Toward a New Strategic Public Health Science for Policy, Practice, Impact, and Health Equity

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See also Brownson, p. 1389.

The COVID-19 pandemic and its social and health impact have underscored the need for a new strategic science agenda for public health. To optimize public health impact, high-quality strategic science addresses scientific gaps that inform policy and guide practice.

At least 6 scientific gaps emerge from the US experience with COVID-19: health equity science, data science and modernization, communication science, policy analysis and translation, scientific collaboration, and climate science. Addressing these areas within a strategic public health science agenda will accelerate achievement of public health goals.

Public health leadership and scientists have an unprecedented opportunity to use strategic science to guide a new era of improved and equitable public health. (*Am J Public Health*. 2021;111(8):1489–1496. https://doi.org/10.2105/AJPH.2021.306355)

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COVID-19 has exposed major unmet needs in our nation's public health system related to workforce, diagnostics, preparedness, health disparities, information systems, and response capacity. While there have been numerous calls for creating and sustaining a robust public health infrastructure and for prioritizing science, antiscience sentiments have also been widespread. Without a thoughtful, strategic approach to scientific research; rigorous evaluation of programs; and development of evidence-based public health policy and communication strategies, the United States will be underprepared again when the next pandemic occurs. Ensuring impactful science as the bedrock for decision-making will set a sound foundation for the future, and lessons from COVID-19 can provide direction for a strategic approach to public health science.[1]

Public health has a mandate to reduce morbidity and mortality and advance health equity at the population level. Metrics and frameworks used to rank the impact and value of public health science vary, often reflecting stakeholder perspectives. They frequently include a focus on tangible health benefits, concern about return on investment, interest in specific diseases, or prioritization of bibliometrics and scientometrics.[2,3] Retrospective metrics alone are insufficient to guide strategic science; effective action requires a prospective approach. We believe strategic science begins with a public health goal in mind, systematically identifies and then builds an evidence base to inform practice and policy, and ultimately results in improvement in health and equity outcomes. To optimize public health impact, high-quality strategic science addresses scientific gaps that inform policy and guide practice.

A prioritized strategic science agenda can help guide use of limited public health scientific resources to fill the evidence gaps that will have the largest impact on population health. Many examples of the impact of strategic science exist,[4] ranging from counterbioterrorism efforts informed by the smallpox research agenda,[5] smoke-free policies that protect millions based on research documenting adverse effects of second-hand smoke exposure,[6] increased vaccine coverage following implementation research, coordinated evidence-based actions to reduce antimicrobial resistance informed by surveillance,[7] and millions of lives saved by HIV antiretroviral therapy resulting from applied research on effective delivery strategies. A strategic pursuit of public health science that provides direction, has delineated measurable goals, and provides opportunities for stakeholders and affected communities to engage is needed more than ever. Developing and implementing an effective strategy is crucial for a new public health era.

The COVID-19 pandemic has illuminated at least 6 key themes that are central to a science strategy for improving public health: health equity science; data science and modernization; communication science; policy analysis and translation; scientific, including laboratory, collaboration; and climate science. With a US domestic focus, for each of these 6 themes, we first summarize related COVID-19 lessons. Second, we discuss their implications to help inform a strategic public health science agenda for a new era (Box 1).

HEALTH EQUITY SCIENCE

Structural racism, long-standing injustices, and neglect of factors that cause health inequities in the United States have worsened the consequences of the COVID-19 pandemic and resulted in substantial disparities in COVID-19 incidence, hospitalization, and mortality. Social determinants of health (SDOH) and vital conditions such as employment settings lacking employee protections and insecure or crowded housing have impeded the use of mitigation measures like social distancing and mask wearing. These factors contributed to 1.4- to 1.8-times-higher COVID-19 incidence, 2- to 3-times-higher hospitalization, and 3- to 5-times-higher mortality rates among Black and Hispanic/Latino persons compared with White persons.[8] In addition to elevated environmental exposure risk, racial/ethnic minority populations have less access to health care and higher prevalence of uncontrolled chronic lung, heart, kidney, liver, and metabolic conditions associated with more severe COVID-19 outcomes.[9] Race and ethnicity data have been incomplete, particularly in the beginning of the epidemic, and SDOH data were not widely leveraged, leaving the effects of structural racism, environmental injustice, and other socioeconomic factors largely unexplored. In addition, adverse impacts of the pandemic on employment, education, and other determinants of health could widen future disparities as well because Black, Hispanic/Latino, older, rural, and underinsured populations were more likely to experience unemployment and education setbacks.[10,11]

Future strategic scientific work can advance health equity by both building on existing recommendations and identifying new effective program and policy interventions. Rigorous evaluations of clinical, community, environmental, and policy interventions that link social determinants with health outcomes and assess impact on health inequities are essential.[12] To expand the evidence base, evaluation of real-world impact and the effect of interlocking contextual systems will be important to supplement experimental efficacy studies.[12] Expanding use of validated methods to document SDOH and assess social and environmental factors will be fundamental to this work.[13] This work can also elucidate how failure to address health disparities leads to less-effective preparedness and how health disparities can be exacerbated during a crisis. Research is needed to identify ways in which better data from modernization and innovation can be used to accelerate health equity.[14] Given how SDOH, structural racism, and health disparities contributed to the impact of this pandemic, implementation science should inform preparedness approaches that recognize health equity as a core pillar of future pandemic preparedness efforts.

DATA SCIENCE AND MODERNIZATION

Existing surveillance and data systems have proven inadequate for COVID-19 response efforts. Public health data systems have been historically undersupported and were unable to acquire, share, and transmit data efficiently. The lack of systematic data collection and automated linkages between laboratory-derived data, clinical data, and case investigation data has impeded COVID-19 response speed. Outdated policies and regulatory processes inhibit data collection and sharing at local, state, national, and international levels. Interconnectivity across a vast array of public–private sector systems in the United States has been nascent, slowing utilization of electronic health records in response efforts. While contact tracing can be an important public health tool to interrupt disease transmission, its application for COVID-19, particularly in the initial months of the pandemic and during spike periods, was largely inadequate. Data science could have greatly improved contact-tracing efforts by providing real-time information to those exposed to reduce transmission. Finally, the public health workforce has had limited expertise and access to new tools, policies, and approaches to data visualization, methods, and analytics including epidemiological modeling and

BOX 1— COVID-19 Lessons and Implications for Strategic Public Health Science

Themes	COVID-19 Lessons	Public Health Science Opportunities
Health equity science	• COVID-19 magnified and widened health disparities and other inequities. • Incomplete data on race, ethnicity, and SDOH limited some analyses. • Race/ethnicity interacted with causal SDOH factors and historical inequities. • Historic neglect of factors that cause health disparities resulted in worse pandemic outcomes.	• Assess how addressing health disparities is part of pandemic preparedness. • Document SDOH, including how they intersect to magnify risk. • Build evidence on intervention effectiveness. • Generate health equity evidence needed by policymakers. • Research how data modernization and innovation can accelerate health equity.
Data science and modernization	• Public health data systems were unable to acquire, share, and transmit data efficiently. • Lack of systematic linkages among laboratory, clinical, and case investigation data impeded response speed. • Outdated policies and regulatory frameworks inhibited data sharing at local, state, national, and international levels. • Public health workforce expertise was insufficient for data linkages and new analytic methods. • Public- and private-sector partnerships were nascent, slowing progress.	• Accelerate modernization to make public health science current. • Expand methods for use of multisectoral data sources, including environmental and climate, community SDOH, geospatial, genomic, and biomarker data. • Evaluate new surveillance and outbreak signal approaches. • Equip public health workforce with data science, genomics, informatics, and analytic skills. • Provide scientific leadership using public health data.
Communication science	• A COVID-19 "infodemic" occurred together with more than 90 million Facebook misinformation warnings • Misinformation and disinformation undermined public health messaging and response efforts. • Public trust in scientific integrity was undermined during COVID-19.	• Evaluate approaches to counter misinformation, such as engaging online influencers. • Expand communication science; assess impact of new technologies and social media. • Strengthen communication strategy as part of research planning. • Evaluate effective methods to amplify research dissemination. • Accelerate pace of science dissemination.
Policy analysis and translation	• Need for universal access to free testing, treatment, and vaccination for COVID-19 was evident. • COVID-19 made intersection of health and other sectors visible, raising plethora of policy issues (e.g., employment, housing, transportation). • Policy barriers hindered consistent mitigation approaches across jurisdictions, (e.g., mask, restaurant, and business opening policies). • Clear, consistent messaging was needed across all levels of policymakers. • COVID-19's postacute health effects (cardiovascular, pulmonary, mental health, and neurologic) raised policy issues in other health care domains. • Telehealth expansion demonstrated both feasibility and need for attention to equitable access.	• Expand use of policy analyses to assess public health impacts. • Utilize strongest methods possible for public health policy research, including randomized and nonrandomized designs. • Leverage partnerships to accelerate dissemination and implementation of evidence-based policy options. • Assess core capacities, policies, and systems, and ethical frameworks needed for future preparedness and resource distribution during public health threats. • Assess incidence, duration, severity, and societal impact of long-term sequelae. • Evaluate approaches to address policy and resource barriers that ensure equitable access as telework expands.
Scientific collaboration	• SARS-CoV-2 sequence was published online in 72 h, setting precedent. • Proliferation of COVID-19 preprints and rapid publications accelerated pace of dissemination. • Community engagement was critical to build trust and mitigation adherence. • Data from multiple sectors and disciplines helped to identify risks and assess mitigation feasibility and effectiveness, including political science, behavioral science, and data science.	• Implement transdisciplinary and convergence research studies. • Pursue research innovation; develop novel methods, such as improving specimen collection or using host genomics to explain health outcomes and responses to treatments and vaccines. • Conduct community participatory research; use tools of collaborative implementation science to enhance public health outcomes. • Facilitate rapid sharing of applied laboratory advances.
Climate science	• Air pollution can aggravate underlying respiratory conditions that lead to more severe COVID-19 outcomes. • Extreme heat, fire, and severe weather complicated COVID-19 mitigation efforts. • New COVID-19 guidance was needed for climate-related emergency response. • Lockdowns and reduced mobility and travel rapidly improved air quality.	• Implement research focused on climate-vulnerable populations. • Leverage predictive analytics to forecast adverse climate effects and intervention needs. • Expand methods and routinely incorporate a climate lens into public health research. • Evaluate effectiveness and impact of interventions designed to mitigate climate change to build evidence base.

Note. SARS-CoV-2 = severe acute respiratory syndrome coronavirus 2; SDOH = social determinants of health.

disease forecasting as a routine part of pandemic planning and response.[15]

As public health strives to keep pace with rapidly advancing technologic innovation, scientists are poised to benefit from advanced data analytic skills, including those for conducting natural language processing and leveraging machine learning and artificial intelligence. Strategic public health science coupled with innovative use of technology could help transform contact tracing methods for the future. Furthermore, development of, building consensus around, and utilization of new and nimble regulatory, legislative, and ethical frameworks for data collection, sharing, quality, and privacy are needed to reduce risks and maximize benefits associated with rapid modernization. Strategic public health science will require expanded scientific methods and analytic approaches for multisectoral data sources, including community SDOH, environmental and climate, genomic and bioinformatics, social media, and geospatial data. As transdisciplinary data scientists increasingly use public health data, public health scientific leadership is needed to establish core method, analytic, ethical, and policy approaches.

COMMUNICATION SCIENCE

The COVID-19 pandemic has called attention to the cultural, structural, and technological barriers that hamper dissemination and acceptance of accurate messages informed by science. Misinformation and disinformation have spread rapidly in social media. Facebook, for example, reported placing warning labels on more than 90 million pieces of content deemed COVID-19 misinformation.[16] COVID-19 misinformation undermined accurate public health messaging; greater exposure to misinformation was associated with lower compliance with mask wearing and social distancing guidelines.[17] Disinformation, defined as deliberately misleading or biased information, has been used to intentionally fuel antiscience views and sentiments, particularly among targeted subpopulations.[18] In addition, the sheer volume of evidence-based information and the speed and frequency with which information evolved made consistent and effective risk communication more challenging and led the World Health Organization (WHO) to declare an "infodemic" around COVID-19 in May 2020.[19] The inconsistency of clear COVID-19 messaging across public-sector authorities at local, national, and global levels further undercut mitigation efforts.

Strategic science can leverage community engagement, behavioral economics, and communications science to study the impact of new technologies and strategies to counter misinformation and antiscience disinformation, including engagement of online influencers and trusted messengers to provide a steady flow of evidence-based information.[20] Research to identify effective interventions can assist both health organizations and social media platforms as they work to counter mis- and disinformation.[21] Planning for strategic dissemination, monitoring audience knowledge and sentiment, and countering misinformation are standard practices for all public health scientists to incorporate into daily practice. Coupled with proactive, consistent messaging that employs sound risk communication principles, strategic science can help rebuild trust in public health.[22–24]

POLICY ANALYSIS AND TRANSLATION

COVID-19 has illuminated the potential of policy as a public health tool and impediment. For example, policy decisions to reduce economic barriers for vaccination and testing increased uptake.[25] COVID-19 has also raised a plethora of multisectoral policy challenges that have an impact on transmission risk, including workplace safety, housing density, and transportation. Inconsistent mitigation policies have hindered the response across sectors and jurisdictions, including mask mandates and restaurant, bar, and other business operating policies. Furthermore, the public has often been confused by inconsistent communications about the importance of mitigation policies. COVID-19 has had numerous collateral and lasting impacts, both at the societal and individual level. Public- and private-sector entities will be confronted with potentially millions of people with long-term cardiovascular, pulmonary, mental health, and neurological sequelae,[26] raising policy needs across health care domains.[27] One success has been the rapid expansion of telehealth[28]; policies to ensure equitable access going forward will be needed.[29]

Assessment of the positive and negative impacts of policies and use of mathematical modeling to predict future impacts are key tools for scientific inquiry. A component of this work will be the identification of the core capacities, policies, and systems needed for preparedness. This includes advance assessment of the epidemiological and ethical implications of policy approaches to distribute resources during public health emergencies. Characterizing overall COVID-19 collateral impacts will be an important research area to inform broader health care policy, starting with assessment and monitoring of the incidence, duration, severity, and societal impact of long-term sequelae. Translational science, which includes both implementation and dissemination approaches and moves knowledge to action by ensuring effective and widespread use of evidence-based policies, can leverage policy analysis and implementation research to accelerate action.[30] For example, policy analysis can be used to identify effective mitigation interventions to support those experiencing long-term impacts, assess SDOH, and achieve widespread impact by applying findings through implementation and dissemination strategies. Success of this policy research will depend on utilization of the strongest designs possible, including both randomized and nonrandomized methods.[12]

SCIENTIFIC COLLABORATION

Within 72 hours of the Chinese and WHO announcement of a novel coronavirus, Chinese researchers shared the full sequence for SARS-CoV-2 online, spurring a global effort toward vaccine and therapeutics development.[31] UNESCO accelerated Open Science efforts with 122 nations[32]; the Open COVID Pledge engaged patent holders and the private sector[33]; and more than 150 scientific institutions and journals reaffirmed their commitment to share data and expand open access during the public health emergency.[34] Peer-review timelines have shortened dramatically for COVID-19 scientific information, with rapid review processes and preprint postings.[35] Dissemination of COVID-19–related information exploded; more than 16 000 scientific publications, including greater than 6000 on preprint servers, were posted in just 4 months. Online and digital technologies supported low-cost and timely remote scientific collaborations.[36] Collaborative scientific innovation on mRNA technology greatly accelerated vaccine development,[37] and scientists in multiple settings worked rapidly to build the evidence base on the effectiveness of masking for both source control and user protection. The pandemic accelerated scientific collaboration and promoted new norms around transparency and sharing.

Sustaining a culture of scientific collaboration positions public health science to be enriched with innovation and cross-sectoral expertise, including with sectors outside of health.[38] Concerted effort by scientists will be needed to implement transdisciplinary and convergence research[39]; advance applied laboratory science; conduct community participatory research; pursue research innovation and develop novel methods, such as transdisciplinary environmental health disparities research[40]; and host transparent genomics studies to explain health outcomes and vaccine response.[41] Creative public health practice and academic linkages as well as transdisciplinary team-based research approaches could help drive innovation going forward, including laboratory advancements.[42,43] Improved laboratory capacities are foundational to enhanced public health science, including not only laboratory quality and safety but also advancements in specimen collection, pathogen inactivation, transport, and rapid characterization; multipathogen and point-of-care assays; and biomarker-based diagnostics. Collaborative sequence-based pathogen surveillance reinforced by a global network of reference laboratories can more swiftly identify new and emerging pathogens. Scientists can improve processes for rapidly posting sequences and early findings to accelerate evidence generation for diagnostics, program implementation, and policy development. Modeling the costs and benefits of reducing chronic disease burden before the next infectious disease outbreak could inform a new paradigm for preparedness. Scientists are poised to continue greater collaboration, which could be enhanced with local, national, and global leadership.

CLIMATE SCIENCE

Health threats from climate change are well-documented,[44] and the interplay between COVID-19 and climate and environmental factors is multifaceted.[40] Environmental determinants of health, including deforestation and increasing human presence in wildlife habitats, have fueled both climate change and emergence of zoonotic infections.[45] Climate change, especially changes in temperature and precipitation, can result in changes in the distribution, seasonality, and prevalence of infectious diseases.[46] Air pollution can aggravate underlying respiratory conditions that lead to more severe COVID-19 outcomes.[47] Extreme weather events, including fires and storms, complicated COVID-19 mitigation efforts[48]; in turn, COVID-19 complicated responses to these disasters.[49] COVID-19 also complicated the ability of local health departments to run climate-relevant congregate facilities, such as cooling centers and disaster shelters.[50,51] Lockdowns and reduced mobility and travel improved air quality, but these positive impacts rapidly eroded as mobility increased again.[52] Our collective response to COVID-19 has been described as "a rapid learning experiment about how to cope with climate change."[53] Indeed, COVID-19 and climate change mitigation share similar policy challenges, including the importance of speedy and decisive action to avoid global financial and public health impact, the difficulties of gaining public support for stringent mitigation policies given politicization of the issues, and the need to address health disparities and counter misinformation.[54]

A strategic public health science agenda creates the opportunity to identify effective approaches for these shared policy challenges. Other key priorities include expanding research on the relationship between climate and health outcomes and emerging pandemic threats and improving surveillance for climate-sensitive pathogens and vectors that identify locations and populations at greatest risk. In addition, use of predictive analytics and forecasting can help build an evidence base for early warning systems and for interventions that effectively counter adverse climate effects, particularly for populations experiencing environmental injustice,[55] such as migrant and refugee populations.[56] Given that climate impacts span across public health, from environmental health to chronic and infectious disease and mental health, an interdisciplinary approach can support scientists to expand methods and demonstrate the value of new mandates to routinely incorporate a climate lens in public health research.[57,58]

A NEW ERA OF PUBLIC HEALTH STRATEGIC SCIENCE

The COVID-19 pandemic and its impacts continue to grow, fueling the imperative to create a new era of public health guided by strategic science. The 6 themes emerging from COVID-19 experience discussed here—health equity science, data science and modernization, communication science, policy analysis and translation, scientific collaboration, and climate science—can help formulate a strategic public health science agenda that accelerates achievement of future public health goals (Box 1). To succeed, public health science should be grounded in scientific integrity and supported by a larger, sustained, well-trained, and innovative workforce. Workforce expansion, diversification, and development will be needed at multiple levels, including for epidemiologists, data scientists, and leadership.[59] This enhanced public health workforce could help break the cycle of panic and neglect that has characterized public health attention and resources for decades.[60] Given the impact of COVID-19, it is possible that public health will remain prominent, especially as vaccination coverage expands, other efforts to reduce community transmission continue, and researchers learn more about COVID-19's long-term effects. Public health leaders and scientists have an unprecedented opportunity to use strategic science to guide and implement a new era of improved and equitable public health. AJPH

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CONFLICTS OF INTEREST

The authors have no potential or actual conflicts of interest with the content presented in this article.

HUMAN PARTICIPANT PROTECTION

This activity did not involve human participant research, was reviewed by CDC, and was conducted consistent with applicable federal law and CDC policy (see, e.g., 45 CFR 46; 21 CFR 56; 42 USC §241(d); 5 USC §552a; 44 USC §3501 et seq.).

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