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Preventing future waves of COVID-19

After seven months of responding to the pandemic, we have learned some things. Here are some of the key lessons and how to apply them.

by Sarun Charumilind, Matt Craven, Jessica Lamb, and Matt Wilson

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When history books one day recount the COVID-19 pandemic of 2020, it may well be a tale of human ingenuity and adaptiveness. Although the novel coronavirus (SARS-CoV-2), the virus that causes COVID-19, has infected more than 24 million people and left more than 800,000 dead as of this writing, the early projections of mortality were much worse.

Fears of millions of deaths by June 2020 have proven wrong—not because the disease is less lethal than anticipated, but because those fears ignored the ability of people to learn and change behaviors. Pockets of resistance against wearing masks and complying with other measures notwithstanding, the global public-health response has saved millions of lives. Increasingly, countries are restarting more aspects of normal life while keeping case numbers tenuously in check.

Yet the threat to lives and livelihoods persists. A COVID-19 vaccine may yet "save the world." But even if one proves effective, it will be many months before we will have the capacity to vaccinate everyone—and there are new concerns about reinfection.[1] Therapeutics such as dexamethasone and remdesivir appear to provide important benefits for those with severe cases but are not alone sufficient to stop deaths from COVID-19. New therapies are possible but by no means guaranteed. Countries will very likely need to plan for almost another year during which public-health measures are their primary tools for saving lives. In the meantime, the world cannot be idle. Societies have been upended, causing unprecedented disruption to economies, education systems, and the day-to-day lives of people everywhere. And as we and others have argued, saving lives and opening societies is a false trade-off.

In that area, too, our ability to learn and adapt is proving dispositive. Countries that have successfully reduced their number of COVID-19 cases have generally been more successful at reopening their economies. For them, controlling the virus ultimately has come down to two things: understanding what to do and executing well. Both have been challenging at various points. For example, the evidence base for the population-wide use of masks only became compelling a few months into the pandemic response. In contrast, the importance of testing has been clear from the earliest days, but many countries have faced operational challenges in ramping up their capacity.

While there is much more to learn, this article summarizes what response leaders have discovered so far about what to do and how to do

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[1] Andrew Joseph, "First Covid-19 reinfection documented in Hong Kong, researchers say," STAT, August 24, 2020, statnews.com.

it. Every jurisdiction is doing some of these things; none of them are new for experts in infectious diseases. But we have tried to describe specific considerations for practitioners looking to adopt and adapt best practices to their management of the COVID-19 pandemic. Given the outsize role that businesses are taking in the crisis response in numerous countries, many of the ideas are as relevant to private-sector leaders as to those in the public sector. Interventions are divided into three categories—detecting disease, reducing the number of new cases, and limiting mortality—and can be tailored for specific populations and settings (Exhibit 1).

Exhibit 1

Interventions are divided into three categories—detecting disease, reducing new cases, and limiting mortality—and tailored for specific situations.

Health interventions to prevent future waves of COVID-19

Detecting disease	Surveillance	Disease surveillance
		Wastewater surveillance
		Cluster analysis
	Testing	Testing (all modalities, including pooled)
Reducing new cases	Identification and isolation	Contact tracing (including tech enabled)
		Quarantine and isolation
	Physical distancing and airflow	General distancing and airflow management
		Limits on social gatherings (including lockdowns)
	Personal protection and hygiene	Facial coverings (masks, shields, and goggles)
		Hand washing and environmental cleaning
	Travel restrictions	Travel bans
		Quarantine, testing, and rapid screening on arrival
	Behavior change	Instillation and sustainment of new public-health behaviors
Limiting mortality	Vaccines and therapies	Supply and access
		Distribution and allocation of supply in jurisdictions
		Demand generation
	Health-system preparedness	Adequate hospital and critical-care capacity
		Maintenance of routine health services
Tailoring interventions	Protecting vulnerable groups and settings	Targeted interventions for in-person work and educational settings and for vulnerable groups (eg, seniors, racial and ethnic minorities, essential-service workers, incarcerated/detained persons)

Detecting disease

The ability to detect cases of COVID-19 is a critical prerequisite for effective public-health programs. A comprehensive program might include traditional disease surveillance, cluster analysis to understand local patterns of transmission, and wastewater surveillance for early warning of disease hot spots.

Disease surveillance

An ability to collect, analyze, and interpret data is fundamental to the management of infectious diseases. While many people have grown familiar with epidemiological metrics such as test-positivity rates and case-fatality ratios, many countries and regions still rely on 20th-century surveillance systems. The biggest gaps are in data collection and integration: there is no shortage of data-crunching horsepower in the world, but everyone is forced to work from the same imperfect data sets. Even seven months into the COVID-19-pandemic response, there is a surprising level of disagreement about questions as basic as the true number of people who have been infected with SARS-CoV-2 and the number of deaths attributable to it. Continuing to expand testing, as described later in this article, is a big part of improving surveillance.

The best surveillance systems seamlessly combine data from traditional sources with newer data sets, such as anonymized mobility tracking—and do so in near real time. They provide a high level of detail and transparency around the characteristics and location of those infected while protecting individual privacy. And they improve over time as a design principle, incorporating new sources of data and improving quality to reduce friction in the response.

Cluster analysis

The medical community has learned much about how COVID-19 is passed from person to person and therefore how to prevent transmission. But there is more to learn about the specific nature of transmission in particular geographies. The examination of chains of infectious-disease transmission, or cluster analysis, helps medical professionals understand how, when, where, and between whom transmission occurs.

Locally relevant information can focus public-health measures on steps that will make a difference and deemphasize those that won't. A study of more than 3,000 cases across 61 clusters in Japan, for example, identified healthcare facilities and retirement centers as among the most important centers of transmission.[2] Similarly, clusters in the United Kingdom have been identified around retirement homes, in hospitals, and in meatpacking factories—the latter also being a source of clusters in Germany.

Cluster analysis has revealed the importance and characteristics of so-called superspreaders (infected individuals who pass the disease to many others). A deeper understanding of transmission dynamics may allow some regions to move from broad-based interventions to targeted ones. It can also allow for more nuanced risk assessments, for example, to determine who can safely access senior-care facilities.

Wastewater surveillance

An important advance in surveillance capabilities came with the discovery that SARS-CoV-2 is present in the stool of infected people and is detectable even in highly diluted samples, such as municipal wastewater. Wastewater sampling, used for decades to monitor for polio, appears to detect viral increases of COVID-19 up to six days earlier than diagnostic tests of individuals do.[3] While a number of locations, including Queensland in Australia, Ashkelon in Israel, and Boise in the United States,[4] are piloting or using this approach to monitor for COVID-19, wastewater remains an underutilized tool globally.

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[2] Yuki Furuse et al., "Clusters of coronavirus disease in communities, Japan, January–April 2020," *Emerging Infectious Diseases*, September 2020, Volume 26, Number 9, pp. 2,176–9, cdc.gov.

[3] Jordan Peccia et al., "SARS-CoV-2 RNA concentrations in primary municipal sewage sludge as a leading indicator of COVID-19 outbreak dynamics," medRxiv, June 12, 2020, medrxiv.org.

[4] AFP and Toi Staff, "Israeli tech firm successfully tracks down COVID-19 in Ashkelon's sewers," Times of Israel, July 30, 2020, timesofisrael.com; Misty Inglet, "Boise city officials work to flush out coronavirus data through continued wastewater testing," KTVB-TV, July 27, 2020, ktvb.com; University of Queensland, "Australian researchers trace sewage for early warning COVID-19 spread," Medical Xpress, April 16, 2020, medicalxpress.com.

The wastewater-surveillance approach is most applicable in low-prevalence settings where an increase in cases is more noticeable and testing of individuals might otherwise be limited. Ideally, public-health leaders would have the ability to work upstream when increases in viral concentration are detected—for example, from testing town sewers to determining which neighborhoods are the source of the virus.

Reducing the number of new cases

Preventing new cases of COVID-19 ultimately requires reducing the opportunity for infected individuals to pass the disease to others. That can be done by identifying and isolating those who have been infected or are at high risk, ensuring physical distance and airflow management, reducing the risk of the encounters that do happen, and reducing case migration from higher-prevalence areas.

The basic tool kit for the reduction of new cases is well understood by experts and nonexperts alike. It includes canceling mass events, restricting capacity in social settings (particularly indoors or with large numbers of people), implementing confinement measures, and restricting internal movement (Exhibit 2). Those measures can be reinforced through effective behavior-change communication and focused implementation for high-risk groups or specific geographies. And since COVID-19 vaccines are likely to be approved eventually, leaders may want to start now in preparing to deploy one effectively. In this section, we highlight some second-order or less appreciated lessons from the pandemic response so far.

Identifying and isolating those infected

Widespread, accurate, efficiently managed testing and contact-tracing programs allow countries to isolate those who have or are at high risk of

Exhibit 2

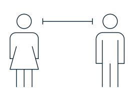
Preventing new cases of COVID-19 ultimately requires reducing the opportunity for infected individuals to pass the disease to others.

How limits on social interactions and gatherings can decrease COVID-19 transmission

Canceling mass events

25%

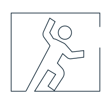
lower transmission by canceling mass events (eg, concerts, sporting events); especially effective for indoor events



Restricting capacity in social settings

30%

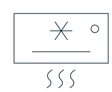
of transmission clusters began in social settings (eg, restaurants, chorus rehearsals, karaoke parties); capacity restrictions can support physical distancing and inhibit transmission



Implementing confinement measures

30%

more cases in US counties without stay-at-home orders after 1 month relative to comparable counties with them



Managing airflow

2–5×

greater air replacement with high-quality filters (eg, those being deployed on New York subways) than recommended air-exchange rates for offices and classrooms; while concerns about transmission on public transportation exist, airflow management can make a significant difference

Source: *Atlantic;* Centers for Disease Control and Prevention; *JAMA*; medRxiv; *Nature; Science*

The best surveillance systems seamlessly combine data from traditional sources with newer data sets, such as anonymized mobility tracking—and do so in near real time.

contracting COVID-19. Testing and tracing have played major roles in the successful response to various phases of the pandemic in a number of countries, including Austria, Iceland, New Zealand, and South Korea.

Despite the apparent simplicity of testing and tracing, practitioners learned the hard way through early missteps. Among their many lessons are the following:

— Communicate clearly with the public about the appropriate uses and limitations of different types of tests, including antigen, molecular, and antibody testing.

— Address supply-chain and logistical challenges to keep expanding testing access until most cases are being detected. Test-positivity rates above 5 percent suggest that too many cases are being missed.

— Make use of pooled testing to boost capacity where needed, especially in low-prevalence settings. Combine testing for surveillance with testing for positive-case identification.

— Accelerate testing turnaround time by ensuring that those performing tests are compensated based on speed and accuracy, not just volume. Accelerate the application of test results by integrating data platforms for testing with those for contact tracing, shortening the time to quarantine.

— Staff enough personnel, as the core of contact-tracing programs is human-to-human conversation. Overinvest in community sensitization to the value of tracing and importance of contact quarantine. Digital contact-tracing tools with high adoption can also accelerate contact identification and shorten the time to quarantine.

— Don't expect contact tracing to work perfectly initially; take a data-centric approach to improving operations and effectiveness over time.

— Recognize that isolating for ten to 14 days is onerous, especially for low-income individuals. Social services and options for out-of-home isolation, such as in converted hotels, can improve the effectiveness of quarantine and make it more tolerable.

Managing risk in encounters between people
COVID-19 is spread primarily from person to person, including from those not showing symptoms, through the air (either on droplets or by truly being airborne). Close proximity and poor airflow increase the risk of transmission, while the use of facial coverings decreases it. Specific considerations for risk reduction vary depending on risk, context, and other conditions.[5]

Limited evidence from US states suggests that mask mandates are correlated with greater reductions in new cases than mask

[5] "Considerations for wearing masks: Help slow the spread of COVID-19," Centers for Disease Control and Prevention, August 7, 2020, cdc.gov.

recommendations are. Different masks offer varying levels of protection. N95 respirators fitted to users provide the greatest protection,[6] protecting both the wearer and those around them. Supply constraints, cost, and user comfort mean that universal N95 use is not practical in many settings. Three-layer surgical masks provide the next greatest protection. Goggles and other eye protection may provide incremental protection to the wearer relative to a mask alone.[7]

Frequent hand washing and environmental cleaning reduce the transmission of COVID-19. However, the relative emphasis on environmental cleaning has decreased, as evidence suggests that transmission primarily occurs from person to person rather than via objects in the environment.

Reducing case migration

Across the world, countries are taking different approaches to restricting importation of COVID-19 cases. They range from complete bans on international travel to targeted bans on travel from locations with high caseloads to screening and quarantine requirements for arriving travelers. In some countries, including Australia and the United States, some of those measures also apply for travel within countries. In many cases, companies and other institutions are implementing their own policies beyond those required by governments. Measures that are based on consistent, easily understood criteria are more likely to maintain high levels of public buy-in and participation.

Changing behaviors

A successful response to the COVID-19 pandemic requires convincing large numbers of people to change their behaviors. Some countries have seen significant resistance to such changes, particularly those around physical-distancing measures and facial-covering mandates. A lack of trust in governments, information overload, and inconsistent messaging over time have all contributed to that opposition. Effective public-health communication can accelerate the adoption of new behaviors.

Effective communication includes segmenting populations based on the combination of channels, influencers, and messages most likely to resonate with individual groups. While there are positive examples from the response to the COVID-19 pandemic, the public-health community could learn more from experts in targeting and tailoring political and consumer-marketing messages. The influence model can help. It suggests that people are most likely to change behaviors when four elements are in place:

— *Understanding and conviction in what is being asked.* “I believe that wearing a face mask will help protect me and my community from COVID-19.”

— *Reinforcement with formal mechanisms, which may include both ‘carrots’ and ‘sticks.’* “The grocery store has both a sign, which I can see as I approach, saying that masks are required and a greeter handing them out.”

— *Confidence and skill building in the new behavior.* “I’ve worn a mask enough times that I’ve stopped worrying about looking silly.”

— *Role modeling the new behavior.* “The mayor of my town and almost everyone around me are wearing masks. Those not doing so look like the exceptions.”

Applying insights from the influence model to COVID-19-related communications is an area in which collaboration might help. Many jurisdictions are enlisting the help of partners, celebrities, and influencers to amplify their messages. For example, in the United States, basketball star Stephen Curry asked questions of infectious-disease expert Anthony Fauci live on Instagram. That served to bring evidence-based public-health information to audiences less likely to access official sources.

[6] “Masks save lives: Duke study confirms which ones work best,” Hartford HealthCare, August 11, 2020, hartfordhealthcare.org.
[7] Derek K. Chu et al., “Physical distancing, face masks, and eye protection to prevent person-to-person transmission of SARS-CoV-2 and COVID-19: A systematic review and meta-analysis,” *Lancet*, June 2020, Volume 395, Number 10,242, pp. 1,973–87, thelancet.com.

Protecting vulnerable populations

The COVID-19 pandemic has a disproportionate impact on a number of vulnerable populations. Such groups include people whose age or health puts them at increased risk and those at greater risk because of socioeconomic factors (Exhibit 3). Communities with severe housing problems, unemployment rates, incarceration rates, poverty levels, and food insecurity suffer 1.4 to 4.0 times as many COVID-19-related deaths as other communities. Vulnerable populations are less likely to have access to healthcare in most countries and are more likely to have underlying health conditions.

In addition to measuring and tracking the impact of the COVID-19 pandemic on vulnerable populations, designing protective interventions requires identifying what makes those groups more vulnerable to infection. Approaches might include prioritizing access to testing, targeting communications, and providing additional support for quarantine and isolation. Interventions will likely need to be multipronged, since the most vulnerable communities are often vulnerable for multiple reasons. Furthermore, the stakeholders best positioned to implement interventions effectively will need resources, which would ideally be allocated proportionately to the outsize impact of COVID-19 infection on vulnerable communities.

Exhibit 3

The COVID-19 pandemic has a disproportionate impact on vulnerable populations.

Vulnerable populations and interventions

	Risk context	Sample interventions
Senior citizens	Senior citizens account for 80% of ~108,000 US COVID-19-related deaths as of June 2020 (29% happen in nursing homes and long-term-care facilities)	In Michigan, regional hubs have been designated to care for seniors from nursing homes without COVID-19-care capabilities
Essential-service workers	Nearly two-thirds of workers earning wages below national median must be in close physical proximity to others to perform jobs	New York State expanded antibody testing and mandated free masks for essential-service workers
Incarcerated or detained persons	All 10 of largest US COVID-19 clusters are correctional facilities; in American jails and prisons, >150,000 people have been infected with and ≥980 have died from COVID-19 as of early-Aug 2020	In Ohio, correctional facilities with largest outbreaks have undertaken mass COVID-19 testing for staff and inmates (including asymptomatic people), and inmates are split into cohorts that don't interact
Racial/ethnic minorities	In America, estimated age-adjusted COVID-19-related mortality rate is 3.8× for Black, 3.2× for American Indian, and 2.5× for Latinx people compared with white people	Various states and localities have set up COVID-19 task forces, such as Boston's, to provide guidance on addressing inequities in data, testing, and healthcare services for communities of color
Additional vulnerable populations	Additional vulnerable populations include people with existing health conditions, people experiencing homelessness, immigrants, rural communities, children and youth, and more	

Source: American Public Media; Brookings Institution; Centers for Disease Control and Prevention; City of Boston; *New York Times;* Ohio Department of Health; State of Michigan; Syracuse.com; McKinsey analysis

Planning for a vaccine

It is reasonable to hope that Emergency Use Authorization (or its equivalent) may be granted to one or more COVID-19-vaccine candidates before the end of 2020.[8] While vaccines will be valuable new tools, their approval will bring a whole new set of questions for leaders.

Planning now will increase the chance of a successful vaccine rollout. Those on point will need to monitor closely the technical characteristics of the most promising vaccine candidates. Such monitoring includes understanding the likely dosing regimen, potential efficacy, and side effects. From there, they will need to develop a clear, scenario-based strategy for prioritizing vaccine access, recognizing the range of potential vaccine outcomes and combinations available.

Every jurisdiction is likely to be vaccine-supply constrained in the short term, so agreeing on grounding principles in advance will make allocation decisions easier down the road. So will designing the end-to-end supply and delivery systems that will be needed. The plan should include systems for ensuring series completion in the case of a multidose vaccine and data systems for tracking those who have been vaccinated. It may include temporarily expanding the roles of medical practitioners—for example, by allowing those with lower levels of qualification to administer vaccines, after training, in uncomplicated cases.

Finally, planners may need to overinvest in addressing vaccine hesitancy in areas where surveys suggest it is a significant concern. Communications around vaccines will be both challenging and important given the likely complexity of information around efficacy, safety, and dosing across multiple vaccine candidates.

Limiting mortality

In addition to limiting case numbers, reducing the mortality associated with COVID-19 is a key element of the fight against the disease. Clinicians and health-system leaders have learned much about both the specific clinical management of COVID-19 and how to prepare health systems to manage surges in cases while maintaining essential services.

Health-system preparedness

In the early days of the COVID-19 pandemic, the world anxiously witnessed many countries' health systems strain under the exponential onslaught of cases. Critical-care capacity was a bottleneck, given that one in five patients, initially, were dependent on ventilators. Healthcare supply chains, especially for personal protective equipment, were overwhelmed.

To create surge capacity, health systems and consumers ceased elective care—seemingly overnight. That resulted in an imbalance of capacity, with overloaded health systems in COVID-19 epicenters transformed into disaster-response hubs. In areas where the disease had not yet spread, care centers sat empty, waiting for an outbreak they were unsure would ever arrive.

We know now that health systems in any developed country should be able to anticipate, plan for, manage, and successfully navigate the pandemic adequately both for patients with COVID-19 and for patients with other diseases. Some require focused action, especially surge capacity, supply availability, workforce readiness, clinical-operations processes, structure for COVID-19-case governance, and financial resiliency.[9]

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[8] Monoclonal antibodies and some drugs also have the potential to prevent COVID-19 cases. Similar principles apply to them, but for simplicity, we refer only to vaccines in this section. China and Russia agencies have also granted conditional use for COVID-19 vaccines in their countries.

[9] Bede Broome, Omar Kattan, Pooja Kumar, and Shubham Singhal, "Reassessing Covid-19 needs: How providers can reexamine their surge capacity, supply availability, workforce readiness, and financial resiliency," *NEJM Catalyst Innovations in Care Delivery*, May 7, 2020, catalyst.nejm.org.

Use of therapeutics and clinical management

The search for effective therapies for COVID-19 has yielded two important advances, so far, but no breakthrough transformative enough to obviate the need to limit cases. Dexamethasone, an injected corticosteroid, was shown to reduce mortality by 35 percent in patients requiring mechanical ventilation and by 18 percent in those requiring oxygen only.[10] Remdesivir has been shown to reduce recovery time by an average of four days.[11]

Both drugs emerged from the medical community's initial focus on repurposing drugs that were already approved or in late-stage development for the treatment of other diseases. The focus is now shifting to new R&D. In the months ahead, additional evidence may support therapies based on other antivirals and monoclonal antibodies. In addition to specific therapeutics for COVID-19, there have been advances in the nonpharmaceutical management of the disease. For example, there is some evidence to support the use of "proning"—placing patients face down—to reduce the need for mechanical ventilation.[12]

Policy makers can continue to keep a close eye on both the evidence for new therapeutics and the standards of clinical practice. Over time and with further advances, strong health systems may succeed in reducing COVID-19-related mortality to the point at which the disease is far less feared.

Public-health measures to control the COVID-19 pandemic will be relevant for as long as its risk continues. Many countries and regions have risen to the challenge by combining multiple public-health measures that work for them, although almost all have some room to improve. As we consider what it will take to respond to current and future waves of COVID-19, we can take some comfort from the fact that far more is known about controlling SARS-CoV-2 than was understood seven months ago. It is up to all of us to learn, adapt, and apply those lessons effectively.

[10] RECOVERY Collaborative Group, "Dexamethasone in hospitalized patients with Covid-19—preliminary report," *New England Journal of Medicine*, July 17, 2020, nejm.org.
[11] John H. Beigel et al., "Remdesivir for the treatment of Covid-19—preliminary report," *New England Journal of Medicine*, May 22, 2020, nejm.org.
[12] "Proning COVID-19 patients reduces need for ventilators," Columbia University, July 2, 2020, cuimc.columbia.edu.

Sarun Charumilind is a partner in McKinsey's Philadelphia office, where **Jessica Lamb** is a partner; **Matt Craven** is a partner in the Silicon Valley office; and **Matt Wilson** is a senior partner in the New York office.

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