Learning From COVID-19 to Improve Surveillance for Emerging Threats

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See also Morabia, p. 462, Elliott et al., p. 514, Dean et al., p. 517, Bendavid, p. 523, Pastor-Barriuso et al., p. 525, Pérez-Gómez et al., p. 533, and Elliott et al., p. 545.

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As the SARS-CoV-2 virus (the causative agent of COVID-19) began rapidly spreading around the globe in the spring of 2020, existing surveillance systems were not robust or comprehensive enough to meet the tremendous need for real-time, representative characterization of both pathogen and disease. Confronted with these challenges in England, as described by Elliott et al. in this issue of *AJPH* (p. 545), an alternative, novel, and broadly applicable surveillance platform was established—the Real-time Assessment of Community Transmission-1 (REACT-1) study. This system was designed and purpose-built through a collaboration of public health officials, health care providers, academic modelers, mathematicians, statisticians, logisticians, and epidemiologists. The methods and execution of REACT-1 proved successful in maintaining situational awareness as reported in more than 15 publications and numerous public health reports, leading to meaningful policies and mitigations with significant positive public health impact.

Several design and methodological factors contributed to REACT-1's success and serve as examples for improving surveillance going forward.

- Bring It Home—During the nationwide lockdown in England, when clinics were closing and health care services were limited, REACT-1 brought the study to the people, where they lived, rather than attempting to implement at the point of testing and care. This helped to prevent collection bias introduced through opportunistic sampling among available patients at available clinics.
- Self-Serve—The study used a novel specimen accessioning approach by sending swabbing kits to volunteering individuals and families for self-collection, thus giving health care providers time to focus on patients in greatest need. Notably, this effort provided a more representative view of COVID-19, demonstrating the spectrum of infection among both symptomatic and asymptomatic persons and estimating the prevalence of infection with fewer biases from varying inclination or ability to be tested.
- Go Long—REACT-1 established repeated collections of specimens and data, occurring in 19 rounds of study, approximately every two to three weeks for almost two years. This sustained effort not only provided point-prevalence and cumulative incidence of infection, but also revealed broad trends of transmission and the emergence and growth rates of new variants over time and across the region.
- Go Large—The study was adequately powered for regular estimates of disease impact and virus evolution prevalence estimates at regional and subregional levels in England. To date, over 2.5 million swabs have been collected from over 14 million people invited to participate. The size of the sample allowed for a frequency of collection that was sufficient and timely enough to inform public health leaders to make evidence-driven decisions on mitigation measures.
- Level Playing Field—One important component of REACT-1 was the use of random sampling. The effort benefited significantly from access to patient records in the country's National Health Service (NHS), utilizing random cross-sectional sampling down to the local level. REACT-1 achieved a response rate of around 18% and utilized linkages to the NHS data. The representativeness of the study's sample uncovered important epidemiological trends in disease by age, race/ethnicity, socioeconomic status, and other health equity measures. These data

supported identification of disparities in infection risk as a major driver of racial/ethnic disparities in COVID-19 mortality. The design, frequency, and data completeness in the sample provided reliable inputs for modeling and forecasts of COVID-19 in the United Kingdom, in contrast to the use of case counts in other countries, whose interpretation was far more variable in space and time.[1]

- Versatile Player—Given the breadth and duration of the REACT-1 investment, its utility exceeded the primary intent for situational awareness and allowed for measuring multiple other public health outcomes. The platform provided vaccine effectiveness estimates specific for vaccine formulation, number of doses, and by predominant variant. Through additional consent and long-term record linkage, the platform also provided a profile of COVID-19 symptoms over time and was able to show evidence of reinfection and the degree of protection from natural infection and vaccination.
- Keeping Score—The results of each round of REACT-1 revealed the transparency of the program's processes and findings. The data were released quickly, publicly, and on a known cadence, and were reported in the media and used by senior decision-makers to guide COVID response policies. Routine and open data release streamlined clearance processes, managed expectations on updates to near real-time situational awareness, and maximized the benefit of the information to decision-makers and the public.

The costs and complex coordination of a platform like REACT-1 were appropriate and proportionate to the significant impact of COVID-19; however, it may be challenging to maintain the effort when no emergency is present, and it may be difficult to emulate in resource-limited settings, even during emergencies. The REACT-1 team improved logistics and, notably, lowered costs as the study progressed. Exploring options to optimize processes and further minimize costs for similar capabilities will be important if the lessons learned from REACT-1 are to be replicated in other locations.

The emergence and circulation of the SARS-CoV-2 virus revealed the foundational need for robust virological surveillance to detect, characterize, and monitor virus variants. Systems such as the SARS-CoV-2 Sequencing for Public Health Emergency Response, Epidemiology and Surveillance (SPHERES) in the United States and expansion of other global genomic sequencing networks were critical for informing public health interventions.[2,3] Going forward, a platform like REACT-1 could provide rich information on virus evolution and impact; at a minimum, however, specimen collection with virus genomic characterization at capable sentinel laboratories in strategic locations globally are needed to provide the first defense.

Other alternative approaches have been applied during the COVID-19 response for improving public health surveillance using byproducts of the data revolution and recent digital health trends.[4] These capabilities may allow resource-limited jurisdictions to jump over traditional methods to use newer data-only approaches for public health surveillance, such as event-based surveillance, social media monitoring, smartphone-based crowdsourcing, exposure notification, use of the Internet of Things, and wearable technology. Nonetheless, without a grounding of these efforts to the clinical and laboratory monitoring of emerging pathogens, they may be limited as nonspecific signals and trends.

Recently, the World Health Organization developed a Health Emergency Preparedness, Response, and Resilience (HEPR) framework, which seeks to improve detection and public health monitoring through "collaborative surveillance."[5] This initiative focuses on public health intelligence, surveillance of threats, improved laboratory capacity for pathogen and genomic surveillance, and better forecasting. Rather than a single, purpose-built system like REACT-1, collaborative surveillance calls for better linkage and coordination between existing epidemiological and laboratory systems in human and animal health to achieve a "mosaic" of community surveillance. Additionally, initiatives for data modernization are being implemented to address gaps that challenged the early COVID-19 response and improve data system readiness and coordination.[6]

The REACT-1 platform was a major accomplishment in collecting, analyzing, and informing essential information in a time of crisis. It provides major lessons learned on how to improve surveillance systems generally and especially during a pandemic. A clear question will be, how do we apply this approach and the lessons learned from REACT-1 into legacy surveillance systems during nonemergency situations? And how can we quickly ramp up similar efforts when needed again? The challenge will be to find ways of optimizing similar approaches in other locations within available resources. Hopefully, collectively we can rise to this challenge. AJPH

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CONFLICTS OF INTEREST

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