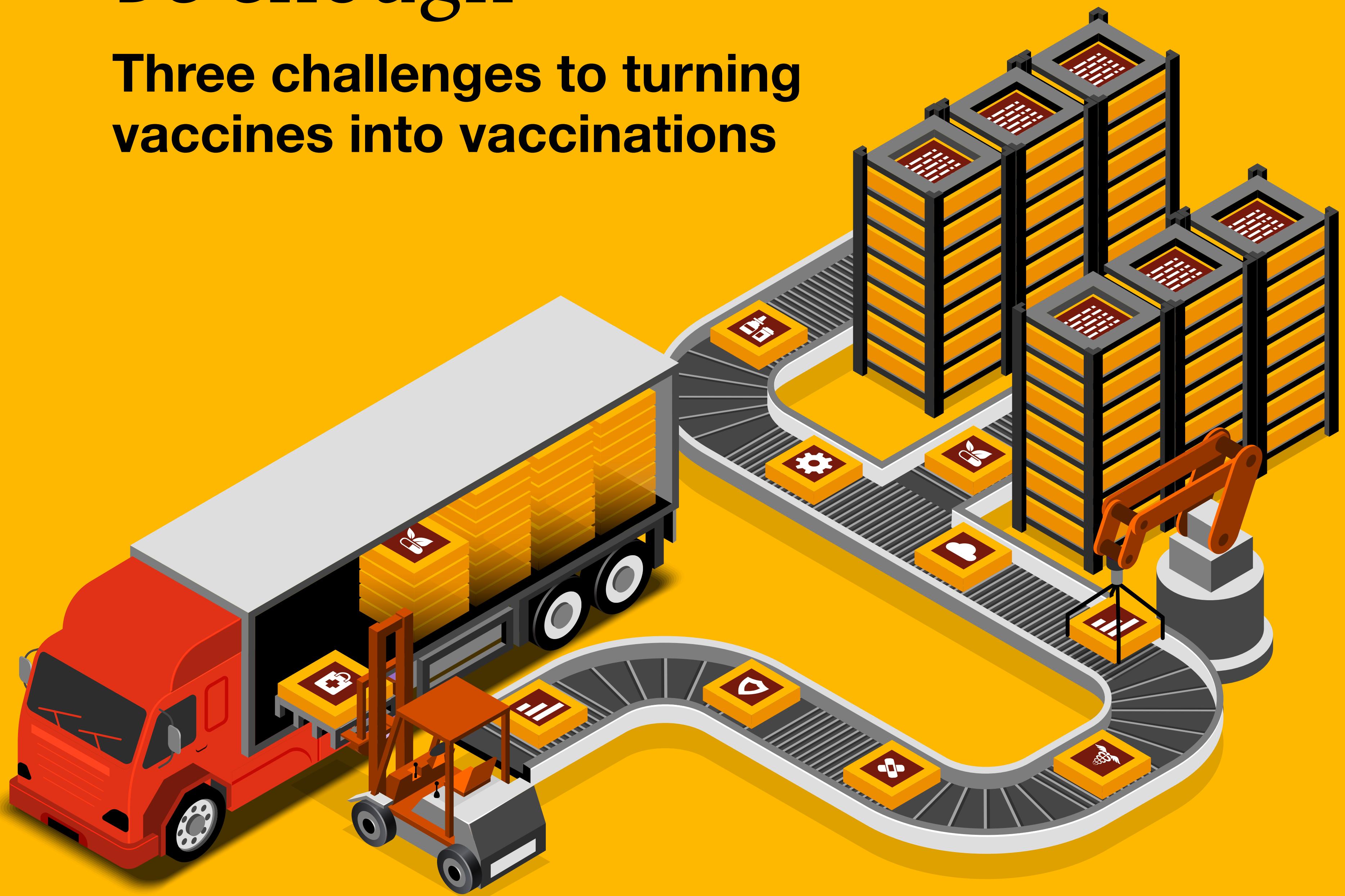


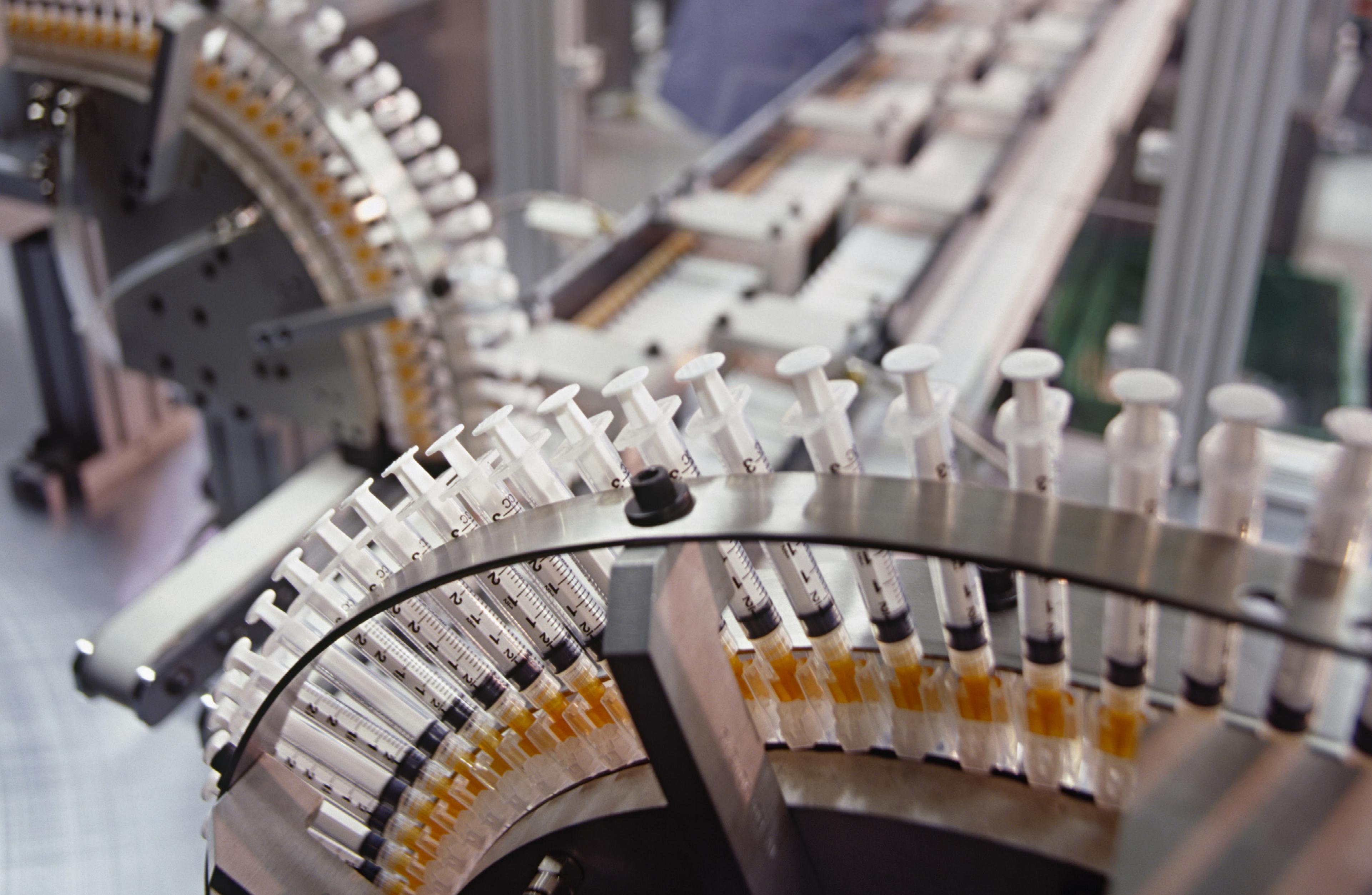
September 2020

PwC Health Research Institute

Developing a COVID-19 vaccine may not be enough

Three challenges to turning vaccines into vaccinations



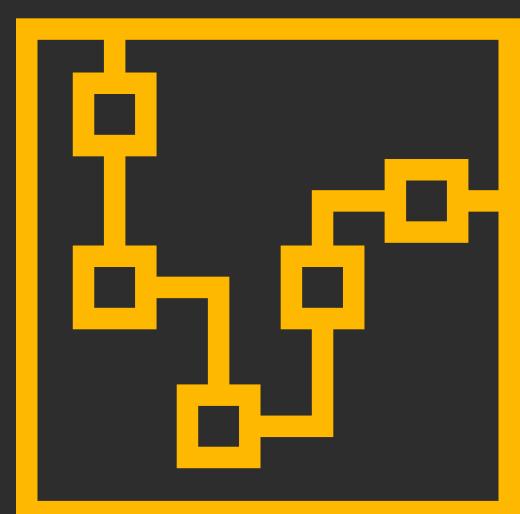


At a glance: COVID-19 vaccines are being developed at a breakneck pace, but a broken supply chain could derail that momentum, stunting the economic recovery and likely increasing the number of lives lost. Nevertheless, there are steps manufacturers and distributors can take to ensure that the medical supply chain is up to the task of quickly turning these vaccines into vaccinations.

As the world struggles to cope with the pandemic, all eyes are on the race for a COVID-19 vaccine to stem the loss of life and the economic woes that have rippled across the globe. Vaccine manufacturers have shattered traditional timelines with innovative new technologies, clinical trial designs and parallel ramp-up of manufacturing, but an arguably bigger challenge awaits: efficiently and equitably distributing a vaccine to over 300 million Americans. The millions of vaccines produced on the most advanced platforms will likely mean little if consumers who need them most cannot get them.

The weaknesses in the United States' fragile and outmoded medical supply chain have been made obvious by the shortages of critical medicines and supplies due to unanticipated demand spikes and breaks in the supply chain from outbreaks of SARS-CoV-2.¹ The pandemic has upended the care delivery model as consumers seek alternative venues for healthcare services to avoid infection at doctors' offices and hospitals, requiring a new way of thinking about mass vaccination.²

While the federal government continues to hash out its vaccine prioritization and distribution strategy, PwC's Health Research Institute (HRI) has identified three factors that could influence on-time delivery and vaccination for COVID-19: the ultra-low transport and storage (cold-chain requirements) temperatures not previously envisioned for vaccines; shifting patient preferences and distancing requirements amid the pandemic; and analytics that do not illuminate a 360-degree supply chain view, predict demand or consider consumer preferences.

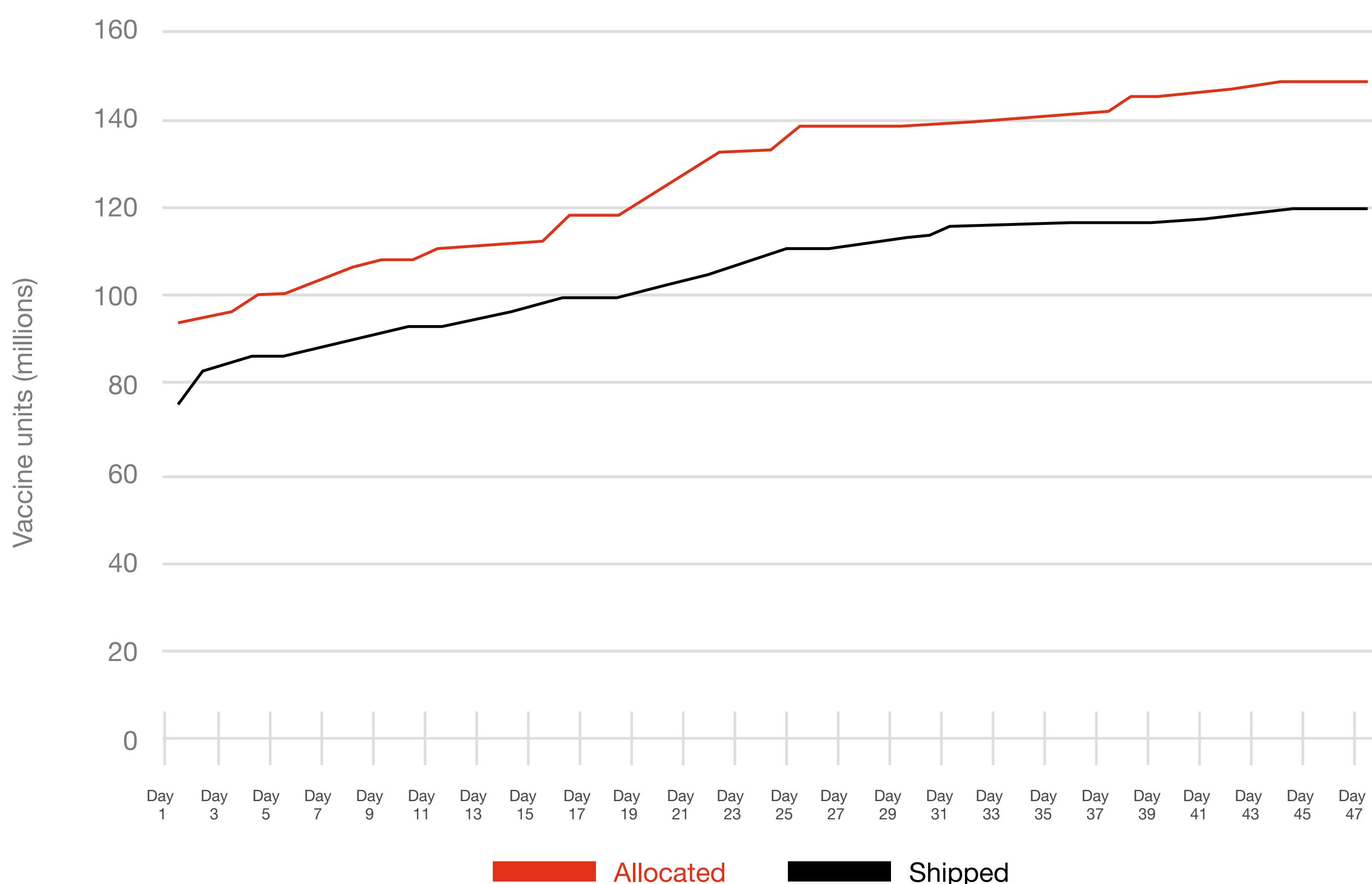


Health industry executives surveyed by HRI in August reinforced these issues, with unprepared infrastructure (30%) and demand exceeding supply (72%) among their concerns.

Health industry executives surveyed by HRI also cited the safety and/or efficacy of potential COVID-19 vaccines (66%) and the lack of transparency on available supply or how to obtain it (66%) among their top concerns. Before vaccines become available, pharmaceutical and life sciences (PLS) companies have opportunities to address those issues and develop a more robust and resilient vaccine supply chain through:

- **The adoption of specialized distribution channels**
- **Consumer-centric vaccination models**
- **Advanced analytics**

Figure 1: H1N1 demand couldn't match supply due to inefficiencies in the supply chain



Source: PwC Health Research Institute analysis of CDC data

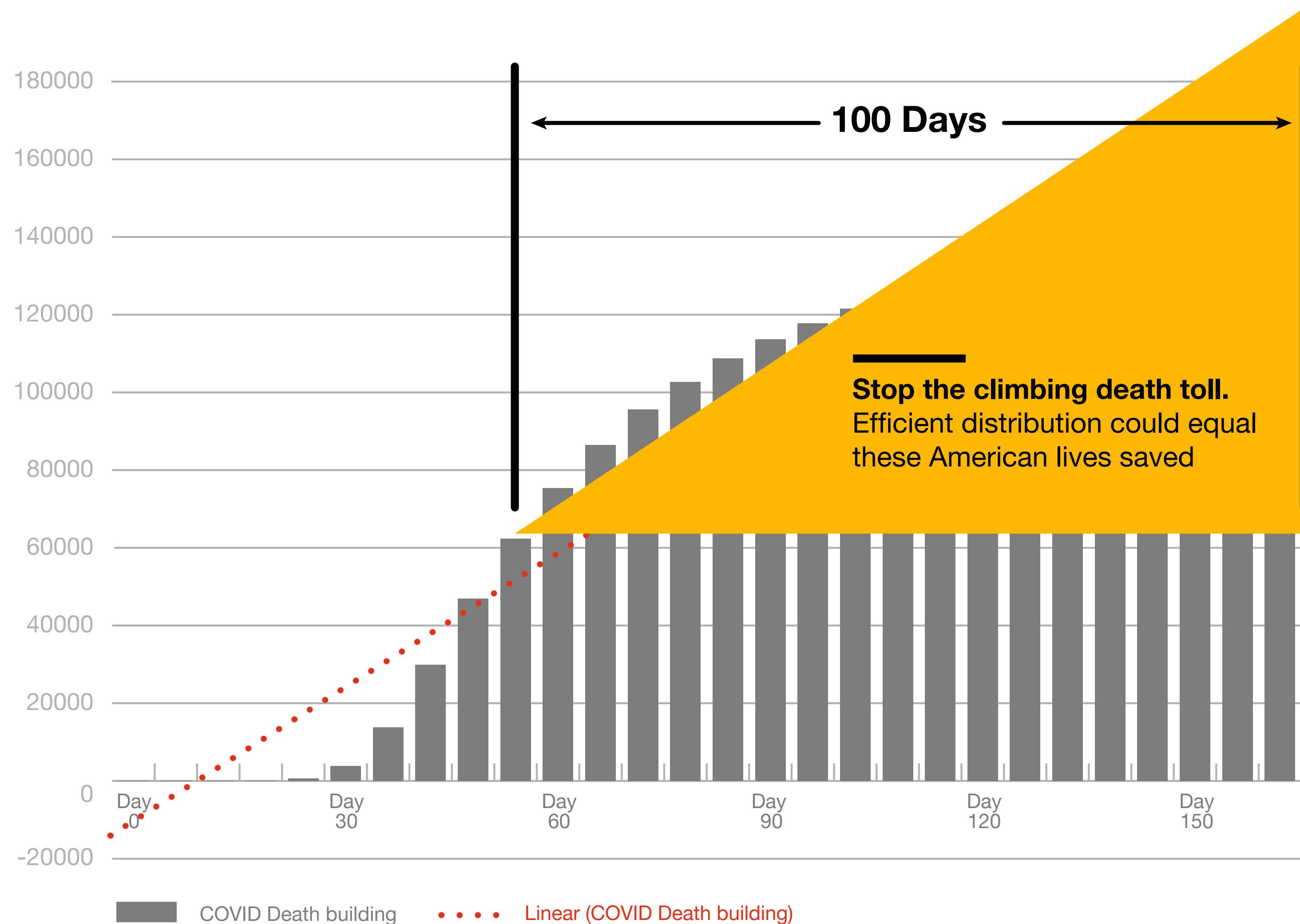
With the 2009-10 H1N1 pandemic response as a guide, in which the US Centers for Disease Control and Prevention (CDC) issued prioritization criteria before the vaccines were available, an analysis by HRI shows that the cost of inaction to shore up the value chain could be severe in terms of lives lost.³ In 2009, the consumer demand for an H1N1 vaccine outstripped the supply because of inefficiencies in the supply chain (see Figure 1). Many doses shipped after demand faded were returned. These mismatches may have delayed the path to effective vaccine coverage.

Supply chains are often measured through key performance indicators (KPIs) like carrying costs, turn ratios and service levels. But the KPI that will matter for COVID-19 will be the lives saved. From mid-March to the end of July, the disease was causing about 1,100 deaths per day, for a total of about 158,000 lives lost. With the progress of months of social distancing, mask wearing and other preventive measures, about 850 Americans per day died of COVID-19 during the second week of August. Pressures to return to workplaces and schools and more people expected to congregate indoors because of cooler weather increase the uncertainty of whether infection and death rates will likely climb.

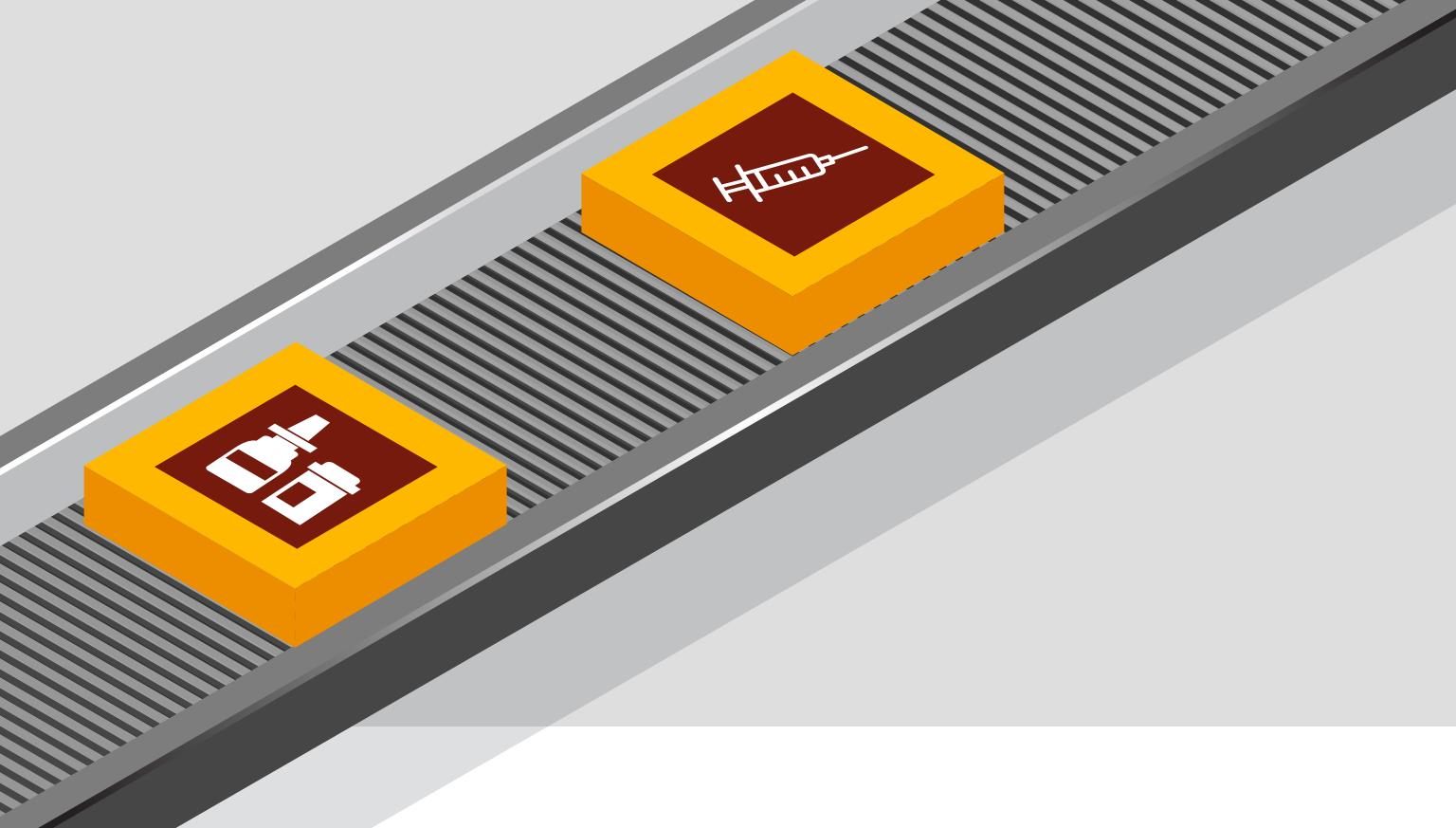
Ideally, COVID-19 vaccines will be available in sufficient supply to distribute without stockout. The vaccination process would likely proceed based on yet-to-be-determined prioritization criteria, with an anticipation for the most vulnerable populations first, such as elderly, immunocompromised and racial minority groups.⁴ The criteria would be expanded as more doses of the vaccine become available to eventually encompass the general population, with herd immunity as the goal. For COVID-19, vaccines for about 230 million people, or 460 million doses assuming two doses per person, would be required to attain herd immunity in the US. HRI modeled the consequence of an inefficient vaccine supply chain with H1N1 as a reference (see Figure 2). Based on the supply and shipped schedules from H1N1, herd immunity could have been achieved in 237 days, according to available finished products under ideal conditions. However, inefficiencies in ordering, local demand spikes and other supply chain failures resulted in lower-than-available shipping rates, delaying herd immunity by almost 100 days.⁵

If COVID-19 vaccine distribution faces the same challenges, tens of thousands of Americans could die during those 100 days.

Figure 2: COVID-19 excess death reduction forecast: “Perfect” supply and demand distribution



Sources: PwC Health Research Institute analysis of Johns Hopkins, CDC data



Glacial temperatures at historical speed: Creating a nationwide network of mini-Antarcticas

While vaccines typically require similar transport and storage parameters, at least one of the most advanced candidate vaccines being developed to address the COVID-19 pandemic is built with a new nucleic acid-based technology—mRNA—that likely will require ultra-low storage temperatures during transport (see Figure 3).⁶

Figure 3: Handling, dosing requirements for COVID-19 vaccine candidates

Vaccine candidate	Special handling requirements	Number of doses	Dosing schedule	Vaccinator instructions
Candidate A	2 to 8 degrees Celsius	2	3 weeks	Intramuscular
Candidate B	Stable at room temperature	2	4 weeks	Intradermal
Candidate C	Refrigerated to room	2	4 weeks	Intramuscular
Candidate D	-20 degrees Celsius	2	4 weeks	Intramuscular
Candidate E	-80 to -70 degrees Celsius	2	3 weeks	Intramuscular
Candidate F	2 to 8 degrees Celsius	2	3 weeks	Intramuscular
Candidate G	Refrigerated to room	2	2 weeks	Intramuscular

Sources: PwC Health Research Institute analysis of ClinicalTrials.gov, Company websites



The CDC has established a pandemic distribution framework that the center says could be used by distributors to deploy 900 million doses of vaccine in a pandemic. However, the plan does not specify a timeline and is based on influenza vaccines that do not require such highly specialized transport and cold chains that are required of at least one of the vaccine candidates in late-stage testing.⁷ Specifically, the instructions on the CDC's pandemic vaccine website for storage and handling allow for temperatures down to -57 degrees Celsius, with anything below -50 degrees considered "too cold."⁸

At least one of the mRNA vaccines is expected to require storage at temperatures of -80 degrees Celsius. Manufacturers of these vaccines may have to find specialized transport and storage channels that could effectively manage the lower temperatures. "If the vaccine is stored frozen, it creates a big challenge. Then there have to be those kinds of facilities set up well in advance," Brent MacGregor, co-chair of the Alliance for Biosecurity and board member of Dynavax Technologies, told HRI.

But manufacturers may not have to build these from the ground up. Cell and gene therapies have similar ultra-low temperature requirements for transport and storage.⁹ For example, the spinal muscular atrophy gene therapy Zolgensma is shipped and delivered frozen at less than -60 degrees Celsius.¹⁰ Luxturna, approved to treat a rare retinal disorder that can lead to blindness, must be kept below -65 degrees.¹¹ The therapies are delivered to the site in dry vapor liquid nitrogen shipping containers known as dewars, which can keep the samples frozen for over 10 days.¹²

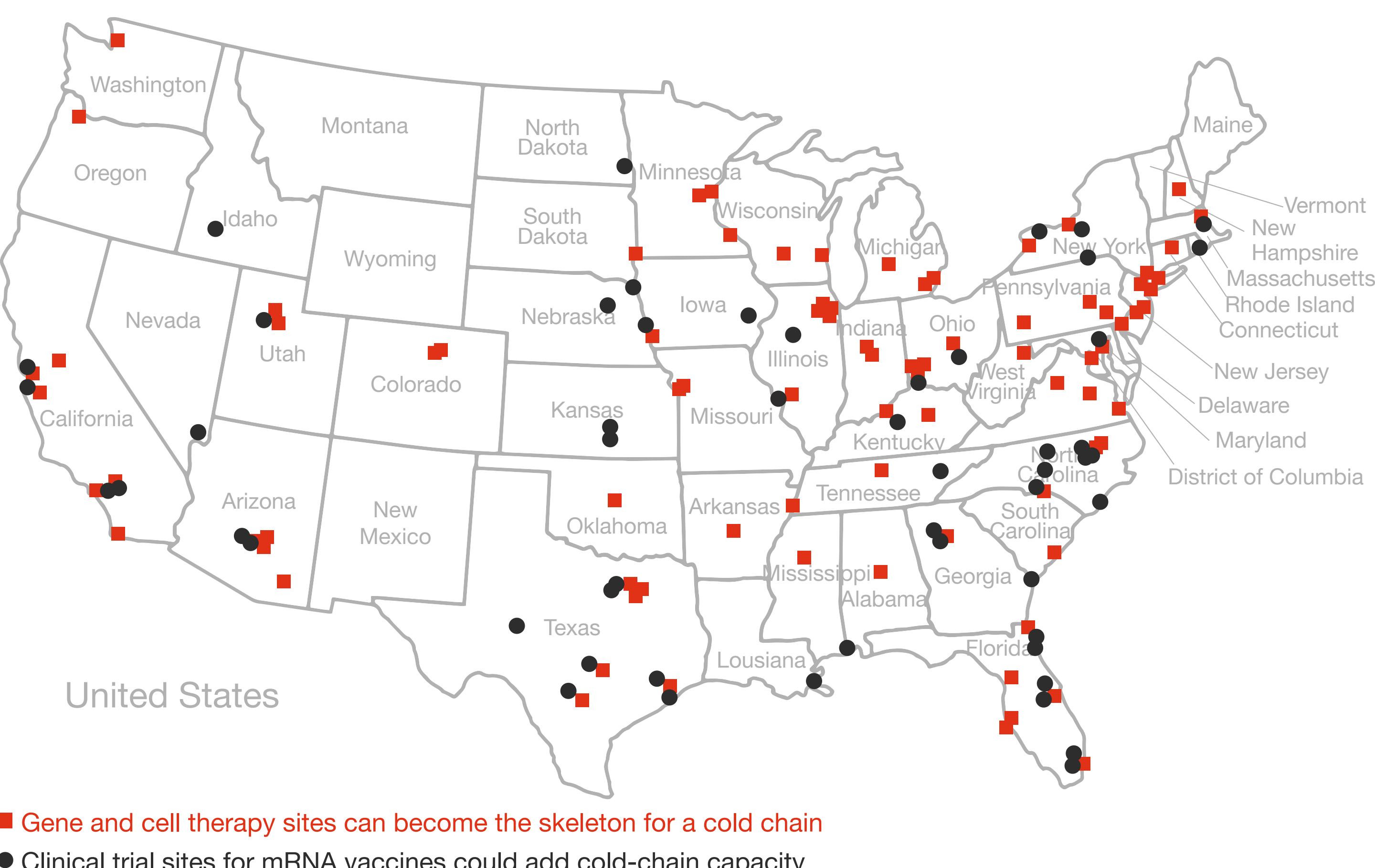
One vaccine manufacturer has said it has temperature-controlled containers that allow it to maintain the low temperatures for up to 10 days.¹³

The channels already in place for cold transport of these therapies, along with the three other cell and gene therapies approved in the US, are likely not at the scale needed for COVID-19 vaccine distribution given the small populations served. For example, as of March 24, Novartis had distributed 335 doses of Zolgensma. There are about 10,000 to 25,000 Americans estimated to have spinal muscular atrophy.¹⁴

According to reports, President Donald Trump's Operation Warp Speed program for COVID-19 vaccines calls for companies and distributors to be ready to distribute a vaccine by Nov. 1. Vaccine manufacturers and distributors can build that scale with gene therapy channels as a skeleton ahead of the deadline.

An analysis by HRI shows that 36 states have sites that receive, store and administer cell and gene therapies. Additionally, the manufacturers of mRNA vaccine candidates also have successfully deployed these products to clinical trial sites across the US. While many of these trial sites are in the same state as the cell and gene therapy sites, HRI identified clinical trial sites for mRNA vaccines in five additional states where there are no cell or gene therapy treatment locations, meaning that at least 41 states have some ultra-low temperature cold chain capacity for biologic products (see Figure 4)

Figure 4: Gene therapy centers, mRNA trial sites as a skeleton for cold chain distribution



Source: PwC Health Research Institute analysis of company websites, ClinicalTrials.gov as of August 10, 2020



These cold chain supply lines could serve as vaccine hubs from which last-mile carriers can take the vaccine the remainder of the route. Many are located in areas with large populations, meaning that most of the skeleton for a vaccine cold chain is in place for the majority of Americans who might need a vaccine. The white space is in more rural areas where additional investment to build cold chain facilities can be targeted, particularly in the states where cold chain sites are lacking.

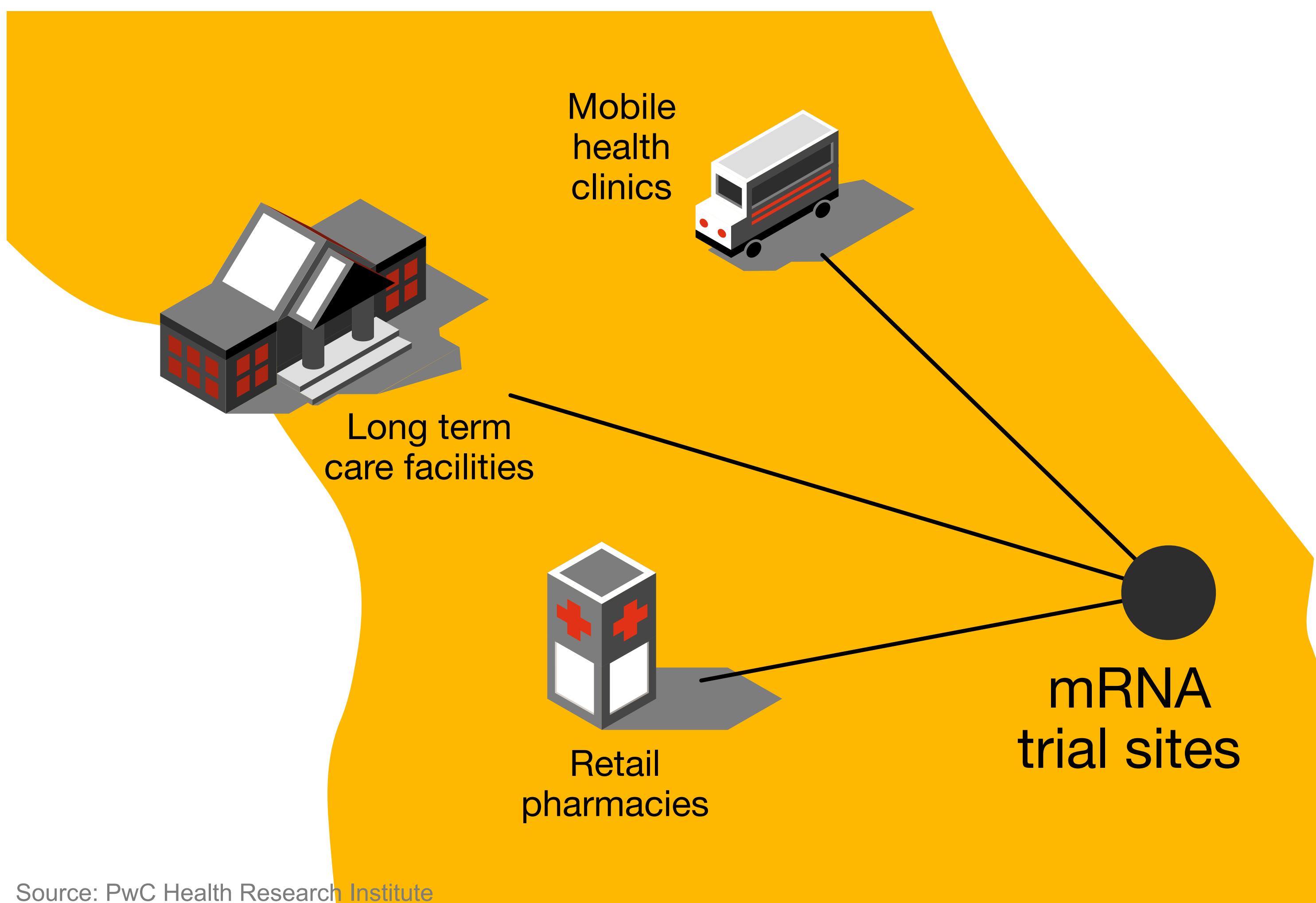
The CDC has asked four states and one city to draft vaccine distribution plans, which suggests that manufacturers will likely have to work closely with state and county public health officials to deploy vaccines from these cold storage hubs to vaccination sites.¹⁵

The CDC announced on Aug. 14 that McKesson would distribute the COVID-19 vaccine. McKesson distributes up to 150 million doses of vaccines each year.¹⁶ In 2018, it partnered with Cryoport to provide cold chain support and real-time monitoring for temperature-sensitive biologics, including cell and gene therapies.¹⁷

On the distributor's Aug. 3 quarterly earnings call, Britt Vitalone, executive vice president and chief financial officer, said that McKesson has been in discussions with all of the most advanced vaccine manufacturers about distribution. "We're in active dialogue with everybody," he said. "Our first and foremost goal will be to do whatever we can do to help accelerate getting a vaccine to market."¹⁸

COVID-19 vaccine implications: Manufacturers can build upon existing cold chain supply frameworks, such as those in place for gene therapies and clinical trial sites, to establish specialized distribution networks for novel vaccine technologies. These could include metro hubs where there is sufficient diversity in consumer demographics, such as elderly and racial minority groups who are at the highest risk of mortality (see Figure 5).

Figure 5: How existing gene therapy centers, mRNA trial sites could serve as hubs for last mile vaccine delivery



The model will have to account for the demand pull with a center for immunization as well as mobile units that branch out from the center or elsewhere to target these more discrete locations where high-priority individuals are located.

Specifically, an outsize majority of the deaths in the US have occurred in long-term care facilities, suggesting that residents and staff at these facilities could be among the first priority groups.¹⁹

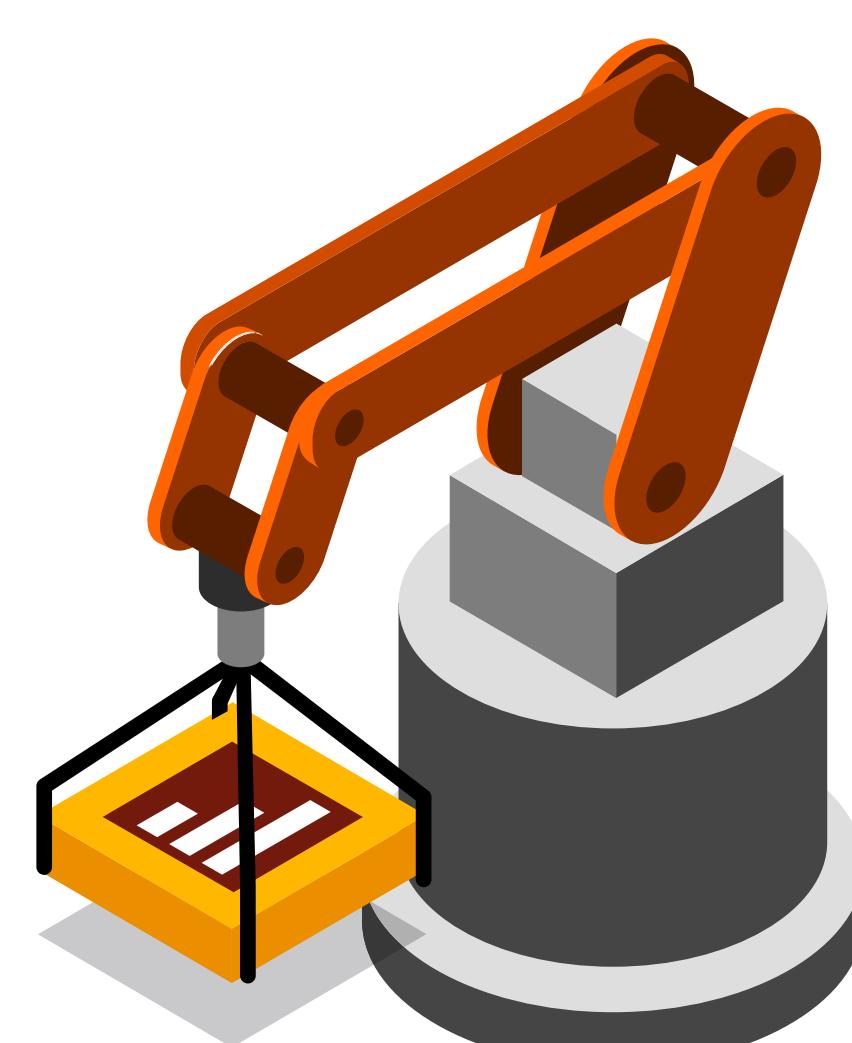
According to the CDC, as of 2016, there were 15,600 nursing facilities in the US and about 1.3 million residents as of 2015.²⁰ More than 70% of these facilities are located in a metropolitan area (more than 50,000 people in an urban area) and over one-third of these facilities, excluding residential care communities, are in the South.²¹

The CDC also found that while non-Hispanic white individuals made up over 70% of the population in these facilities in 2016, Hispanic and Black individuals accounted for 22.7% and 15.4% of users, respectively, at adult day service centers. Black people also accounted for about 13% of users of home health agencies and 14.3% of nursing home users. Black and Hispanic individuals have also been at greater risk of mortality from COVID-19.²²

With the help of the federal and state governments, nongovernmental organizations and industry investment, vaccine companies have already ramped up manufacturing before knowing whether the Phase III trials of their candidates will be successful. They may have to assume additional risk as they continue to build out the cold storage distribution chain in advance of final results, but the risk could be mitigated through partnerships with traditional distributors that are already building their cold chain capabilities in response to cell and gene therapies. They can also forge partnerships with other experienced cold chain providers (see Sidebar 1), such as packaging and transportation companies, to help ensure consistent delivery of quality products along the vaccine value chain to the consumer.

Implications for the broader supply chain: While vaccines are ramping up in parallel, many of these changes can be used for massive therapeutic distribution as the platforms mature. Specialized therapies such as mRNA vaccines and gene therapies are expected to increase. Manufacturers that invest in partnerships and infrastructure to support the efficient deployment of COVID-19 mRNA vaccines will likely be able to launch new cell and gene therapies or mRNA products more rapidly in the future. The challenges with putting this infrastructure in place could also drive companies to develop more stable generations of these technologies, further speeding patient access to treatments and vaccines.

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Vaccination 2.0: Getting the last mile right will require consumer-centric vaccination models

The vaccination itself is perhaps the most critical step in the last leg of the journey for a vaccine to meet its goal of allaying disease transmission. For COVID-19, the challenges in the last mile could come down to manufacturers' ability to effectively address shifting consumer care patterns and social determinants of health.

Vaccination is likely to occur in waves as the federal and state governments make decisions about which groups should be highest priority and how the criteria for vaccine recipients are broadened as more doses become available. As the funnel of prioritized individuals widens, consumer preferences could become a major factor to ensure vaccine uptake and minimize concerns over vaccine hesitancy or pandemic fatigue, the latter of which could make individuals more complacent with the notion that the pandemic is now just a part of their lives.

An August survey of Americans by Gallup found that 35% of respondents said they would not get an FDA-approved vaccine; the question did not specify a time range for obtaining a vaccine.²³

HRI's consumer research over the past several years shows that different consumers have different preferences for the site of care based on multiple factors, including medical condition, demographics and socioeconomic status.²⁴ Moreover, the COVID-19 pandemic has accelerated the shift in consumer preferences for their site of care, and social distancing requirements along with other infection control measures could translate into people seeking new venues for seasonal vaccinations.²⁵ For example, HRI estimates that about 25 million Americans went to a retail clinic or urgent care center for the first time during the pandemic through May (see Figure 6).

Figure 6: Vaccination locales may need to address consumers' shift to alternative care settings brought on by the pandemic

Had you or a family member ever received healthcare treatment in any of the following settings or ways?

Percentage of new users during COVID-19 pandemic

At home, do-it-yourself (DIY) care



Urgent care clinic



Retail clinic



Free standing ER



0% 1% 2% 3% 4%

Source: PwC Health Research Institute COVID-19 Consumer Survey, April 2-8, 2020

Amid the pandemic, retail pharmacies, community churches and other centralized locations have become diagnostic testing hubs, offering drive-through services where people in some cases have even self-administered the test to minimize transmission of SARS-CoV-2.²⁶

CVS, Kroger, Rite Aid, Walgreens and Walmart offer testing at a total of more than 2,200 locations.²⁷

It may be critical to keep people who want the vaccine from using the acute care setting or the clinic, where there could be opportunities for exposure to the virus. Instead, manufacturers may have to work with other providers to vaccinate people in a place with a more controlled environment, including possibly in the home or through mobile clinics (see Sidebar 2).

Many essential businesses, such as grocery stores, factories and restaurants, established social distancing protocols and other measures such as alternating work schedules to avoid the risk of exposure to the virus, making them potential vaccination sites for employees.²⁸ “Essential businesses that

have remained open during the pandemic have put systems in place to keep employees safe. Why not use those establishments as vaccination sites with traveling nurses or partnerships with retail pharmacies?" Mark Twyman, vice president, commercial, at Inovio Pharmaceuticals, told HRI. Inovio has a COVID-19 vaccine candidate in clinical testing.

Worksite vaccination clinics were among the steps that health industry executives said they were taking in preparation for COVID-19 vaccines. According to HRI's executive survey, 37% of provider executives and 27% of pharmaceutical executives said they were establishing on- or near- worksite clinics while 57% of provider executives and 47% of pharmaceutical executives said they were training or educating their staff (see Figure 7). Diagnostic companies such as LabCorp and Quest could also be tapped as potential partners for employer-based vaccination programs. The testing companies have nurses on staff that do in-home assessments.

Figure 7: Healthcare executives are also prioritizing vaccination through worksite clinics, staff education

If a COVID-19 vaccine becomes available, what is your organization doing to prepare for it?

Training or educating staff



Dedicating space for administration of the vaccine to patients



Coordinating with partners upstream or downstream in the supply chain



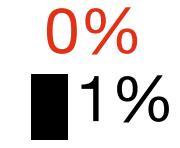
Establishing on- or near- worksite vaccination clinics



We do not have plan to prepare for it



I don't know



Providers

Pharmaceutical and life science executives

Source: PwC Health Research Institute Cross-sector Executive Survey, August-September 2020

Drive-through testing has had mixed success, with reports of extended wait times and supply challenges, but vaccine manufacturers and providers could improve upon this framework, perhaps taking a page from fast food restaurants, which offer multiple lines and surge staffing during busier hours.²⁹

The high transmissibility of SARS-CoV-2 also means that scheduling vaccinations is a likely scenario, particularly in retail settings. Pharmacies such as CVS and Walgreens quickly spun up scheduling apps for individuals to reserve a spot for a test.³⁰ Other startups are also emerging to provide scheduled, rapid testing such as Innovative Express Care in Chicago. The same tools could be used to schedule vaccinations at retail pharmacies, in the workplace or elsewhere.

Frail elderly who are also at a higher-risk for mortality from COVID-19 tend to seek care via a different avenue, in home, according to HRI's 2020 Consumer Survey. The survey found that 11.6% of frail elderly respondents said that they used in-home care for wellness visits before the pandemic, compared with 4.1% of individuals with a chronic condition and 3.8% with mental health conditions.

Mobile providers, such as DispatchHealth and Heal, which deliver medical care to patients in their homes, could be a source for vaccinators of frail elderly people.³¹

More testing sites and different vaccine technologies with different dosing schedules will likely require more trained vaccinators. "We should be training up as many people as possible to make access as wide as possible," Dynavax's MacGregor told HRI.

While the pool of vaccinators is likely to include pharmacists, doctors and nurses, the rules around who is permitted to administer vaccines vary by state. Other cohorts of individuals can also be trained in advance, such as veterinarians and medical, nursing and pharmacy school students, but waivers may be needed to enable that process. CMS issued a waiver earlier this year to allow pharmacists to test consumers for COVID-19. And in August, HHS permitted pharmacists in all 50 states to give pediatric vaccinations (children ages 3 to 18), preempting restrictions in 22 states.³² Hospitals or other sites of care may need to add access privileges for some of these nontraditional vaccinators.

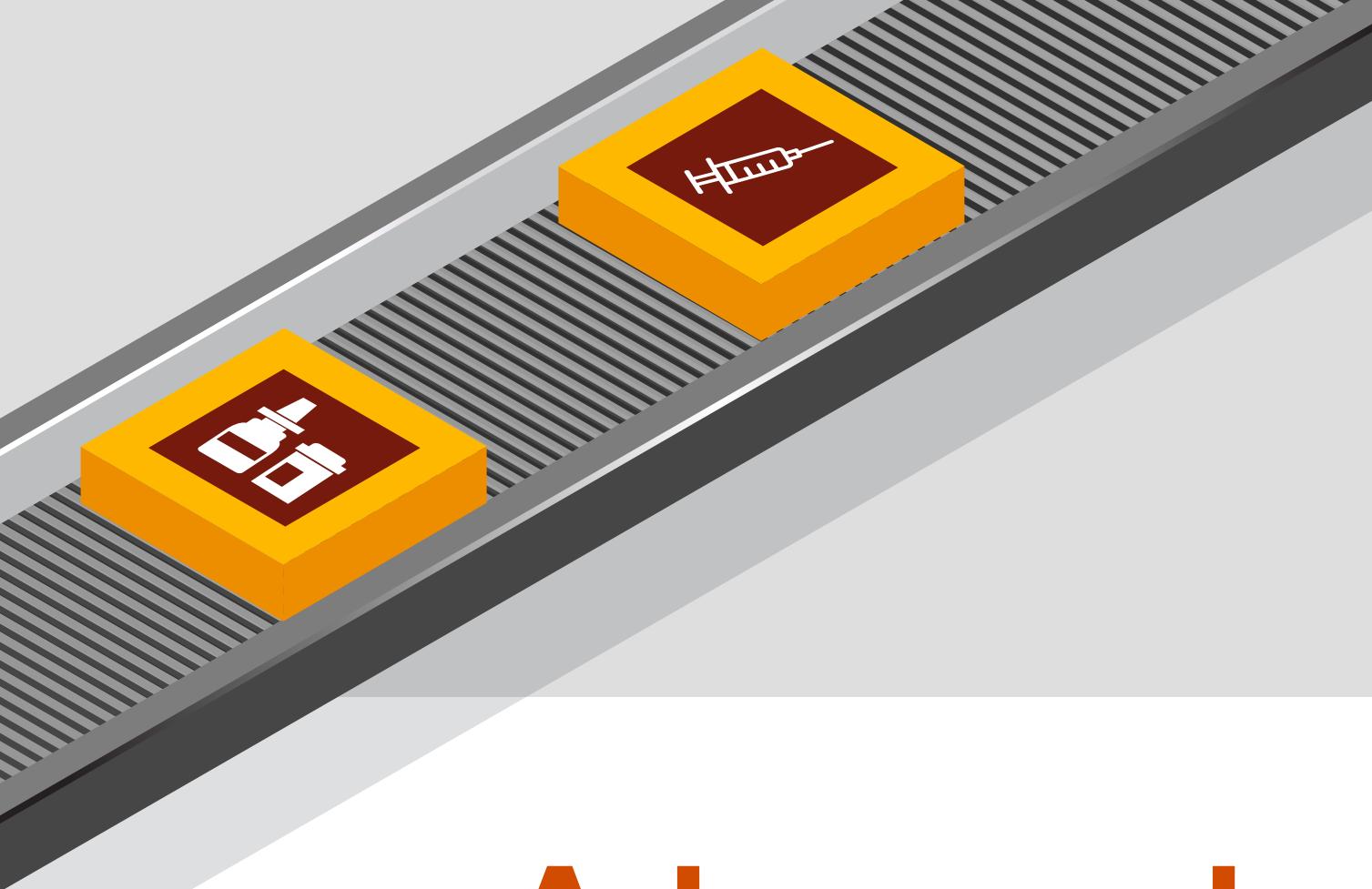
COVID-19 vaccine implications: Vaccination may not be a one-size-fits-all model. Manufacturers should hone their delivery models to account for segmentation of consumers and work with stakeholders such as distributors, pharmacists, employers and other traditional as well as nontraditional vaccinators to match vaccination sites to consumers' preferences. The need to engage with all stakeholders is paramount, as HRI's research has found that no one entity has the data to meet consumer needs and expectations.³³



If they are successful, the process should be more convenient for consumers, enabling greater compliance with follow-up booster shots and ensuring that a greater proportion of the population, particularly vulnerable groups, has access to a vaccine.

Through segmentation of consumers, pharmaceutical and life sciences companies could forge collaborations with entities such as mobile care providers and organizations like the American Medical Association (AMA). Groups such as the AMA could help develop training materials or videos that educate vaccinators as well as patients about the different dosing regimens, delivery modes, side effects and other relevant factors for each of the vaccines.

Implications for the broader supply chain: New patient-centric delivery models developed for vaccines could be built out to address other population health issues such as diabetes and heart disease, increasing the ability to match the patient to the right treatment, improve adherence and ensure that patients who need a medicine get it. Additionally, delivery models that improve vaccine uptake among minority groups and vulnerable populations could be extended to chronic conditions and better address the social determinants of health in the future. Manufacturers that start to build new networks and collaborations to meet consumers where they live and work should be better equipped to effectively deliver medicines to patients of all socioeconomic and demographic segments in the future.



Advanced analytics: Connecting the dots between distributors, vaccinators and consumers

Advanced analytics underpin the ability of a complex web of stakeholders—manufacturers, distributors, providers, pharmacists, public health officers and others—to deploy vaccines via specialized distribution networks and get them to consumers at the right time and in the right place.

Some drug and device companies have deployed analytics to drive commercial improvements.³⁴ Other industries have successfully used advanced analytics to improve business outcomes and meet consumer needs. For example, Delta Air Lines used real-time performance monitoring to reduce mechanical problems resulting in flight delays and cancellations. The technology allowed the airline to avoid 2,000 cancellations in 2018.³⁵

Without real-time performance monitoring of supply chain, distribution and administration for vaccines, the products may not make it from the warehouse to the storage facility on time, or providers, and subsequently consumers, could be waiting for a shipment without realizing it has been delayed or is still sitting in the warehouse.

The global not-for-profit Gavi, the Vaccine Alliance, invests in vaccine development and administration in developing countries. The group has invested in cold chain infrastructure, such as solar-powered refrigeration vehicles, as well as analytics. Under a 2017 partnership with Google, Gavi helped startup Nexleaf Analytics to develop a cloud-based analytics platform that monitors cold chain performance in real time. The system tracks temperature data when vaccines are transported and stored, and provides the data to the health worker and the government.³⁶

Analytics will also be important for determining which vaccines should not be stored at ultra-low temperatures. For example, vaccines that contain alum as an adjuvant could be damaged if stored at the same ultra-low temperatures required for mRNA vaccines. “There are vaccines that will require deep freezing, and there are those that will be destroyed by deep freezing. These need to be clearly maintained and identified throughout the supply chain,” Marie-Liesse Le Corfec, global portfolio marketing head, prefilled systems, at Becton Dickinson (BD), told HRI.



Food logistics providers have also developed real-time temperature monitoring that has allowed producers to improve margins while maintaining supply.³⁷

Pharmaceutical and life sciences companies can use technologies similar to those implemented by Gavi and others to monitor the progress of vaccines in the shipping process and predict when they will get from the manufacturing facility to the warehouse and then to the vaccination site. This could also provide transparency for distributors and vaccination sites.

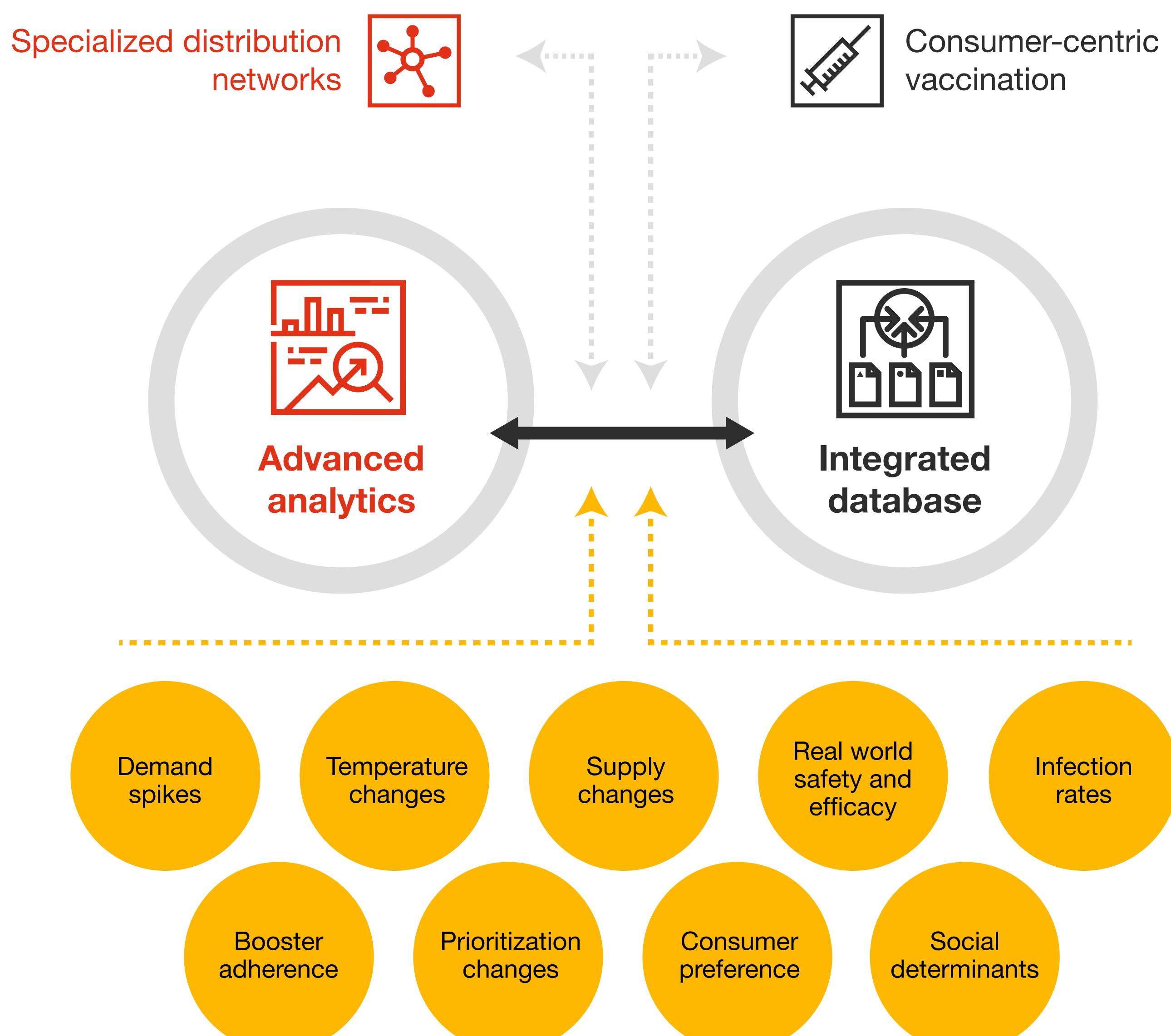
Logistics planning software tools are available for a variety of industries, including pharmaceuticals, to perform network optimization. Even if manufacturers are using existing facilities, network optimization tools can help them configure a new supply chain that takes the different handling and storage requirements into consideration, helping them to plan and identify the appropriate routes of delivery.

For example, AnyLogic allows the simulation of trucks, trains and other parts of the supply chain to understand the appropriate routes and how to plan even under various uncertainties, such as where the vaccine priority areas might be and how they might change.³⁸ It could also allow manufacturers and distributors to model or forecast where vaccine allocation could have the greatest impact or predict the optimal number of vaccination sites in a given area.

Simulations can be targeted to specific needs such as cost savings or speed of service. The latter is more relevant for vaccine distribution, and modeling this out will likely be a critical factor as customer segmentation changes during each phase of the vaccination campaign.³⁹

The analytics would also link the vaccine availability and shipping information with the information on the ancillary supplies needed to actually perform the vaccination. “For every syringe and needle that you would need to match up with one vaccine dose, you will likely need other ancillary products like alcohol swabs, masks, sharps containers,” Chee Lum, vice president and medication delivery platform leader at BD, told HRI (see Figure 8).

Figure 8: COVID-19 advanced analytics underpins specialized distribution, consumer-centric vaccination



Source: PwC Health Research Institute

Unit-level tracking for pharmaceuticals exists. UPS has tested radio frequency identification (RFID) chips to track its on-time performance. In a pilot with seven customers, the company saw a “full percentage point improvement on our on-time performance,” CEO Wes Wheeler said on a March podcast.⁴⁰

But the analytics required for vaccine tracking and tracing would not need to be at the unit level. “You can scale it to the packaging. If you get 1,000 pallets, you can track the pallets and get a real-time read on where they are throughout the US,” Lum said.

Similarly, many retail outlets have started to harness advanced analytics for consumers that could be deployed in the coming months to ensure that pharmacies and retail outlets have enough vaccine supply on hand to meet demands. Walmart has used advanced analytics to identify customer preferences and shopping patterns to segment customers and understand their buying patterns.⁴¹

With COVID-19 vaccines, pharmaceutical and life sciences manufacturers, distributors and healthcare providers can use tools that forecast vaccine demand to the ZIP code level. These tools could integrate health, socioeconomic and demographic information to understand who is most likely to benefit from a vaccine based on their current health profile. They can also allow distributors to manage distribution in a more dynamic way to follow where the demand is emerging.

To understand who is eligible for a vaccine as the prioritization criteria broaden, advanced analytic tools could estimate demand based on factors such as whether they have used vaccines in the past, the side effect concerns they may have and whether they are the first among their peer group to take a new vaccine.

Analytics required for vaccine tracking and tracing would not need to be at the unit level. “You can scale it to the packaging. If you get 1,000 pallets, you can track the pallets and get a real-time read on where they are throughout the US.”



Providers and payers have begun using these analytic tools to better predict where new COVID-19 cases could soon surge and help to plan and manage personnel, ICU bed capacity and other care delivery logistics.⁴² A Dallas not-for-profit, Parkland Center for Clinical Innovation, built a system that tracks comorbidity, age, social factors and the ability to observe stay-at-home measures to help hospitals tailor their response to specific neighborhoods.⁴³ In Chicago, CommonSpirit Health used deidentified cellphone data along with public health data and relaxed social distancing criteria to predict COVID-19 surges.⁴⁴

Other hospital systems have developed dashboards to provide seven-day and four-month predictions at the state and county levels based on infection data from the World Health Organization, Johns Hopkins University and other sources.⁴⁵



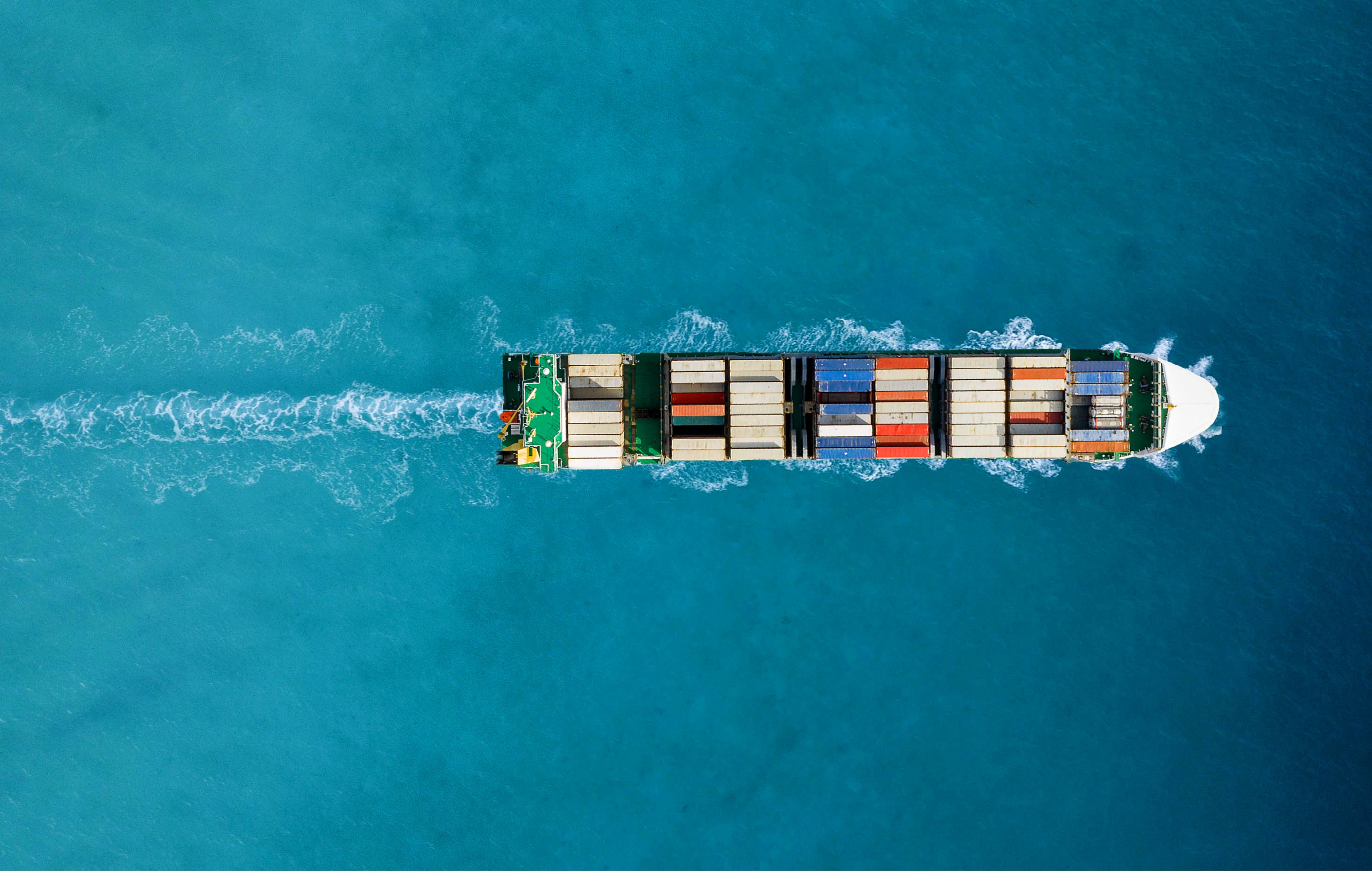
A database or registry of shared information on who is getting what vaccine, when and where could also be critical to a learning analytics system that adapts its predictions. The registry could track compliance with booster shots, whether individuals have become infected and other critical information to understand vaccination patterns, adherence issues and any adverse events as more people receive vaccines.

Each state already maintains its own registry of vaccination information. Additionally, the FDA and the CDC maintain the vaccine adverse event reporting system (VAERS), but this is a passive system that requires physicians to report adverse events noted by individuals.⁴⁶

Manufacturers could build the framework for a national registry that would link the disparate sources of data. “We could be integrating all of this so that people have more confidence, and we can have a much better understanding of pharmacovigilance signals and how they [the signals] can be linked to different disease levels in the region at the time of the vaccination,” Le Corfec told HRI.

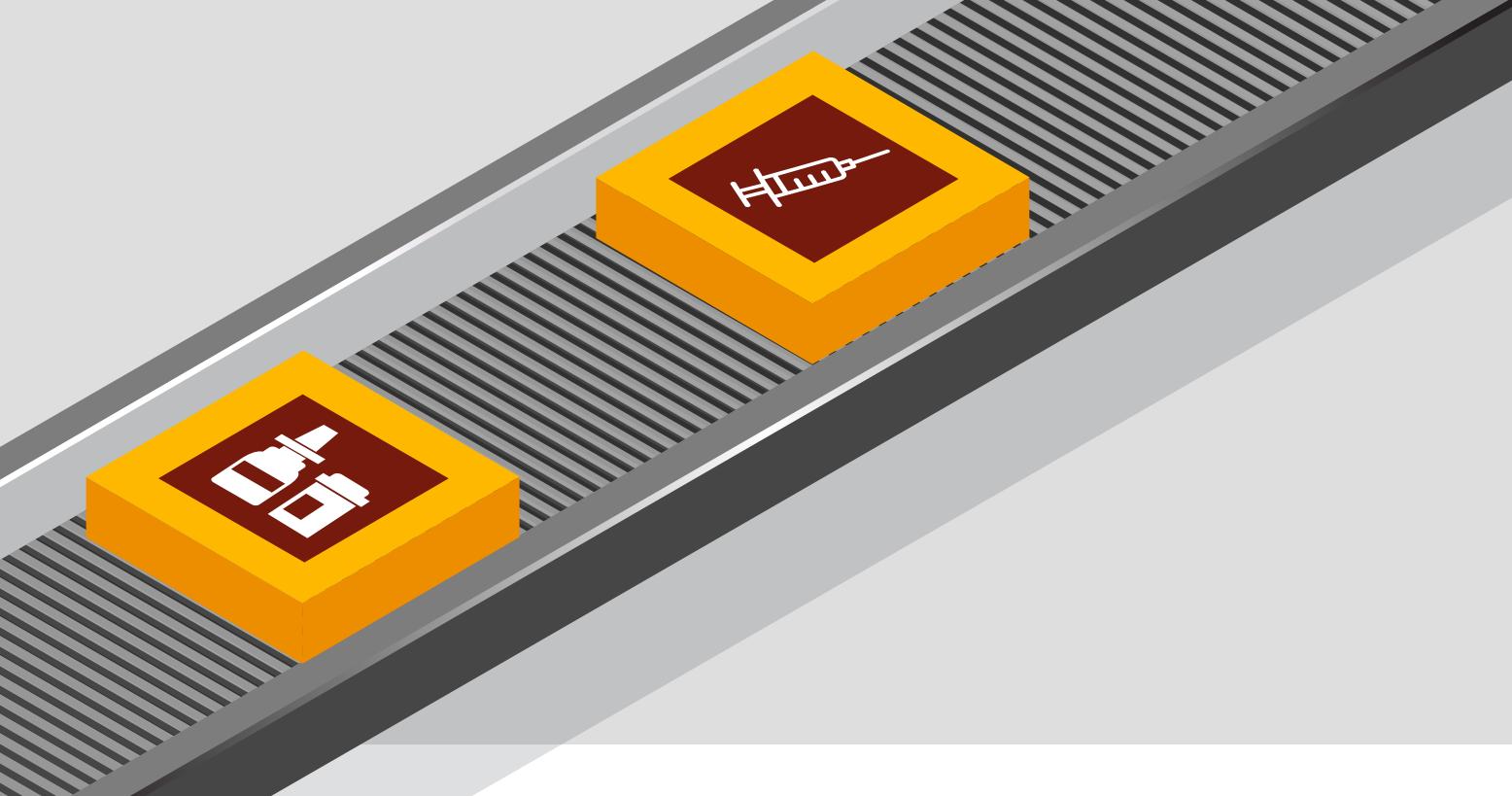
The data network could also include hospital registries and collect information on demographics, the vaccine received, the patient’s level of comorbidities and whether they have had a positive test for COVID-19. The inclusion of test results could help understand whether the vaccine is working and quickly detect the emergence of antibody-dependent enhancement—a potentially severe side effect of some vaccines.⁴⁷ “Whatever we do here we should consider as the foundation for what we build on top in the future,” BD’s Lum told HRI.

COVID-19 vaccine implications: Manufacturers can take advantage of existing software tools to help model the supply chain, identifying the most optimal distribution systems and how those could evolve throughout the pandemic. Additionally, they can collaborate with providers, pharmacists and others in the supply chain to share data such as the number of vials shipped, expected delivery dates, any potential delays in real time and other aspects that can inform efficient delivery of vaccines. This should also enable a virtual feedback loop with the vaccinators and consumers to forecast demand and improve just-in-time delivery of vaccines as more data are obtained, including information on where consumers are getting vaccinated, whether they are returning for the booster shot and other inputs to guide efficient distribution.



Implications for the broader supply chain: The analytics needed to integrate the supply chain will likely require investment, but that could pay dividends well after the COVID-19 pandemic passes. Whether for the next pandemic or across the pharmaceutical supply chain, investment in advanced analytics could allow manufacturers to more closely deliver on the promise of the right treatment to the right patient at the right time and in the right place. Companies will likely reduce their chances of stockouts or spoilage by tracking shipments in real time. New tools to understand consumer behaviors will likely enable pharmaceutical and life sciences companies to target adherence programs and outreach to individuals based on both their current health condition and other important factors that will influence their health outcomes, including socioeconomic and demographic information.

A framework for a national registry could also provide new avenues into managing population health, better predicting and mitigating future public health crises, and helping track medicines to help avoid diversions or other untoward uses.



Conclusion

The COVID-19 pandemic is unlike anything our healthcare ecosystem has faced in modern times, and the consequences of failing to efficiently and equitably deploy a vaccine are severe. A specialized, consumer-centric and connected vaccine value chain approach could help save lives, prevent additional suffering, and allow students to return to classrooms and the economy to rebound. The collaborative, innovative models built should pay dividends beyond vaccines and allow the US healthcare system and economy to emerge stronger, nimbler and better prepared than it was before the pandemic.





Sidebar 1: Lending experienced hands to cold chain transport and storage

Even before the pandemic, the distributor AmerisourceBergen started building out its cryogenic supply chain capabilities for cell therapies where cryogenic temperatures are typically –150 degrees Celsius or lower.⁴⁸ AmerisourceBergen offers cryogenic storage and temperature-controlled transport from the manufacturer to the storage facility and ultimately the point of care.

On its Aug. 5 quarterly earnings call, in response to investor questions about COVID-19 vaccine distribution, Steven Collis, AmerisourceBergen chairman, president and CEO, said that in the US, the distributor has “deep cold supply chain capabilities.”⁴⁹

Other suppliers could play a role. The transport company UPS is readying “freezer farms” with 600 deep freezers that can each hold about 48,000 vials of vaccine at temperatures as low as –80 degrees Celsius.⁵⁰ UPS already has experience at shipping cell and gene therapies for clinical trials at temperatures down to –150 degrees.

UPS is partnered with e-commerce pharmacy and last-mile delivery provider MedVantx on the delivery of these therapies. On a March 27 podcast, Rob Feeney, CEO of MedVantx, said the company is “thinking more about how to move that kind of infrastructure closer to the consumer.⁵¹ We’re actually trying to leverage those types of models to be able to deliver these new clinical therapies very quickly to the home setting.”

In the podcast, the company also suggested that it may build on its cold chain infrastructure for COVID-19 vaccines.

Companies such as Cryoport provide cryogenic packaging and shipping for two of the gene therapies approved in the US. Cryoport also uses its proprietary monitoring system to manage the shipments from the manufacturing facility to the administration sites.⁵²

Yourway Biopharma Services provides cold chain logistics and transport for these therapies, including warehouse and distribution and temperature-controlled processes that use real-time temperature monitoring.⁵³

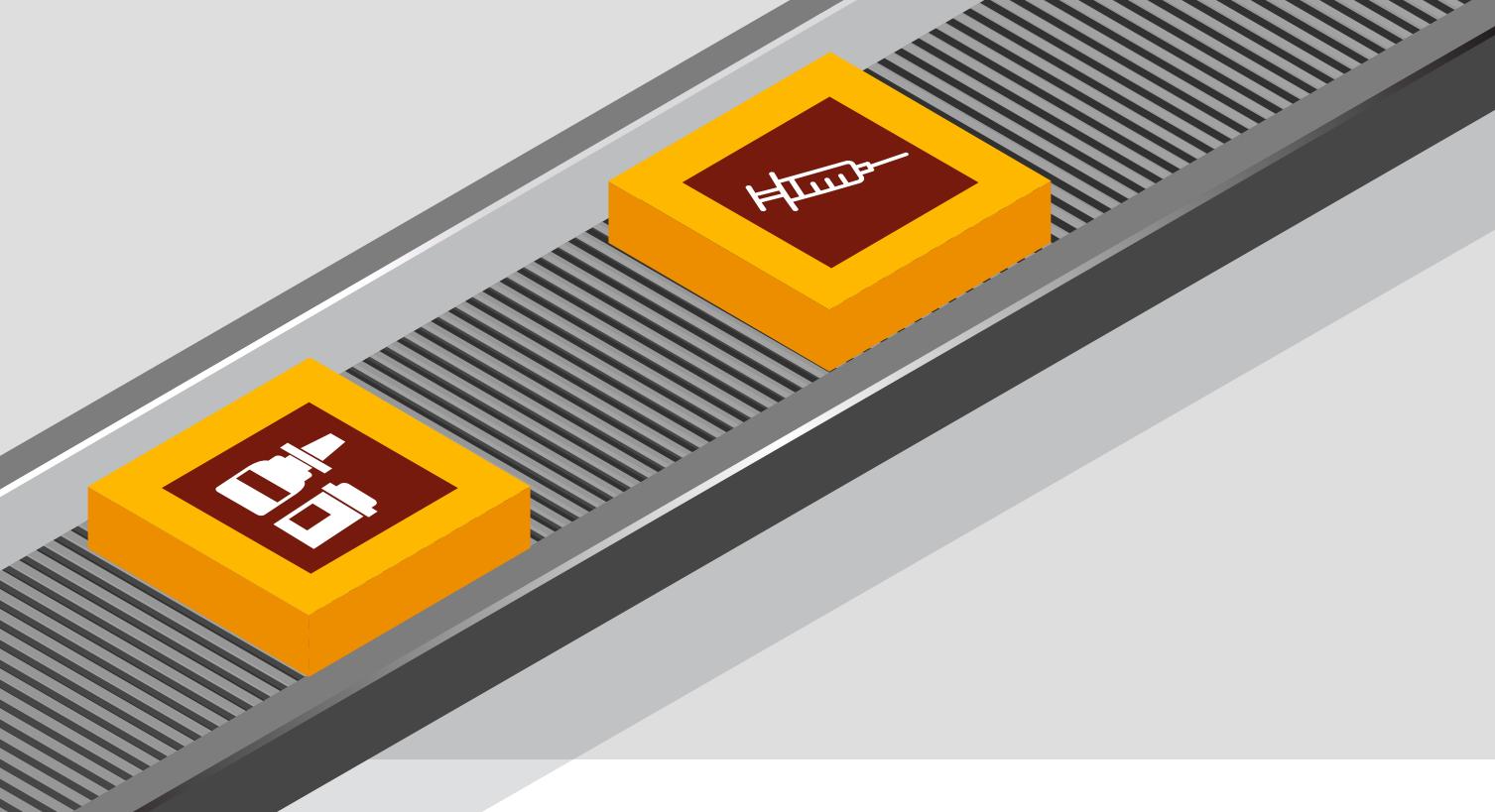


Sidebar 2: Using social determinants of health to drive the vaccination model where it's most needed

Racial minorities, including Black and LatinX populations, are some of the hardest hit by the pandemic. The CDC has found that these individuals are dying of COVID-19 at a disproportionate rate.⁵⁴ Positions that frequently lack the ability to social distance and have been prone to outbreaks, such as at meatpacking facilities, are held by a larger proportion of people of color.⁵⁵

Mobile clinics already being deployed to underserved neighborhoods may also be used to vaccinate the most vulnerable populations.⁵⁶ There are about 2,000 mobile clinics across the US, with at least one in each state and Washington, DC. They provide up to 6.5 million visits annually, including primary care, preventive screening, disease management and other services, with about 40% of visitors identified as LatinX and Hispanic, and 30% as Black.⁵⁷ The deployment of mobile vaccination units could likely be critical to keeping these vulnerable populations away from acute care settings where they might risk exposure to the virus.

According to HRI's consumer survey, those on Medicaid were more than twice as likely to seek care for COVID-19 symptoms at an emergency room (6.3%) compared with patients with employer-sponsored insurance (2.8%), those on an exchange plan (2.1%) or those on Medicare (2.8%). Black people made up 19.7% of the Medicaid group surveyed by HRI, the second largest source of insurance coverage for this group next to employer-sponsored plans, while 13.8% of Medicaid consumers were LatinX or Hispanic.



Endnotes

1. “Medical Device Shortages during the COVID-19 Public Health Emergency,” US Food and Drug Administration, August 20, 2020, <https://www.fda.gov/medical-devices/coronavirus-covid-19-and-medical-devices/medical-device-shortages-during-covid-19-public-health-emergency>; Erin McCallister, “Compounders Win Some Flexibility as FDA Responds to Pandemic-Related Shortages,” PwC Health Research Institute, May 7, 2020, accessed August 10, 2020, <https://www.pwc.com/us/en/industries/health-industries/library/compounders-flexibility-fda.html>; Erin McCallister, “COVID-19: Drugmakers May Find It Harder to Procure India-Produced APIs, Mostly Antibiotics,” PwC Health Research Institute, March 6, 2020, accessed August 10, 2020, <https://www.pwc.com/us/en/industries/health-industries/library/india-produced-apis-restricted-covid-19.html>.
2. *The COVID-19 Pandemic Is Influencing Consumer Health Behavior. Are the Changes Here to Stay?*, PwC Health Research Institute, April 8, 2020, accessed August 12, 2020, <https://www.pwc.com/us/en/library/covid-19/covid-19-consumer-behavior.html>.
3. “H1N1 Flu Clinical and Public Health Guidance,” US Centers for Disease Control and Prevention, last modified May 5, 2010, accessed August 10, 2020, <https://www.cdc.gov/h1n1flu/guidance/#statelocal>.
4. Moncef Slaoui and Matthew Hepburn, “Developing Safe and Effective Covid Vaccines—Operation Warp Speed’s Strategy and Approach,” *New England Journal of Medicine*, August 26, 2020, accessed August 28, 2020, <https://www.nejm.org/doi/full/10.1056/NEJMmp2027405?query=TOC>.
5. “Weekly 2009 H1N1 Flu Media Briefing,” US Centers for Disease Control and Prevention, December 1, 2009, accessed August 10, 2020, <https://www.cdc.gov/media/transcripts/2009/t091201.htm>.
6. “Vaccine Storage and Handling,” US Centers for Disease Control and Prevention, last modified July 2020, accessed September 9, 2020, <https://www.cdc.gov/vaccines/pubs/pinkbook/vac-storage.html>.
7. “Pandemic Vaccine Program Distribution, Tracking, and Monitoring,” US Centers for Disease Control and Prevention, April 20, 2020, accessed August 16, 2020 <https://www.cdc.gov/flu/pdf/pandemic-resources/pandemic-influenza-vaccine-distribution-9p-508.pdf>.
8. “Storage Best Practices for Frozen Vaccines,” US Centers for Disease Control and Prevention, February 1, 2018, <https://www.cdc.gov/vaccines/hcp/admin/storage/downloads/D-vax-temp-best-practices-frozen-C.pdf>.
9. *Beyond the Hype: Gene Therapies Require Advanced Capabilities to Succeed After Approval*, PwC Health Research Institute, September 1, 2019, accessed August 10, 2020, <https://www.pwc.com/us/en/industries/health-industries/assets/pwc-health-research-institute-beyond-the-hype-gene-therapy-report.pdf>.
10. Zolgensma prescribing information, US Food and Drug Administration, May 2019, accessed September 9, 2020, <https://www.fda.gov/media/126109/download>.

11. Luxturna prescribing information, US Food and Drug Administration, July 2018, accessed September 9, 2020, <https://www.fda.gov/media/109906/download>.
12. Faryar Tavakoli, “Cryogenic Transport for Gene Therapy Products—Exploring the Pros and Cons,” *Cell & Gene*, March 21, 2019, accessed August 20, 2020, <https://www.cellandgene.com/doc/cryogenic-transport-for-gene-therapy-products-exploring-the-pros-and-cons-0001>; “The Process of CAR-T Cell Therapy,” Novartis, January 1, 2019, accessed August 22, 2020, <https://www.novartis.com/our-focus/cell-and-gene-therapy/car-t/car-t-healthcare-professionals/process-car-t-cell-therapy>.
13. Elizabeth Weise, “Feds Want a COVID-19 Vaccine Distribution System Ready by Nov. 1. Freezer Farms and UPS Are Part of the Plan,” USA Today, last modified August 23, 2020, accessed August 25, 2020, <https://www.usatoday.com/story/news/health/2020/08/21/covid-vaccine-government-wants-distribution-system-ready-nov-1/3413109001/>.
14. “Zolgensma Data Shows Rapid, Significant, Clinically Meaningful Benefit in SMA Including Prolonged Event-Free Survival, Motor Milestone Achievement and Durability Now Up to 5 Years Post-Dosing,” Novartis, March 24, 2020, accessed August 20, 2020, <https://www.novartis.com/news/media-releases/zolgensma-data-shows-rapid-significant-clinically-meaningful-benefit-sma-including-prolonged-event-free-survival-motor-milestone-achievement-and-durability-now>.
15. Lena H. Sun, “CDC Asks 4 States and a City to Draft Coronavirus Vaccine Distribution Plans,” *Washington Post*, August 14, 2020, accessed August 16, 2020, <https://www.washingtonpost.com/health/2020/08/14/cdc-asks-4-states-city-draft-coronavirus-distribution-plans/>.
16. “McKesson to Distribute Future COVID-19 Vaccines in Support of Operation Warp Speed,” McKesson, August 14, 2020, accessed August 15, 2020, <https://www.mckesson.com/About-McKesson/Newsroom/Press-Releases/2020/McKesson-Distribute-Future-COVID-19-Vaccines-Operation-Warp-Speed/>.
17. “McKesson Specialty Health and Cryoport Collaborate to Bolster Logistics Services to Support Commercialization of Cell and Gene Therapies,” McKesson, February 26, 2018, accessed August 15, 2020, <https://www.mckesson.com/about-mckesson/newsroom/press-releases/2018/msh-and-cryoport-collaborate/>.
18. “McKesson Corp (MCK) Q1 2021 Earnings Call Transcript,” The Motley Fool, August 3, 2020, accessed August 15, 2020, <https://www.fool.com/earnings/call-transcripts/2020/08/03/mckesson-corp-mck-q1-2021-earnings-call-transcript.aspx>.
19. Gregg Girvan, “Nursing Homes & Assisted Living Facilities Account for 45% of COVID-19 Deaths,” FreOpp, May 7, 2020, accessed August 23, 2020, <https://freopp.org/the-covid-19-nursing-home-crisis-by-the-numbers-3a47433c3f70>.
20. “Nursing Home Care,” US Centers for Disease Control and Prevention, last modified May 20, 2020, accessed August 10, 2020, <https://www.cdc.gov/nchs/fastats/nursing-home-care.htm>.
21. *Long-term Care Providers and Services Users in the United States, 2015–2016*, National Center for Health Statistics, US Department of Health and Human Services, February 2019, accessed August 24, 2020, https://www.cdc.gov/nchs/data/series/sr_03/sr03_43-508.pdf.
22. “Health Disparities: Race and Hispanic Origin,” US Centers for Disease Control and Prevention, August 24, 2020, accessed August 26, 2020, https://www.cdc.gov/nchs/nvss/vsrr/covid19/health_disparities.htm.

23. Shannon Mullen O'Keefe, "One in Three Americans Would Not Get COVID-19 Vaccine," Gallup, August 7, 2020, accessed August 12, 2020, <https://news.gallup.com/poll/317018/one-three-americans-not-covid-vaccine.aspx>.
24. *Provider Systems of the Future: What Happens When the Hospital Is No Longer the Center of the Health Universe?*, PwC Health Research Institute, October 1, 2018, accessed August 12, 2020, <https://www.pwc.com/us/en/industries/health-industries/health-research-institute/provider-systems-future.html>.
25. *The COVID-19 Pandemic Is Influencing Consumer Health Behavior. Are the Changes Here to Stay?*, PwC Health Research Institute, April 8, 2020, accessed August 12, 2020, <https://www.pwc.com/us/en/library/covid-19/covid-19-consumer-behavior.html>.
26. *Acceleration of the New Health Economy: The Pandemic Edits the DNA of the Health System*, PwC Health Research Institute, June 2020, accessed August 12, 2020, <https://www.pwc.com/us/en/industries/health-industries/health-research-institute/new-health-economy-accelerates.html>.
27. "No-Cost COVID-19 Testing in Your Community," CVS, accessed August 12, 2020, <https://www.cvs.com/content/coronavirus/community-testing-sites>; Kane Webb, "Testing, Testing: Walmart's Plan to Stand Up a COVID-19 Testing Site in Eight Days," Walmart, July 27, 2020, accessed September 3, 2020; <https://corporate.walmart.com/facing-the-outbreak/testing>; "Kroger Health COVID-19 Testing Locations," Kroger, accessed September 3, 2020, <https://www.krogerhealth.com/covid-locations>; "Covid-19 Testing Available," Rite Aid, accessed September 3, 2020, <https://www.riteaid.com/pharmacy/services/covid-19-testing>.
28. "Albertsons Companies Implements Social Distancing Protocol across All Stores," Albertsons, March 23, 2020, accessed August 10, 2020, <https://www.globenewswire.com/news-release/2020/03/23/2005131/0/en/Albertsons-Companies-implements-social-distancing-protocol-across-all-stores.html>.
29. Joey Hadden, "Coronavirus Testing Sites across the US Are Overwhelmed. Aerial Photos of Long Drive-Thru Lines in Texas, California, and Virginia Show What That Looks Like," *Business Insider*, July 14, 2020, accessed August 8, 2020, <https://www.businessinsider.com/drive-thru-coronavirus-testing-lines-photos-2020-7>; Charlie Pogacar, "Smaller Footprints, More Drive Thru: Restaurant Design in a COVID World," QSR, July 2020, accessed August 13, 2020, <https://www.qsrmagazine.com/drive-thru/smaller-footprints-more-drive-thru-restaurant-design-covid-world>.
30. "No-Cost COVID-19 Testing in Your Community," CVS, accessed August 12, 2020, <https://www.cvs.com/content/coronavirus/community-testing-sites>; "No-Cost COVID-19 Testing at Walgreens," Walgreens, accessed August 12, 2020, <https://www.walgreens.com/findcare/covid19/testing>.
31. "The DispatchHealth Difference," DispatchHealth, accessed September 2, 2020, <https://www.dispatchhealth.com/how-it-works/>.
32. Mike Stobbe, "Pharmacists Can Give Childhood Shots, U.S. Officials Say," Associated Press, August 19, 2020, accessed August 20, 2020, <https://news.yahoo.com/pharmacists-childhood-shots-u-officials-140941638.html>.
33. *Customer Experience in the New Health Economy: The Data Cure*, PwC Health Research Institute, February 2018, accessed August 20, 2020, <https://www.pwc.com/us/en/health-industries/health-research-institute/publications/pdf/pwc-hri-customer-experience-in-new-health-economy.pdf>.

34. *Advanced Analytics Fuel Tomorrow's Commercial Strategy for Drugs and Devices*, PwC Health Research Institute, March 2019, accessed August 15, 2020, <https://www.pwc.com/us/en/health-research-institute/assets/pwc-pls-advanced-analytics-report.pdf>.
35. Romain Guillot, "Skywise: A Look at the New Digital Alliance between Airbus and Delta for Cross-Fleet Predictive Maintenance Solutions," *Journal of Aviation*, October 31, 2019, accessed September 2, 2020, <https://www.journal-aviation.com/en/news/43331-skywise-a-look-at-the-new-digital-alliance-between-airbus-and-delta-for-cross-fleet-predictive-maintenance-solutions>.
36. "Cold Supply for Hot Demand," Gavi, the Vaccine Alliance, accessed August 14, 2020, <https://www.gavi.org/vaccineswork/cold-supply-hot-demand>.
37. Jeremy Schneider, "How a Real-Time Temperature Monitoring Solution Helps Reduce Supply Chain Product Losses," Food Logistics, July 8, 2020, accessed August 8, 2020, <https://www.foodlogistics.com/technology/article/21138323/controlant-how-a-realtime-temperature-monitoring-solution-helps-reduce-supply-chain-product-losses>.
38. "Supply Chain Simulation Software," AnyLogic, accessed August 22, 2020, <https://www.anylogic.com/supply-chains/>.
39. "Apparel Company Chose Location for New Distribution Center Using Simulation Modeling," AnyLogic, accessed August 23, 2020, <https://www.anylogic.com/simulation-modeling-helped-apparel-company-choose-location-for-new-distribution-center>.
40. Wes Wheeler, "Healthcare Logistics in the Age of Coronavirus," interview by Brian Hughes, *Longitudes Radio* podcast, March 27, 2020.
41. "Five Ways Walmart Uses Big Data to Help Customers," Walmart, August 7, 2017, accessed September 9, 2020, <https://corporate.walmart.com/newsroom/innovation/20170807/5-ways-walmart-uses-big-data-to-help-customers>.
42. Sierra Hawthorne, "COVID-19: Q&A on Building a COVID-19 Local Planning Model for Health Systems," interview by PwC Health Research Institute, March 30, 2020, <https://www.pwc.com/us/en/industries/health-industries/library/qa-building-local-health-model-pandemic.html>.
43. Katie Adams, "Dallas Hospital's COVID-19 Vulnerability Index Shows Social Factors as Leading Cause of Disparities," *Becker's Hospital Review*, June 23, 2020, accessed August 14, 2020, <https://www.beckershospitalreview.com/data-analytics/dallas-hospital-s-covid-19-vulnerability-index-shows-social-factors-as-leading-cause-of-disparities.html>.
44. Laura Dyrda, "CommonSpirit Develops Predictive Models for Next COVID-19 Surge: 5 Details," *Becker's Hospital Review*, June 22, 2020, accessed August 10, 2020, <https://www.beckershospitalreview.com/data-analytics/commonspirit-develops-predictive-models-for-next-covid-19-surge-5-details.html>.
45. Katie Adams, "Iowa State's COVID-19 Dashboard Will Now Feature a Mobile Version," *Becker's Hospital Review*, July 16, 2020, accessed August 12, 2020, <https://www.beckershospitalreview.com/data-analytics/iowa-state-s-covid-19-dashboard-will-now-feature-a-mobile-version.html>.

46. "Vaccine Adverse Event Reporting System (VAERS)," US Centers for Disease Control and Prevention, July 23, 2020, accessed August 13, 2020, <https://www.cdc.gov/vaccinesafety/ensuringsafety/monitoring/vaers/index.html>.
47. Stephanie Soucheray, "Sanofi Restricts Dengue Vaccine but Downplays Antibody Enhancement," University of Minnesota Center for Infectious Disease Research and Policy, December 1, 2017, accessed August 22, 2020, <https://www.cidrap.umn.edu/news-perspective/2017/12/sanofi-restricts-dengue-vaccine-downplays-antibody-enhancement>.
48. "World Courier and ICS Become First End-to-End Specialty Logistics Provider for Advanced Therapies," AmerisourceBergen, January 28, 2020, accessed August 21, 2020, <https://www.mychesco.com/a/news/business/world-courier-and-ics-become-first-end-to-end-specialty-logistics-provider-for-advanced-therapies/>.
49. "AmerisourceBergen Corp (ABC) Q3 2020 Earnings Call Transcript," The Motley Fool, August 5, 2020, accessed August 24, 2020, <https://www.fool.com/earnings/call-transcripts/2020/08/05/amerisourcebergen-corp-abc-q3-2020-earnings-call-t.aspx>.
50. Catherine Leffert, "UPS Readies Freezer Farms to Ship Virus Vaccine—If We Get One," Bloomberg, August 3, 2020, accessed August 12, 2020, <https://www.bloomberg.com/news/articles/2020-08-03/ups-readies-freezer-farms-to-ship-virus-vaccine-if-we-get-one>.
51. Rob Feeney, "Healthcare Logistics in the Age of Coronavirus," interview by Brian Hughes, *Longitudes Radio* podcast, March 27, 2020.
52. "Cryoport: Management's Discussion and Analysis of Financial Condition and Results of Operations. (form 10-Q)," Marketscreener, May 5, 2020, accessed August 21, 2020, <https://www.marketscreener.com/quote/stock/CRYOPORT-INC-23132732/news/CRYOPORT-MANAGEMENT-S-DISCUSSION-AND-ANALYSIS-OF-FINANCIAL-CONDITION-AND-RESULTS-OF-OPERATIONS-f-30568640/>.
53. "Temperature Control Solutions," Yourway, accessed August 17, 2020, <https://www.yourway.com/premium-courier/temperature-control-solutions>.
54. "Characteristics of Persons Who Died with COVID-19 — United States, February 12–May 18, 2020," US Centers for Disease Control and Prevention, July 17, 2020, accessed August 23, 2020, <https://www.cdc.gov/mmwr/volumes/69/wr/mm6928e1.htm>.
55. "Labor Force Statistics from the Current Population Survey," US Bureau of Labor Statistics, last modified January 22, 2020, accessed August 25, 2020, <https://www.bls.gov/cps/cpsaat18.htm>.
56. Ahmed Ahmed and Nancy Oriol, "Mobile Clinics Can Provide Equity in the Defense against COVID-19," Scientific American Voices blog, April 15, 2020, accessed August 23, 2020, <https://blogs.scientificamerican.com/voices/mobile-clinics-can-provide-equity-in-the-defense-against-covid-19/>.
57. "Impact Report," Mobile Health Map, accessed August 25, 2020, www.mobilehealthmap.org/impact-report.

About this research

PwC convened a coalition of 20 health industry executives working at the forefront of the pandemic across the healthcare ecosystem to discuss all elements of the vaccine, distribution and administration chain from July through August 2020. The participants represented the viewpoint for their node in the value chain and not the views of the companies with which they are affiliated. The report is based upon the best available information through August 2020.

PwC's Health Research Institute consumer survey was conducted online from April 2 to 8 among 2,533 US adults representing a cross section of the population in terms of insurance type, age, gender, income and geography.

The survey collected data on consumer perspectives about the healthcare landscape before, during and after the COVID-19 pandemic, including their use of health services and thoughts about how they will interact with the health system in the future. HRI's executive survey was conducted online from Aug. 21 to Sept. 14 among 150 providers, 125 pharmaceutical and life sciences, and 125 payer executives.

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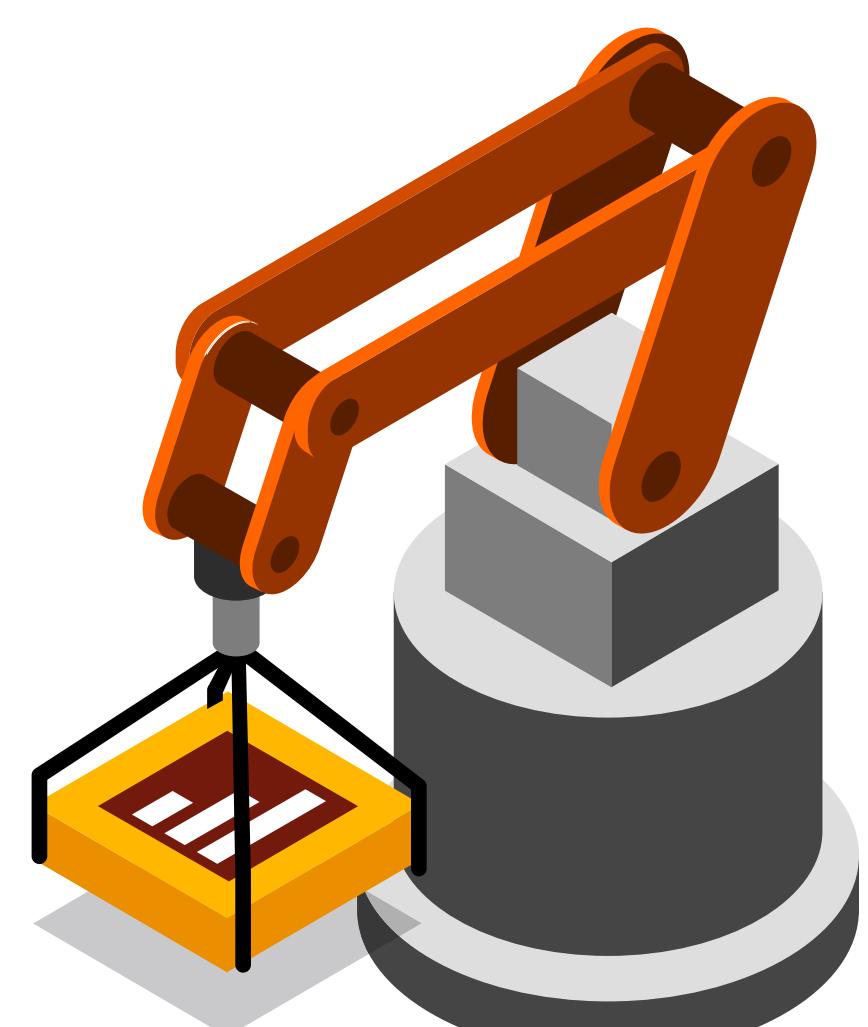
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