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by or vaccinations with antigenically closely related strains<sup>24</sup> is not relevant to coronaviruses. If COVID-19 vaccines have acceptable effectiveness in reducing morbidity and mortality in high-risk groups, they would have an important role, irrespective of impact on transmission and population immunity. If high-risk populations can be shielded by vaccination, COVID-19 control measures could be recalibrated. Crucially, it will be important to communicate to policy makers and the general public that first-generation vaccines are only one tool in the overall public health response to COVID-19 and are unlikely to be the ultimate solution that many expect.

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Malik Peiris, \*Gabriel M Leung  
gmleung@hku.hk

School of Public Health, LKS Faculty of Medicine, The University of Hong Kong, Pokfulam, Hong Kong Special Administrative Region, China

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## Strategy, coordinated implementation, and sustainable financing needed for COVID-19 innovations



Innovative tools and approaches are needed in the response to the COVID-19 pandemic. But innovation alone is insufficient and requires resources and an overarching strategy for implementation in a planned and coordinated way. Furthermore, it is important to evaluate the effectiveness of innovations before they

are implemented in clinical care even in an emergency situation. Unfortunately, this strategic approach is not happening in many parts of the world as the numbers of COVID-19 cases and deaths continue to rise. Since so much innovation is bottom-up and entrepreneurial, it can be unclear how best to evaluate, coordinate, or



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scale up innovations. The problem is not the science, but insufficient infrastructure and strategy to scale up and implement innovations at the population level.

There has been no shortage of innovation during this pandemic. With new technology platforms, such as DNA and RNA based vaccines, viral vectors, recombinant proteins, and nanoparticles, scientists have rapidly developed COVID-19 vaccine candidates.<sup>1</sup> Effective and safe COVID-19 vaccines might be ready for deployment in less than a year.<sup>2</sup> Similarly, research has been accelerated for new COVID-19 therapies with antivirals, convalescent plasma, monoclonal antibodies, and immune modulators under investigation in clinical trials,<sup>3</sup> as well as the repurposing of existing medications such as dexamethasone.<sup>4</sup> In the realm of testing, scientists are pioneering new diagnostic tests based on CRISPR-Cas9 genome editing, next generation sequencing, and microfluidic chips that might increase testing capacity and provide rapid results at the point of care.<sup>5</sup>

A range of innovations in digital technology are also being applied for pandemic planning, surveillance, testing, contact tracing, quarantine, and health care.<sup>6</sup> Dashboards and web-based platforms, such as the Johns Hopkins COVID-19 Dashboard, have emerged to track COVID-19 cases and deaths globally. BlueDot, a Canadian commercial health surveillance company, gathers disease data from online sources, such as official reports from organisations like the US Centers for Disease Control and Prevention and WHO, as well as non-traditional information, such as airline flight information, to make predictions about locations of infectious disease outbreaks.<sup>7</sup> Digital contact tracing

smartphone applications can detect when individuals have been in close proximity for an extended period of time to people who have tested positive for severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2).<sup>8</sup> Countries such as South Korea, Singapore, Taiwan, and Switzerland were early adopters of the use of this technology.<sup>9</sup> In addition, mobile applications are being developed to allow patients' health data to be securely shared with scientists and public health professionals to identify new outbreaks, understand how SARS-CoV-2 is spreading, identify at-risk populations, and evaluate the effectiveness of interventions.<sup>10,11</sup> In Germany, public health authorities launched a smartwatch application that gathers vital information to screen for signs of illness; these data are presented online in an interactive map that displays the likelihood of COVID-19 incidence across the nation.<sup>12</sup> Innovations leveraging artificial intelligence (AI) are also on the rise. HealthMap, for example, uses AI and data mining to provide real-time information on infectious disease outbreaks and sounded an early alarm on the pandemic.<sup>13</sup>

There have also been digital innovations in health-care delivery, such as telemedicine and digital health. In China, clinicians are using AI-assisted CT screening tools to help identify patients with pneumonia due to COVID-19.<sup>14</sup> Some health-care providers are using AI-supported chatbots to screen people with common COVID-19 symptoms and advise them to seek testing.<sup>15</sup>

Although such innovations are encouraging, they are insufficient if not deployed in a strategic and scalable way that targets areas of greatest need. A central strategy at the national and global levels and financial resources are required to direct, evaluate, coordinate, prioritise, and integrate the innovations for effective implementation. Furthermore, an overarching national or global command centre would be useful for all COVID-19-related innovations. Existing initiatives for COVID-19 vaccines, therapeutics, and diagnostics—eg, the Accelerating COVID-19 Therapeutic Interventions and Vaccines (ACTIV) partnership and the Rapid Acceleration of Diagnostics (RADx) initiative in the USA and the global Access to COVID-19 Tools (ACT) Accelerator—are promising, but to our knowledge there are no similar approaches for digital health innovations. Additionally, there is a need for a systematic forecasting system at

For Johns Hopkins COVID-19 Dashboard see <https://coronavirus.jhu.edu/map.html>

national and international levels for predicting future disease outbreaks and pandemics, analogous to the US National Weather Service and the European Centre for Medium Range Weather Forecasts, which use extensive data from multiple sensors and supercomputing.

So far during the COVID-19 pandemic in the USA, there has been inadequate central coordination and command in public health surveillance, response, and innovation. Although ACTIV and RADx have been established, it is unclear how such efforts work together. Furthermore, there are challenges for the coordinated implementation of innovations. A lack of coordination between US state and local public health departments, for example, led to difficulties in delivery of contact tracing programmes.<sup>16</sup>

Globally, there is inadequate financing to sustain a coordinated strategy for COVID-19 innovations. The ACT-Accelerator, for example, brings together governments, health organisations, scientists, businesses, civil society, and foundations to accelerate development, ensure equitable allocation, and scale up delivery of new COVID-19 tools. But the ACT-Accelerator is principally dependent on funding from donor countries and foundations, which is an insufficient and unsustainable way to finance a global public good. The ACT-Accelerator will require long-term, predictable, and sustained financing based on global solidarity. Innovation to tackle COVID-19 must be centred within strategy, command, coordination, and sustainable financing.

VJD served previously as a member of the Board of Medtronic Inc, ending in June, 2014, and received deferred compensation until 2018, unrelated to the topic of this Comment. CB declares no competing interests.

\*Victor J Dzau, Celynne Balatbat  
vdzau@nas.edu

National Academy of Medicine, Washington, DC 20001, USA

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## A pledge for planetary health to unite health professionals in the Anthropocene



In 1948, the Declaration of Geneva<sup>1</sup> was passed as one of the first official acts of the World Medical Association. The Declaration updated the ancient Hippocratic oath and defined ethical principles applicable to the medical profession worldwide.<sup>2</sup> Other health professions have similar pledges and oaths that guide their practice,

generally based on the four bioethical principles of justice, autonomy, non-maleficence, and beneficence. Over time, these pledges have been updated to account for evolving societal norms, expectations, and challenges,<sup>3</sup> and many students and health education institutions use adaptations of the original oath.<sup>4,5</sup>

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