims to flatten the infection and mortality curves, improve outcomes, and enable clinics and hospitals to continue to respond to patient needs. The initiative's guiding principles stipulate no participants receive pay or preferential advantage.[9]

Although international collaboration has long been common practice in research, the pandemic has shown the ability to achieve clinical results at an unprecedented pace through data sharing with trusted partners. Initiatives such as the Global Initiative on Sharing All Influenza Data,[10] which gather sequenced viral COVID-19 genomes from laboratories all over the world, have proven to be essential open access tools, so investigators can learn more about the virus and its spread. To study 4 potential COVID-19 therapeutics, a new international consortium of researchers rose up immediately to organize the Solidarity trial, which is being conducted in more than a dozen countries.[11] With the same agility, a group of international researchers establishing the COVID-19 Clinical Research Coalition have mobilized and committed to addressing clinical research in countries with weak health systems.[12]

Within the United States, collaborations among health care institutions and industry are facilitating speedy access to experimental treatments. Working with the Food and Drug Administration, institutions with research infrastructures, such as Mayo Clinic, have been able to initiate clinical trials of potential therapies within a few weeks. We have worked closely with pharmaceutical companies to access drugs for compassionate use and clinical trials.

In addition, our collaborations have enabled us to massively scale up innovation. We have collaborated with investigators across the country to initiate a national effort to procure convalescent plasma from eligible donors who have recuperated from COVID-19. To date, more than 8000 patients have been treated with convalescent plasma, and there are more than 2000 participating sites across the United States.[13] When tests for severe acute respiratory syndrome coronavirus 2 were in short supply from the Centers for Disease Control and Prevention, our Mayo Clinic Laboratories developed a polymerase chain reaction test within 3 weeks, and our partnership with Roche Diagnostics increased capacity and relieved testing backlogs in several states. Mayo Clinic Laboratories also developed a serology test as the next critical tool for health care providers. Simultaneously, we are working with the state of Minnesota, the University of Minnesota, and other Minnesota health care providers to accelerate statewide testing using both types of tests, while also working with other US states including Florida and Arizona. All these efforts provide a view of an even more robust and nimble approach to medical science and application that needs to carry forward beyond this era.

Meanwhile, we are observing firsthand the power of engaging industries with diverse, even seemingly unrelated, capabilities. Medical device makers and car manufacturers have joined forces to mass produce ventilators and streamline ventilator design.[14] The partnerships may exhibit new avenues for device development that will set us in better stead to address future pandemics.

The COVID-19 outbreak has also vaulted collaborative opportunities to apply artificial intelligence (AI) and machine learning to new medical problems. Researchers in China have used AI to reveal distinctions between the computed tomography scans of patients with COVID-19 and those with other pneumonias.[15] Other research teams are using AI to identify new treatment pathways.[16] Tech

companies are working with hospitals in New York City to use AI platforms to assess the risk profiles of nonhospitalized patients. To help with diagnosis and risk stratification even before infection occurs, Mayo Clinic researchers are using AI to study whether data from electrocardiograms can help predict who is infected with and susceptible to COVID-19.

Overall, the new challenges posed by the pandemic are sharpening our skills and quickly teaching us the ways AI can enhance care. Before the outbreak, Mayo Clinic had established a partnership with Boston-based company nference to use AI to match potential treatments to diseases. Through the pandemic, our partnership has greatly expanded its AI applications to various COVID-related questions, from keeping track of testing in real time to predicting hot spots.

In fact, efforts to track and trace the virus, particularly using big data and AI, reveal that health care organizations, industry partners, and government agencies will be engaged together in matters of epidemiology well into the future. Some governments, as in China and South Korea, are deploying tracking initiatives by using combinations of smartphones and other tools that gather information on location and activities, such as credit cards.[17] These and future efforts will have to balance the imperative for large-scale, rapidly acquired epidemiological data collection with individual privacy.

DIGITAL LEGACY OF COVID-19

The health care industry has been on the precipice of a digital revolution for too long, and the pandemic has pushed it past the tipping point. For Mayo Clinic, a central enabling mechanism is the Mayo Clinic Platform, a portfolio of digital initiatives that uses data, AI, connected health care devices, natural language processing, and partnership to transform health care.

Mayo Clinic created the Mayo Clinic Platform in 2019, and together with our partners and many other health care providers, we had already been investing in

expertise and technology, which made it possible to shift quickly to more virtual care when COVID-19 struck. Now, we are accelerating plans to integrate virtual and in-person care to create a system that is more accessible, scalable, and sustainable while always focusing on patient needs. This goes beyond virtual patient visits to include pursuing advanced care at home with physician-led 24/7 remote monitoring and on-demand immediate medical care management, along with rapid response teams to deliver supplies and services.

Additional remote diagnostic and monitoring options are also on the horizon. For example, through machine learning and neural networks, we can identify diseases such as heart failure before symptoms even arise.[18] We can also remotely monitor thousands of patients at a time through programs such as the electronic intensive care unit. In the near term, integrated data from electronic health records, combined with the power of remote diagnostics and AI, will allow complex diagnosis to happen anywhere in the world. However, to do so in a way that transforms health care and makes it more patient centric, we must translate the cooperation that was catalyzed by COVID-19 to a platform for future innovation to benefit people globally. We must continue to activate large networks and resources to solve complex problems simultaneously instead of solving them one at a time in isolation. This will accelerate the digital platform model in health care and help more people.

Now is the time to build upon new digital care options to address urgent needs for the crisis we face today, but also to form the foundation for how we deliver care tomorrow. Through our united efforts, the pandemic will eventually come under control, and, in the process, we will have achieved a more nimble, consumer-friendly digital health care system that can better stand up to future challenges. Considering everyone and everything we have lost to COVID-19, we should fight determinedly for this thin but essential silver lining.

Correspondence: Address to Gianrico Farrugia, MD, Mayo Clinic Department of Administration, Mayo Clinic, 200 First St SW, Rochester, MN 55905 (Farrugia.gianrico@mayo.edu; Twitter: @GFarrugiaMD).

ORCID

Gianrico Farrugia: https://orcid.org/0000-0003-3473-5235

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