EDITORIAL

Modeling, post COVID-19

Much of the public first learned about epidemiological modeling during the early months of the coronavirus disease 2019 (COVID-19) pandemic. The first models resulted in more confusion than clarity. Even though coronavirus cases were rising exponentially in the United States and Europe, some models predicted a rapid peak followed by a rapid decline, whereas other models predicted cycles of infection continuing over several years. Much has been learned since those early months. In retrospect, it is clear that modeling requires both reliable data and an accurate understanding of how disease spreads, and that the field of epidemiological modeling requires a diversity of approaches. Support for this field must increase and be coordinated, with a designation of responsibilities among funding agencies.

Early models relied on sparse, sometimes unreliable, data, and modelers did not anticipate the emergence of important new facts—frequent transmission by asymptomatic carriers, the disproportionate impact of superspreaders, and the role of aerosol-mediated transmission. As data accumulated and new information about transmission was incorporated, the modeling improved.

Basic research in forecasting epidemics ranges from traditional models that can be run on a laptop to those that simulate the daily activities of a hundred thousand or more people and require a supercomputer. However, research on modeling is funded haphazardly in the United States, with no single federal agency having ownership. If the nation expects to do better in the inevitable next pandemic, basic research needs more support, and it needs a lead agency to strengthen coordination across research groups from a wide variety of disciplines including public health, medicine, statistics, computer science, and the behavioral sciences.

For use in an emergency, models developed through basic research need to be "operationalized"—that is, made robust for evaluating specific policy interventions. "Nowcasting" requires models that integrate incomplete, real-time data and emerging medical knowledge to provide situational awareness. Such specialized models can address questions such as, "If we do this, how many fewer deaths are likely?" Models must also incorporate behavioral responses to policy interventions that may change the course of an epidemic. By contrast, forecasts of a hurricane's path and intensity need not take into account behavioral responses: The forecaster may tell people to take shelter; whether they do so does not change the path of the hurricane.

The comparison to weather research and prediction is helpful when considering the changes needed to bolster the effectiveness of epidemiological modeling. For the weather, two federal agencies have clear responsibilities: The National Science Foundation (NSF) supports basic research in weather and climate modeling, whereas the National Oceanic and Atmospheric Administration's National Weather Service distributes results of its operational models to weather-forecast offices. The United States needs an analogous structure for epidemiological modeling and forecasting—one or more agencies with clearly defined responsibilities for supporting basic research in modeling, coordinated with one or more agencies with defined operational responsibilities.

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We and other former members of the Obama administration's President's Council of Advisors on Science and Technology (http://opcast.org), after consultation with modelers and policy analysts, recently concluded that NSF, because of its unmatched outreach into computational and data sciences, is well-positioned to act as the lead research agency and should work closely with the National Institutes of Health to ensure that epidemiological models are consistent with what is known about human disease. The U.S. Centers for Disease Control and Prevention should be the lead operational agency, with a new office for epidemic forecasting and analytics. The national supercomputing infrastructure of the Department of Energy could help support the computing requirements of the combined programs.

To conquer the next pandemic, it will be essential to have a diverse array of improved models that quickly incorporate new data and emerging medical knowledge, and that simulate the effects of various public policy interventions. If the United States takes action now by increasing funding through agencies with well-defined roles and responsibilities, it will be better prepared to save lives in the future.

–William H. Press and Richard C. Levin

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