

APPLYING LESSONS LEARNED FROM COVID-19

TO CREATE A HEALTHIER, SAFER,
MORE EQUITABLE WORLD

May 2022



IFPMA

FOREWORD

COVID–19 Can Teach Us To Build a Safer, Fairer World

When the history of the COVID-19 pandemic is written, future generations will be as stunned by the remarkable successes as they will be by the flagrant collective flaws. This may seem a harsh verdict on all those who have worked themselves into noble exhaustion. But it is the only perspective that will help ensure that we are equipped for the next pandemic, even as we continue to fight this one.

Let's not sugar coat it. The world was ill prepared for this pandemic, and even many of the most advanced health systems were overwhelmed by the biggest public health crisis we have been faced with since the Spanish flu in 1918-19. Without the development of vaccines in under a year, there's no telling how many more people would have perished from COVID-19, or how much more economic activity would have been lost.

But the global healthcare community has collectively failed. Failed in a shared commitment to equity and solidarity, in the moral obligation to the most vulnerable, and in the foundational conception of health security.

Now, the challenge for the global healthcare community, of which the biopharmaceutical industry is a part, is to turn our painful lessons into strategic commitments – to create an architecture for effective pandemic preparedness and response that we didn't have two years ago. Together, we need to build structures that prevent pandemics and expand structures for the pandemic response. And we need to sustain them as an insurance policy against being caught unprepared when the inevitable next public health crisis arrives.

The first priority has to be information on viruses. This is the most effective defence we have against infectious diseases. We must ensure that pathogen surveillance and sharing are not left to chance or the goodwill of nations.¹ Chinese scientists² posted quickly the genomic sequence of the SARS-CoV-2 virus on GISAID³, a widely available data-sharing platform: this should be both the scientific norm and the legally binding obligation that every nation owes to every other nation.

The approval of the first vaccine in just 326 days after that genome was published was a scientific marvel – but it did not happen in isolation.⁴ Innovations such as mRNA and viral vector vaccines were developed thanks to decades of prior research conducted within a robust innovation ecosystem that depends on the protection of intellectual property.

¹ <https://www.statnews.com/2021/11/28/nagoya-protocol-shouldnt-shield-not-sharing-pathogens-genetic-sequences/>

² <https://www.science.org/content/article/chinese-researchers-reveal-draft-genome-virus-implicated-wuhan-pneumonia-outbreak>

³ <https://www.gisaid.org/>

⁴ https://cepi.net/news_cepi/a-leap-forward-in-vaccine-technology-2/

And yet, even though the globe more than doubled its pre-pandemic vaccine manufacturing capacity to the extent that today there may be too many COVID-19 vaccines, a large part of the population in most African nations remains unvaccinated.

This inequitable distribution of COVID-19 vaccines is not the fault of any single entity. But none of the stakeholders, including the biopharmaceutical industry, should see themselves as irreproachable, either. Today, the challenge of the current pandemic has shifted from developing and manufacturing vaccines in never-seen volumes to now turning them into vaccinations. Precious time has been wasted not only in waiting for vaccines to be delivered in part sadly due to trade barriers, but also because the resources were not secured and deployed to ensure the infrastructure and people were trained so that countries were ready to get vaccines from the tarmac into arms. Learning the lessons so far, we must act to ensure equitable access and the means to deliver prevention and treatment are hard-wired into our future pandemic preparedness and response construct.

In today's globalized world, our vulnerability to contagious diseases mirrors supply chains and how people and goods circulate around the world. We are only as strong as the weakest link, and underfunded and understaffed healthcare systems that are in the front line of tackling infectious diseases pose a danger to everyone.

That's why we need to invest in making healthcare systems more resilient and in expanding Universal Health Coverage (UHC) to be better prepared for the future. As global healthcare stakeholders, we will be judged in the future by the investments we make now to bolster the networks of trust, trade and access; necessary to bridge the "equity chasm" that afflicts global healthcare.

We have seen heroic work done by the world's healthcare regulators during the pandemic, which saved millions of lives. Regulatory flexibility and collaboration among the leading agencies proved invaluable, from fast-tracked approvals and e-signature authorizations to expedited scientific guidance and rolling review processes.

But we have also seen vaccine nationalism: a fast move from hedging (placing bets on multiple vaccines, not knowing which would work) to hoarding, export bans and restrictions, and a lack of initial funding needed for partnerships such as COVAX to procure enough vaccines. Strategically planned, geographically diversified vaccine manufacturing and supply chains are necessary, and reflect the reality that governments will likely continue to prioritize their domestic responses in future pandemics, especially if they are significantly underwriting research and development and expanded manufacturing capacity. Wealthy countries must build the needs of other countries into their pandemic preparedness and response. Ignoring them is a perilous plan.

This new pandemic architecture needs to look resolutely into the future. The key question can't be: "Is this better than things were in 2020?" It must be: "Is this what the world will need in 2030? Or in 2060?" Meeting that standard will require significant investment. But we also know – after millions of deaths and trillions of dollars of losses to the global economy over the last two years – that inaction extracts an even more terrible price.

We have seen the strength of a robust innovation ecosystem expand partnerships, knowledge-sharing, and technology transfer in unprecedented ways. This system, composed of universities and academic research bodies, biotech start-ups, small and

large biopharmaceutical companies from industrialized and developing countries, must be preserved and strengthened. Research labs, and the network of licensing agreements and technology sharing that connect them to each other and to other stakeholders in both the public and private sectors, must be treated like frontline defenders against our lethal enemies.

Ultimately, the world can never protect itself completely from a pandemic, any more than a coastal city can from a hurricane or cyclone. COVID-19 has taught the global healthcare community priceless lessons. Let's use them to make our defences against the next pandemic more nimble, more robust, and – above all – more equitable.

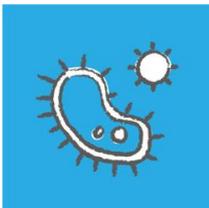
Thomas Cueni, Director General of the International Federation of Pharmaceutical Manufacturers and Associations (IFPMA)

Geneva, May 2022

EXECUTIVE SUMMARY

Since the world's response to COVID-19 began, we have all worked to outrun a virus that has so far proven faster than we have been. Industry, governments, hospitals, providers, suppliers, researchers – indeed entire countries – found themselves on their heels for much of 2020. As health systems improvised to meet each new day's challenges, it was clear a comprehensive, end-to-end, lab-to-last-mile strategy was needed. That is the only way to recover from the current pandemic, and it is the only way for a new global health security architecture to prepare effectively for the next one.

Early on in the pandemic, the International Federation of Pharmaceutical Manufacturers & Associations laid out [seven commitments](#) to communicate, guide, and measure our work in the fight against COVID-19. A definitive analysis of our efforts will be possible only when the pandemic is over. However, the significant efforts and associated learnings accumulated since early 2020 enable meaningful early insights to inform the current crisis and the future course. This report identifies 10 insights the biopharmaceutical industry has gathered so far as the world moves into the third year of the COVID-19 pandemic. We present them as hard-learned lessons to date – and as urgent strategies to end this pandemic and better prepare for the next one.



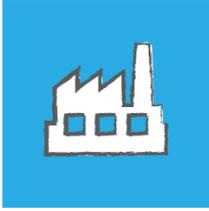
1. Health Security Starts with Pathogen Surveillance and Sharing

Investments in global health security, especially improved and expanded pathogen and disease surveillance, will not achieve the ultimate goal of protecting people worldwide if immediate and unfettered access to pathogens and their genetic information is constrained.



2. Partnerships Accelerate R&D and Manufacturing

Effective voluntary partnerships spanning the globe accelerated research and development and manufacturing for COVID-19 vaccines and therapeutics. More than 330 partnerships – public-private, private-private, private-academic, and others – bolstered manufacturing capacity, facilitated technology and knowledge transfer, and drove historically rapid R&D.



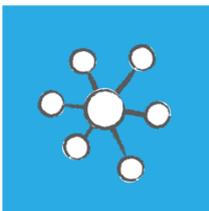
3. Advance Market Commitments Support Manufacturing Scale-Up for Global Pandemic Response

Advance market commitments for COVID-19 vaccines and therapeutics – prior to stringent regulatory authorizations – allowed for vital supplemental investments in production capacity and voluntary technology transfer. Even amid the shifting uncertainties of the pandemic – evolving variants, changing epidemiology, and fluctuating geographic hotspots – those commitments sustained at-risk but indispensable investments.



4. Innovation Is Essential for Preparedness and Response

More than two decades of investment powering tenacious research and development – even in the face of costly failures – laid the groundwork for the record-shattering development timelines for the mRNA and viral vector vaccines now in use to mitigate COVID-19 disease. Global legal frameworks supporting innovation were essential to that continuous pursuit of safe and effective vaccines and need to be maintained.



5. Global Upstream Supply Chains Disruptions Put Production and Distribution at Risk

The lack of multiple, globally sourced components delayed pharmaceutical distribution throughout the pandemic. Shortages of raw materials and intermediate products made worse by trade restrictions and competition for and among vendors resulted in inefficient allocation of available supply, leaving most developers less capable of rapidly testing, manufacturing, and delivering COVID-19 vaccines and therapeutics. Proposed investments to expand manufacturing capacity must also build capacity for sufficient and rapid supply of critical commodities and raw materials.



6. An Established Procurement Mechanism for Low-Income Countries Is Vital

COVAX was not sufficiently funded or organized quickly enough to secure advance purchase agreements for doses on a par with high-income country purchasers. When a pandemic is declared, sufficient, dedicated, and sustainable financing must be available immediately to procure goods for countries with limited or no capacity to finance their own pandemic purchases. Technical assistance must also be quickly provided to speed response implementation.



7. Regulatory Agility and Convergence Guard Safety and Speed of Access

COVID-19 vaccines and therapeutics were developed in record time thanks in no small part to the extraordinary degree of collaboration between industry and national and regional regulatory authorities. The collaborative consultations – between industry and regulators as well as among regulators – saved lives by managing speed, efficacy, and safety. If COVID-19 regulatory abilities lapse, however – for pandemic-potential vaccines and medicines and for other life-threatening diseases– the promise of scientific advancements and technology to speed development, production, and access to vaccines and therapeutics will not be realized.



8. Vaccine Nationalism Imperils Everyone

The first obligation of any government is to ensure the safety of its people. But narrow understandings of that duty have led to the rise of "vaccine nationalism." Policies like export restrictions and vaccine hoarding, regardless of global public health need, have intensified and likely prolonged the COVID-19 pandemic. Refining the concept of "national health security" in a global context will be essential before the next pandemic.



9. Delivery Infrastructure Must Be Strengthened

By late 2021, the world's vaccine supply was no longer constrained. Yet too many people in lower-income countries still lack access to COVID-19 vaccines and treatments. The pandemic has once again demonstrated the imperative of strengthening national health systems and ensuring universal health coverage for everyone, everywhere. All stakeholders – governments, civil society, manufacturers, and others – have a collective responsibility to ensure equitable access to vaccines and treatment starting now, in this pandemic, and to build the necessary infrastructure supporting countries' ability to deliver needed vaccines and medicines ahead of the next one. Strong national resilient health systems and global health security are two sides of the same coin.



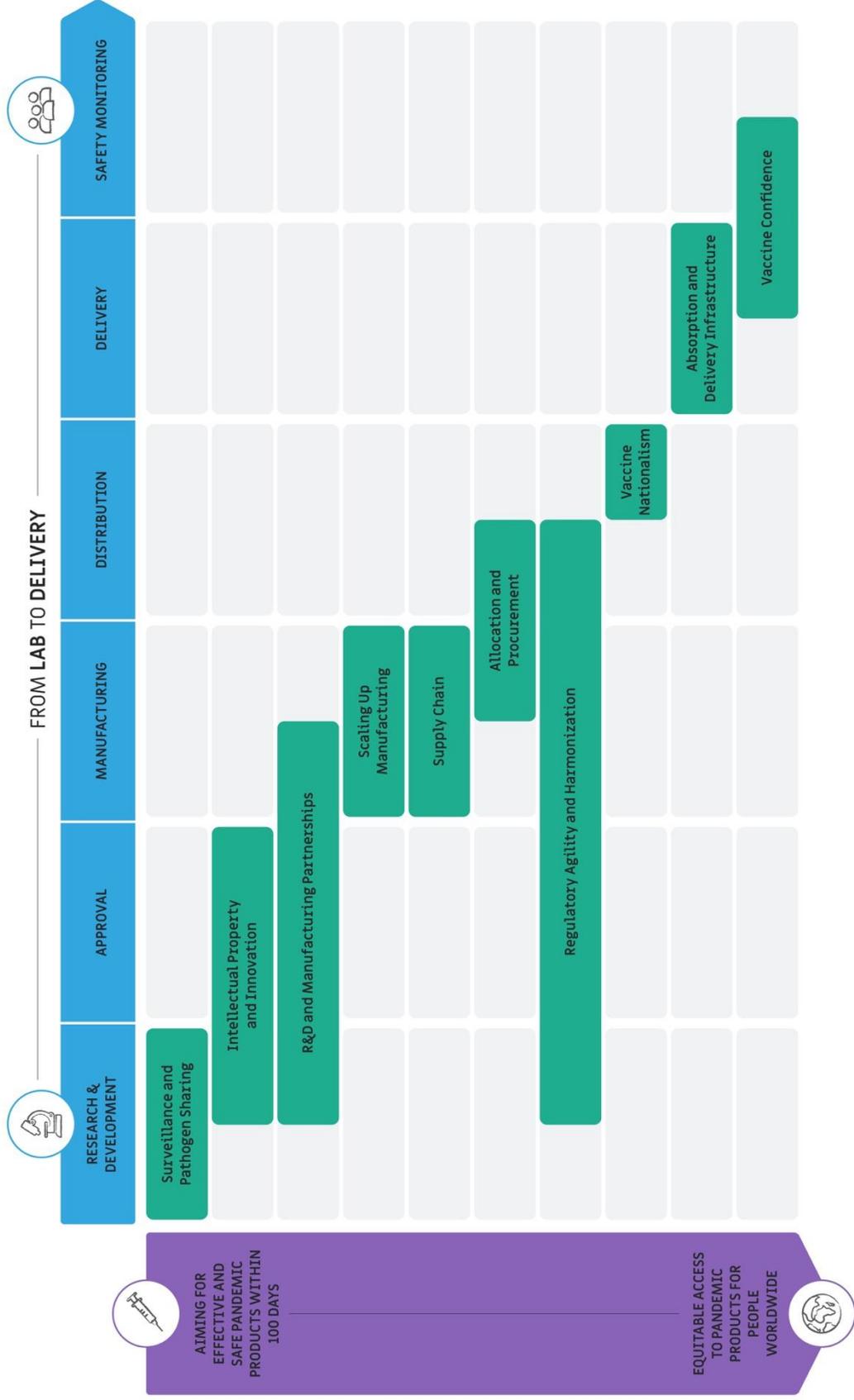
10. Vaccine Confidence Is Critical for Success

Ending the pandemic demands that public confidence in COVID-19 vaccines and the systems that deliver them be high and sustained. Vaccines won't work if people won't take them. Concerted, cross-sector action to build public trust is critical now and will need to be maintained long after the pandemic has ended. Strong

pharmacovigilance and no-fault-compensation systems contribute to improved confidence.

“Stopping the next pandemic, let alone in 100 days, isn’t something that a single country or organization can do alone. Success will require advances in the organization, governance, and financing of global-preparedness systems and the development of multiple interconnected, scientifically guided collaborative efforts.”¹

Improving pandemic response and preparedness



10 LESSONS LEARNED TO THIS POINT IN THE COVID-19 PANDEMIC: FROM LAB TO LAST MILE

1. Health Security Starts with Surveillance and Pathogen Sharing

Investments in global health security, especially improved and expanded pathogen and disease surveillance, will not achieve the ultimate goal of protecting people worldwide if immediate and unfettered access to pathogens and their genetic information is constrained.

Our power to prepare for pandemics and respond rapidly to activate research and development for medical countermeasures rests on improved pathogen surveillance; on swift, sure, and unencumbered pathogen and data sharing, and on the global scientific community's ability to collaborate efficiently and effectively. **Immediate and unfettered access to pathogens and their genetic information – known as digital sequence information (DSI) or genetic sequence data (GSD) – is the bedrock of global health security.** The SARS-CoV-2 genetic sequence was published on the GISAID data bank on January 1, 2020, 19 days before WHO declared a PHEIC (public health emergency of international concern). Candidate vaccines were underway within a few days, and the first regulatory approvals came 328 days later. **Access to pathogens is the crucial first step to developing tests, medicines, and vaccines needed around the world.**

COVID-19 demonstrated the vital importance of rapid pathogen access^{2,3,4,5,6,7}

Dec 31 2019: China notifies WHO about a pneumonia cluster in Wuhan

Jan 1 2020: The SARS-CoV-2 genetic sequence was published on the GISAID data bank

Jan 9 2020: WHO announces a novel coronavirus is the cause

Jan 11 2020: Scientists post entire genetic sequence on virological.org

Jan 13 2020: NIH and Moderna finalize candidate vaccine sequence

Jan 30 2020: WHO declares COVID-19 a Public Health Emergency of International Concern (PHEIC)

Feb 7 2020: First clinical batch of Moderna's vaccine candidate is completed

Mar 16 2020: Moderna begins safety tests

Jul 27 2020: Pfizer and Moderna begin large late-phase clinical trials

Aug 28 2020: AstraZeneca begins Phase 3 trial

Nov 9 2020: FDA grants emergency use authorization (EUA) for Lilly's monoclonal antibody therapy

Nov 20 2020: Pfizer seeks FDA EUA

Dec 2 2020: UK grants emergency use authorization for Pfizer's vaccine

Dec 11 2020: FDA issues EUA for Pfizer's vaccine

Dec 18 2020: FDA issues EUA for Moderna's vaccine

Dec 30 2020: UK grants EUA for AstraZeneca's vaccine

Dec 31 2020: WHO issues EUL for Pfizer's vaccine

There is broad agreement – across UN agencies and member states, along with science, public health, and legal experts, civil society, foundations, and industry – that access to pathogen samples and their genetic information is fundamental to improved preparedness and response. Starting from this consensus, the critical task now is rapidly and permanently building that into the global health security architecture.

Several approaches under consideration to improve pandemic preparedness and response include proposals related to pathogen sharing: a global pandemic treaty or framework, revisions to the 2005 International Health Regulations (IHR), changes to the

Convention on Biological Diversity's Nagoya Protocol expressly to exclude outbreak pathogens, an expansion of the Pandemic Influenza Preparedness Framework to incorporate additional pandemic-potential pathogens, and the [BioHub System](#) under development by the World Health Organization (WHO). Each of these global frameworks is separate and distinct from the others – but they intersect in critical aspects, and immediate access to pathogens and genetic information must be guaranteed in each one as discussions progress to ensure that diagnostics, vaccines, and therapeutics are well-matched to circulating strains or variants, have the highest possible effectiveness, and are rapidly manufactured and supplied. **Anything else risks lives and livelihoods.**

GISAID: A Unique Public-Private Partnership for Pathogen Sharing⁸

The timely detection of the Omicron variant and immediate sharing of the viral genomes and metadata was possible by contributions from researchers in Botswana, Hong Kong, and South Africa. Subsequent [bans](#) on travellers from multiple countries in southern Africa sent a strong disincentivizing signal for future transparency and did little to stop the spread of Omicron, which was circulating within weeks on all seven continents. Swift pathogen sequence sharing allowed companies to begin developing new vaccine candidates and to update existing mRNA vaccines to address emerging variants, which could be available in as little as 3 months.

The Global Initiative on Sharing Avian Influenza Data ([GISAID](#)) enabled this response. It serves as a model for rapid pathogen GSD access and public-private partnership, successfully built over 13 years as a response to the lessons of the H5N1 pandemic.

In January 2006, when mainstream media first took notice of human fatalities caused by a deadly bird flu, public access to the latest genetic sequences of H5N1 was limited and often restricted due to the hesitancy by affected countries to share their information through traditional public domain archives such as EMBL, DDBJ, and GenBank.

These archives, where data access and use occur anonymously, didn't offer any protection of the owners' intellectual property rights to the data or any other valuable incentive to data sharing, such as transparency on the use of data. Another hurdle to data sharing was scientists' concerns that they were often not credited for their data contributions, and their worry of being "scooped" by others publishing a manuscript first, without their consent.

GISAID provided an entirely new approach to overcome these hurdles. Since its 2008 launch, GISAID has proven time and again its value as a trusted and effective mechanism for sharing vital information on pathogens. By December 2021, GISAID had shared nearly 6 million SARS-CoV-2 genome sequence submissions. As essential as GISAID has proven, however, it has a critical limitation: It shares DSI, but not physical virus samples. As SARS-CoV-2 has shown, rapid access to the virus itself is crucial to swift pandemic response, and should be built into the system going forward.

Inconsistent implementation of the Nagoya Protocol and its associated access and benefit-sharing provisions has proved complex and counterproductive for timely access to pathogens in many countries. It has delayed sharing of both genetic information and physical samples for pathogens including influenza, Zika, and Ebola, in some cases by

months – delays untenable in a pandemic. Adding DSI into the scope of the Nagoya Protocol would significantly increase the probability of delays, because, unlike physical virus samples, DSI can now be shared instantaneously electronically. Mechanisms requiring commercial negotiations before access to pathogen samples is granted, such as those proposed for WHO’s BioHub System, are also bound to cause delays and would be a substantial disincentive for developers of vaccines, therapeutics, and diagnostics.

What Industry Has Learned from Influenza

Since September 2018, access to more than 30 influenza viruses has been delayed for 3 weeks to 9 months until legal clarity was achieved. From the time virus strains are identified by WHO, manufacturers have very little time, in some cases only weeks, to research, develop, and begin large-scale manufacturing for seasonal influenza vaccines. Any delay can have a knock-on effect in terms of the quantity and effectiveness of doses finally produced, leading to preventable infections, illness, and deaths.

Industry has learned three challenging lessons on the real-world realities of pathogen sharing:

1. A lack of clarity on the ground about what is and isn’t covered by national access and benefits sharing (ABS) legislation creates confusion and delays.
2. The reality of how pathogens are shared among national laboratories, WHO collaborating centres, researchers, and manufacturers means that national legislation can require multiple bilateral agreements to be agreed before samples are shared.
3. Even countries with sophisticated ABS legislation have created legal regimes that don’t account for the actualities of pathogen sharing. This has caused significant delays due to the lack of legal clarity and predictability.

Reports from numerous high-level panels and others have documented the need for massive investment to strengthen health security, beginning with improved and expanded viral surveillance. **That investment will not achieve the ultimate goal of protecting people worldwide if access to pathogens and their DSI is constrained.**

The [100 Days Mission](#) set an ambitious goal of developing tests, treatments, and vaccines within 100 days of WHO declaring an international emergency. Industry shares that ambition and knows it hinges on swift, sure, and unencumbered access to pathogens and their genetic information. **A delay of even a few days will jeopardize the mission and risk lives during a pandemic.**

“DSI from pathogens is a global public health good that should benefit all.”

– World Health Organization⁹

2. Partnerships Accelerate R&D and Manufacturing

Effective voluntary partnerships spanning the globe accelerated research and development and manufacturing for COVID-19 vaccines and therapeutics. More than 330 partnerships – public-private, private-private, private-academic, and others – bolstered manufacturing capacity, facilitated technology and knowledge transfer, and drove historically rapid R&D.

Indeed, a study of candidate vaccines in clinical and pre-clinical development registered by WHO as of May 11, 2021, found that 30% were being developed jointly by two or more partners.¹⁰ During COVID-19, public-private partnerships, including advance purchase agreements, accelerated R&D investment when societal needs outpaced normal market forces. There was not a singular approach to risk sharing, and some companies proceeded and succeeded without it.

“The need for better, more broadly protective, more durable vaccines is clear. But if we want them, we must invest in the research and development to produce them. Making such investments shouldn’t be a hard choice for forward-thinking governments.”

– Richard Hatchett, CEO Coalition for Epidemic Preparedness Innovations (CEPI)¹¹

Governments recognized the health and socioeconomic impact of vaccines and therapeutics and their investment was proportionate to the risk the world faced. The most successful COVID-19 public-private partnerships – such as the US government’s Operation Warp Speed, now the Countermeasures Acceleration Group – ran on three key principles:

Government funding was fast. WHO declared COVID-19 a PHEIC on January 30, 2020. On May 15 the federal government announced Operation Warp Speed, a partnership between the Department of Defense (DOD), the Department of Health and Human Services (HHS), and the private sector. The goal was to produce 300 million doses of COVID-19 vaccines, with initial doses available by January 2021.

Government funding was substantial. By the end of 2020, DOD and HHS had obligated approximately \$13 billion to six companies to accelerate vaccine development, manufacturing, and distribution and \$450 million to manufacture a monoclonal antibody (mAb) treatment.^{12,13} The government recognized that clinical development, process development, and manufacturing scale-up “can be substantially accelerated by running all

streams, fully resourced, in parallel. Doing so requires taking on substantial financial risk, as compared with the conventional sequential development approach.”¹⁴

Government funding was flexible. Recognizing the inherent uncertainty of biotechnological R&D, the US government deliberately employed a strategy of selecting different platform technologies.¹⁵ The office was not directive but rather sought “to enable, accelerate, harmonize, and advise” and to leverage “the full capacity of the US government to ensure that no technical, logistic, or financial hurdles hinder vaccine development or deployment,¹⁶ including actions outside of funding. For example, officials worked with the State Department to expedite visa approvals for key technical personnel including technicians and engineers to assist with installing, testing, and certifying critical equipment manufactured outside the US¹⁷

These principles were also key to the UK’s approach, which balanced investment in the country’s science infrastructure and advance purchase commitments with global companies.

Innovative private-sector partnerships have driven some of the most effective pandemic responses. To create these partnerships, companies assessed potential partners’ quality, compliance, and safety track record; technical capability; capacity availability; workforce knowledge and training; project management abilities; prior working relationships and mutual trust; and commitment to working together flexibly to progress a fast-paced program while assuring safety.

“Pfizer has been investing at risk since the early days of the pandemic to perfect our manufacturing processes and rapidly build up capacity.”

– Albert Bourla, Pfizer CEO¹⁸

Partnerships have been critical to advancing COVID-19 vaccines and treatments, and have taken various forms. For example:

Pfizer and BioNTech leveraged each partner’s knowledge and capabilities, building on their existing partnership to develop mRNA-based influenza vaccines.¹⁹ With BioNTech contributing multiple mRNA vaccine candidates and Pfizer its global vaccine clinical research and development strengths, regulatory, manufacturing and distribution infrastructure and capabilities, the companies have produced a COVID-19 vaccine in use worldwide.²⁰

AstraZeneca and University of Oxford entered into a partnership to develop a COVID-19 vaccine candidate²¹ and AstraZeneca reached a licensing agreement with Serum Institute of India (SII) to supply 1 billion doses for LMICs.²² AstraZeneca also partnered with the Oswaldo Cruz Foundation (Fiocruz²³) CSL/Seqirus,²⁴ Siam Bioscience,²⁵ and SK Biosciences²⁶ to produce its vaccine. As a result of licensing agreements and multiple tech transfers, two thirds of AstraZeneca’s 2.3 billion doses produced in 2021 went to LMICs. AstraZeneca also licensed coronavirus-neutralising antibodies from Vanderbilt

University²⁷ and developed Evusheld (tixagevimab co-packaged with cilgavimab), a long-acting antibody combination which was authorised by FDA for EUL in December 2021.²⁸

Novavax and SII partnered on the clinical development, co-formulation, filling and finishing, and commercialization of the Novavax COVID-19 vaccine candidate in LMICs and India.²⁹ **Novavax and Takeda** announced in August 2020 that the companies are partnering on manufacturing, clinical development, and regulatory activities in Japan. Novavax will license and transfer manufacturing technologies to enable Takeda to manufacture the vaccine antigen and will supply its proprietary adjuvant to Takeda. Takeda will be responsible for regulatory submission to the government and will produce and distribute the vaccine in Japan. The Japanese government provided funding to Takeda for technology transfer, infrastructure, and manufacturing scale-up.³⁰

MSD and biotech Ridgeback Biotherapeutics co-developed molnupiravir, an oral antiviral agent. Starting in 2004, research was conducted at Emory University's Drug Innovation Ventures at Emory (DRIVE) program, a non-profit formed by the university to develop early-stage drug candidates for viral diseases of global concern. The antiviral agent had previously demonstrated broad-spectrum activity against other viruses such as influenza, Ebola, and Venezuelan equine encephalitis, and Emory's work was supported in part by funding from the National Institute of Allergy and Infectious Diseases and the Defense Threat Reduction Agency. Ridgeback Biotherapeutics licensed the drug from DRIVE in March 2020; in May, MSD and Ridgeback joined forces to drive development and global access. In September 2021, BARDA procured 1.7 million courses of the five-day regimen.³¹

Johnson & Johnson and Aspen agreed in November 2020 to the technical transfer and proposed commercial manufacture of J&J's COVID-19 vaccine candidate, which was then undergoing clinical trials. Aspen Pharmacare is performing formulation, filling, and secondary packaging of the vaccine for supply to J&J. Aspen Pharmacare agreed to provide the necessary capacity required at its existing sterile facility in Port Elizabeth, South Africa.³²

GSK and Sanofi announced their collaboration in April 2020. The companies are developing an adjuvanted booster vaccine for COVID-19, using innovative technology from both companies. Sanofi contributed its S-protein COVID-19 antigen, which is based on recombinant DNA technology, and GSK contributed its adjuvant technology. Sanofi is leading the clinical development and registration of their COVID-19 vaccine.³³

Roche and Regeneron announced in August 2020³⁴ a collaboration to develop, manufacture and significantly increase global supply of an antibody combination known as Ronapreve (casirivimab and imdevimab). The companies worked closely with governments and health authorities in a concerted effort to bring the antibody combination to as many patients as possible, resulting in the provision of 1.5 million doses across 60 countries to date.

MSD and Johnson & Johnson cemented an uncommon partnership between two global competitors, in which one multinational vaccine company – MSD – will produce another's – J&J's – vaccine. With funding from BARDA, MSD repurposed existing vaccine

production facilities to produce drug substance and to expand form-fill-finish capacity.³⁵ Sanofi and Johnson & Johnson struck a similar partnership.

GSK and Vir are partnering to develop sotrovimab, a monoclonal antibody delivered by intravenous infusion for the early treatment of COVID-19. The FDA issued an EUA in May 2021 for sotrovimab, the European Commission purchased 220,000 doses in July 2021,³⁶ and the US government agreed to a purchase of approximately \$1 billion worth of doses in November 2021, with an option to purchase additional doses through March 2022.³⁷

Public-Private Partnerships Essential to Advancing COVID-19 Vaccines

The US government supported multiple vaccine candidates by contributing funding toward multiple research and development programs, manufacturing capacity expansion efforts, and advance purchase commitments. R&D funding amounted to nearly \$1.5 billion USD. Advance purchases totalled \$16.75 billion USD, with nearly 30% (\$4.84 billion USD) provided to companies whose vaccines are not yet authorized for use in the US or have been discontinued entirely.

Some might conclude that the US wasted tax dollars funding vaccines that aren't being used. But in a pandemic you want to progress as many likely interventions as possible, and it isn't possible to know which will ultimately succeed and which will fail. On average, before the COVID-19 pandemic, developing a novel vaccine took 8 to 17 years and cost \$560 million to \$1.12 billion USD to go from antigen identification to post-marketing surveillance.³⁸ Manufacturers typically bear the full costs of the most expensive component – very large late-stage trials – and vaccines (and medicines) can and do fail in later stages. Those failures have to be paid for, regardless of whether a commercial product advances to market.

The public-private partnership between the US government and vaccine companies was critical for successful development and large-scale manufacturing of multiple vaccines now in use around the world - from Moderna, Johnson & Johnson, and AstraZeneca. Germany, the UK, the European Union, and other governments, along with CEPI, also supported R&D and manufacturing through direct investments and advance purchase agreements.³⁹

Both pathogens and pandemics are dynamic, and innovation must continue for the world's response to SARS-CoV-2 to succeed. Industry continues its quest to discover, develop, and deliver new generations of COVID-19 vaccines that provide longer lasting and stronger protection and are easier to transport, store, and administer, along with new treatments to respond to variants. Companies are working on developing universal or multivalent vaccines that could offer protection against multiple strains of COVID-19, or even the whole family of coronaviruses. They are developing COVID-19 vaccines that can be co-administered with other vaccines, such as flu or pneumonia, eliminating barriers to uptake and reducing pressure on our healthcare systems. Developers are exploring different administration methods such as patches and nasal sprays. And they are optimizing production and compressing delivery timelines, pioneering new vaccine manufacturing methods that enable existing facilities to quickly pivot and expand production.

Despite scientific advances that have driven vaccine and therapeutic development at historic speed and scale, the uneven distribution of pandemic products has caused some to call for a complete refashioning of R&D⁴⁰ and manufacturing, “shifting from a model where innovation is left to the market to a model aimed at delivering global public goods.... R&D and all other relevant processes [should] be driven by a goal and strategy to achieve equitable and effective access.”⁴¹ Industry wholeheartedly supports the aim of access for everyone, everywhere – because the true public good is the prevention and treatment of COVID-19, reducing transmission of the virus, and benefitting all. That can happen only through effective delivery programs, and achieving that goal should be an ambition the world shares. The best vaccines and treatments in the world won’t work if people don’t receive them. Centralising planning and funding for pandemic R&D, manufacturing, and procurement for the world won’t solve that challenge and is unlikely to be a workable solution, as international arrangements for other global problems – for example, climate accords – have shown.

“Policies promoting fair and effective collaboration and knowledge-sharing are key for public health to avoid stumbling blocks for vaccine development, deployment, and equitable access, both for COVID-19 and expected future pandemics.”⁴²

The 100 Days Mission: A Global Ambition

The [100 Days Mission](#) builds on the public-private partnerships formed in the current pandemic and adopts a mission-oriented approach to achieving the ambition of making safe and effective diagnostics, therapeutics, and vaccines available within the first 100 days of a pandemic threat being identified.

In June 2021 G7 leaders and global life science industry leaders welcomed the 100 Days Mission following the recommendations by the pandemic preparedness partnership, an international group of experts convened by the UK’s Government Chief Scientific Adviser Sir Patrick Vallance to advise the G7 Presidency. The Mission was also supported by the G20 in October 2021, where leaders agreed to back science to shorten the cycle for the development of safe and effective products from 300 to 100 days following the identification of future pandemic threats.

In December 2021 the UK published the [100 Days Mission: First Implementation Report](#), which documents the progress and plans for the Mission, serving both as a testament to the critical work already underway by international organisations and the private sector (including WHO, CEPI, IFPMA, FIND) to achieve the mission. It serves as a reminder that sustaining momentum over the coming years will be essential to combating future pandemic threats. The 100 Days Mission is now a global ambition

expanding beyond its inception in the G7, and experts will report annually on progress, demonstrating continued commitment to achieving this vital mission by 2026.

3. Advance Market Commitments Support Manufacturing Scale Up for Global Pandemic Response

Advance market commitments for COVID-19 vaccines and therapeutics – prior to stringent regulatory authorizations – allowed for vital supplemental investments in production capacity and voluntary technology transfer. Even amid the shifting uncertainties of the pandemic – evolving variants, changing epidemiology, and fluctuating geographic hotspots – those commitments sustained at-risk but indispensable investments.

Firm purchase commitments given before products in development have proven their safety and efficacy – known as advance market commitments – ensure that products that do prove safe and effective have a secure market. These commitments were essential to enable at-risk scale up of manufacturing for COVID-19 vaccines and therapeutics well in advance of product authorizations by stringent regulatory authorities. In the [100 Days Mission](#),⁴³ the G7's Pandemic Preparedness Partnership has wisely called for an automatic mechanism to procure and distribute diagnostics, therapeutics, and vaccines and for consideration of advance commitments for procurement. Advance market commitments are crucial for rapid access, enabling at-risk investments in capacity, and spurring technology transfer. But they also had the unintended consequence of high-income countries tying up nearly all the supply of doses during 2021 as the primary public funders of R&D and expanded manufacturing contracted for doses – sometimes greatly in excess of their populations.⁴⁴ Because COVAX was unable to compete on equal footing, and some rich nations delayed dose donations, the world's poorest countries were forced to wait. Allocation decisions for contracted doses are not in manufacturers' control, a reality acknowledged by the heads of the IMF, World Bank, WHO, and WTO in November 2021, when they “encouraged all G20 governments to join the effort to meet the vaccination target of 40% by end-2021 by **allowing** manufacturers to prioritize COVAX and African Vaccine Acquisition Trust (AVAT) contracts; streamlining donations to COVAX and pledging more doses; exploring possibilities for effective vaccine swaps with COVAX and the AVAT; and eliminating export restrictions to vaccines and their inputs” [emphasis added].⁴⁵ Ahead of the next pandemic, wealthier nations should proactively consider mechanisms to provide doses to poorer countries at the same time they receive their contracted allotments. (See Lesson 6 An Established Procurement Mechanism for Low-Income Countries Is Vital.)

In an early review of the US government's efforts to drive development, manufacturing, and deployment of COVID-19 vaccines and therapeutics, the Government Accountability Office (GAO) identified four critical challenges:

Limited manufacturing capacity. Before the COVID-19 pandemic, most existing vaccine manufacturing capacity was already in use, so new capacity had to be created or production shifted from other products.

Disruptions to manufacturing supply chains. Supply chains may be strained by disruptions caused by the global pandemic, including changes in the labour market, increases or decreases in the demand for certain goods, and export restrictions implemented by some countries. [See Lesson 5.]

Difficult technology transfer processes. Transferring unique equipment and knowledge about how to produce COVID-19 vaccines and therapeutics across multiple manufacturing sites, often involving subcontractors, is a complex process, and especially difficult for new technologies such as mRNA vaccines, where there is no experience in scaling up production.

Gaps in available workforce. The ability to hire and train personnel with the specialized skills needed to run vaccine manufacturing processes may be a challenge even for experienced manufacturers.⁴⁶

In hindsight, GAO's report was prescient. Pre-COVID, global vaccine manufacturing capacity was 5 billion doses a year. In 2021 more than 11 billion COVID vaccines were produced, even as production for other vaccines and medicines continued in parallel. Going into 2022, more than 1 billion COVID-19 vaccines are being produced every month. Despite this unprecedented scale up, the challenges GAO predicted have temporarily constrained industry's ability to satisfy needs of countries around the world. Slower vaccine delivery to lower-income countries has led to calls for yet more manufacturing know-how and capacity to be created, with a focus on underserved regions such as Africa.

Individual companies are working with governments on new initiatives to ensure the necessary global manufacturing know-how and capacity to vaccinate and/or treat the world's population as quickly as possible during a pandemic. Many companies are already working to expand current manufacturing capacity for high-volume production through voluntary partnerships and innovative approaches to facility design, while preserving existing manufacturing capacity to ensure continuity of the global supply of routine vaccines. Johnson & Johnson was first to partner with a South African firm to fill-and-finish vaccines in November 2020,⁴⁷ and Pfizer signed a similar agreement in July 2021.⁴⁸ BioNTech has announced plans to build an mRNA vaccine production facility starting in mid-2022 in Africa.⁴⁹ Moderna has likewise announced plans to build a mRNA vaccine production facility on the continent.⁵⁰ Strong support from the African Union, the Africa CDC, national governments, the creation of the African Medicines Agency, and WHO's intent to build needed workforce capacity contributed to manufacturers' willingness to make these commitments.

Challenges on the Ground: Pfizer's Manufacturing Experience in Africa⁵¹

Scaling out manufacturing is not as simple as sharing a vaccine's "blueprint." Pfizer has experienced a variety of challenges over time in pursuing local manufacturing, including:

Consistent electricity and water supplies. In South Africa, the national electricity and water providers ration quantities.

Retaining employees. Employees newly trained in the complexities of vaccine manufacturing frequently seek opportunities elsewhere, and often outside of Africa.

Volume. High fixed costs require large volumes to break even, let alone make a profit. So far, every localization has resulted in higher costs of goods than making at Pfizer's global site and shipping out.

Regulatory record. Local companies may not have a strong history of regulatory inspections by their NRAs (National Regulatory Authorities).

Regulatory oversight. High-performing NRAs are critical, and may be lacking in emerging economies, leading to longer review and approval timelines.

Cold-chain capacity. Pfizer's COVID-19 vaccine requires dry ice, which is in short supply on the continent. Instead, the company had to make its own.

Time. Pfizer and the Biovac Institute announced a deal in 2015 to produce the company's pneumococcal vaccine in South Africa. The tech transfer took 5 years.

In the longer term, a coordinated strategy to locate new capacity across all regions of the world would facilitate effective scale-up for future pandemic vaccines and treatments and mitigate the risk of inefficient, excess manufacturing capacity. A holistic and strategic vision and roadmap for flexible, sustainable global manufacturing capacity needs to be jointly developed by public sector organizations, industry, and other stakeholders. Expanded production capacity will require sustainable business plans that reliable public sector funding over years and comprise not only pandemic products but also routine vaccines and treatments, to continue production between pandemics, assuring surge capacity when needed. The jointly developed roadmap should propose how the extensive upstream and downstream COVID-19 vaccine capacity should be utilized in the future and include provisions for strengthening national preparedness capabilities; trade, customs, and regulatory policies; investments in workforce expansion and up-skilling; retaining scale during non-pandemic periods; and support for manufacturing upstream components, raw materials, and consumables.

Planning the construction of any new vaccine or medicine capacity is a complex and costly undertaking that will require defined public health needs, policy goals, technological

and geographical ambitions, and close collaboration between the public and private sectors. Building the necessary capabilities will require sufficient long-term funding and realistic timescales. The goal should be to achieve a healthy market dynamic over time, including in inter-pandemic periods, that provides appropriate incentives balancing global access and innovation.

Learning from the Past: Distributed Manufacturing of Influenza Vaccines

In 2006, WHO launched the Global Action Plan for Influenza Vaccines to serve as a ten-year strategy with the overarching goal of increasing equitable access to pandemic influenza vaccines. This strategy included plans to increase global production capacity to be able to produce enough vaccine to immunize 70% of the world's population with two doses of a pandemic vaccine within six months from the availability of the vaccine virus strain.

By 2016, annual production capacity was estimated to have almost tripled, reaching 1.47 billion doses of seasonal vaccine and potentially translating to capacity to produce 6.37 billion doses of monovalent pandemic vaccine. However, the ten-year global progress report⁵² documented a **decrease** in the number of countries with seasonal vaccine production capacity in place, shown in the table below. This fall off occurred despite a technology transfer project under the plan where WHO, supported by partners including BARDA and PATH, provided seed funding and technical support to vaccine manufacturers located in LMICs to establish local influenza vaccine manufacturing.

Countries with seasonal influenza vaccine production capacity in place by WHO region, 2006, 2011, 2016

WHO Region	2006	2011	2016
African region	0	0	0
Region of the Americas	2	2	4
South-East Asia region	0	1	1
European region	12	13	6
Eastern Mediterranean region	0	0	0
Western Pacific region	3	4	4
TOTAL	17	20	15

“Sustainable local production and procurement of influenza vaccines requires a coherent and coordinated approach to industrial, economic and public health policies, brought forward through transparent and joint actions of all stakeholders (e.g. government agencies, manufacturers, international multilateral institutions and donor communities),” the report noted.

Influenza vaccine manufacturing facilities have closed because of a lack of continuous demand for vaccination – leading to a production capacity deficit that will constrain future pandemic response absent improvement. This experience underscores the need for careful planning: for the facilities themselves and, equally important, for how they will remain productive and sustainable over time. Building vaccine confidence and acceptance – particularly among adults – will improve health and wellbeing. It will also help build the needed vaccine delivery infrastructure and sustain manufacturing between pandemics, maintaining the ability to flex and surge in the face of a global threat.

“There are so many complex issues which one has to really understand before getting into the tech transfer. Even before you get into technology transfer, you have to understand and have skills in a complex process. The ability of a company to absorb technology transfer, have the skilled manpower, and scale up is a challenge and not everyone has that.”

– Rajinder Kumar Suri, Developing Countries Vaccine Manufacturers Network⁵³

Emergent: The Complexities of “Warm-basing” and Tech Transfer^{54,55}

Despite years of experience producing vaccines for smallpox and anthrax for the US government, Emergent stumbled badly in manufacturing COVID-19 vaccines for AstraZeneca and Johnson & Johnson, ruining millions of desperately needed doses through cross-contamination.

In 2012, the US government awarded Emergent a contract to expand its Baltimore, Maryland, manufacturing site to ready it to produce vaccines against an unknown, novel pathogen, while keeping the facility “warm” by producing small stockpiles of anthrax and smallpox vaccines. But when SARS-CoV-2 struck in 2020, the Baltimore site had yet to secure regulatory approval to mass-produce any approved product.

In March 2021, ingredients of the AstraZeneca vaccine contaminated 15 million doses of the Johnson & Johnson vaccine. In April, the government halted manufacturing, moved the AstraZeneca production, and put Johnson & Johnson in direct control of vaccine production.

In June, the FDA required another 60 million doses be discarded. Following Johnson & Johnson intervention and repeated regulatory reviews by FDA, Health Canada, the European

Medicines Agency, and the South African Health Products Regulatory Authority, some doses were cleared for use as of November 2021.

No tech transfer is ever easy, simple, or straightforward, even between highly experienced manufacturers. Building know-how, capacity, and capability ahead of the next pandemic will require coordination and collaboration across the ecosystem. Equally important, the system must incorporate redundancy to mitigate the risk of failure.

Sectors other than the biotechnology and pharmaceutical industries have a critical role in enabling and supporting medical countermeasure research, development, and manufacturing – for example, the development of improved culture media for cell cultures; bioreactors; and fermenters to enhance yields and improved membranes, chromatographic, and other methods for concentration and purification are provinces of chemical and engineering companies specializing in these products. These and other industries that play a role in the larger ecosystem should be included in preparedness assessments.

4. Innovation Is Essential for Preparedness and Response

More than two decades of investment powering tenacious research and development – even in the face of costly failures – laid the groundwork for the record-shattering development timelines for the mRNA and viral vector vaccines now in use to mitigate COVID-19 disease.⁵⁶ The global legal frameworks supporting innovation were essential to that continuous pursuit of safe and effective vaccines.

Disparities in access to vaccines and therapeutics – a global failure to this point in the pandemic – have led some to advocate for radical changes to the world’s intellectual property architecture. These changes would not speed up access to vaccines and treatments now and would undermine the world’s ability to respond to the next pandemic by discouraging research and development of needed vaccines and medicines. Ahead of the next pandemic, agreed-to strategies to support equitable access among countries and, critically, to ensure health systems can swiftly deliver treatments and vaccines are imperative.

All stakeholders share the objective of faster and broader access. Waiving patents on COVID-19 vaccines and medicines will not speed production, deliver vaccines and treatments, or bring this pandemic to an end. Producing safe and effective products requires extensive knowledge of the methods, facilities, and controls used in manufacturing, processing, and packing – know-how monitored by stringent regulatory authorities such as the FDA under Current Good Manufacturing Practice (CGMP).⁵⁷ Without that know-how, the intellectual property itself cannot drive faster production. Multiple governments, non-governmental organizations (NGOs), civil society, and academics have stated that this debate is distracting us from the urgent task at hand – getting life-saving vaccines and medicines to people who need them.

"Some COVID-19 vaccines involve hundreds of individual components, as many as 50,000 discrete production steps and dozens of quality control checks, all of which requires vital know-how that does not come with a patent."

– José Manuel Barroso, Gavi Board Chair⁵⁸

Before COVID-19, no nucleic acid vaccines were authorized or licensed for human use by any stringent regulatory authority anywhere in the world. Through decades of R&D, 15 mRNA vaccine candidates had entered clinical trials, but by

the end of 2019 none were in Phase 3. Experts believed it would be another 5–6 years before an mRNA vaccine would obtain regulatory approval. The investment, partnerships, and many years of hard work and innovation that led to the historically rapid development and manufacturing of COVID-19 vaccines and treatments would not have happened without global legal frameworks supporting intellectual property.⁵⁹ “Even if the IP was waived, I guarantee to you that it would mean nothing. How are we going to do it? We don’t have the facilities to do this at scale. We don’t have the expertise, the knowledge, the infrastructure. People need to balance the IP issue with reality.”

– Kelly Chibale, Founder of the integrated drug discovery and development centre H3D in Cape Town, South Africa⁶⁰

Manufacturers Take Action To Improve Access

Long before the SARS CoV-2 pandemic, pharmaceutical companies engaged in voluntary licensing agreements (VLAs) as an important part of their strategy to reach patients globally with their medicines and vaccines, with robust IP frameworks providing them the necessary confidence to engage in these transactions. Several IFPMA member companies have established long-term partnerships with the twelve-year-old Medicines Patent Pool (MPP) to license their HIV, tuberculosis, and hepatitis C medicines to well over 100 countries. The MPP uses established frameworks for the public health management of intellectual property through public-private partnerships, negotiating licences with patent holders and then licensing those patents to multiple manufacturers, who develop the licensed medicine.⁶¹

COVID-19 amplified voluntary licensing by IFPMA members as a mechanism to increase manufacturing volume and expand access. In April 2021, MSD announced bilateral VLAs with multiple generic manufacturers to supply its oral antiviral, molnupiravir, to 105 countries. In October 2021, MSD and the MPP announced they had entered into an agreement for the MPP to grant additional sublicenses to manufacturers to supply these 105 countries. Pfizer similarly voluntarily licensed intellectual property related to its oral COVID-19 treatment through the MPP to enable qualified generic medicine manufacturers to produce and distribute generic versions of the treatment to 95 countries. Gilead Sciences entered into voluntary licensing agreements with nine generics manufacturers and provided technology transfers to further expand supply of remdesivir to 127 countries, representing nearly all low-income and lower-middle income countries.

Gilead also expanded its global network of both internal manufacturing sites and external organizations, including partnering with industry peers, to add manufacturing capacity around the world. The remdesivir manufacturing network includes more than 40 companies in North America, Europe, and Asia. In response to the rapid increase in COVID-19 cases in India in

2021, Gilead provided its voluntary licensing partners with technical assistance, supported new local manufacturing facilities, and donated critical drug substance (known as active pharmaceutical ingredient, or API) to rapidly scale production.

At the outset of SARS-CoV-2, scientists at Eli Lilly and Company quickly collaborated with partners to advance innovative therapies. This work led to the first monoclonal antibody authorized for Emergency Use (EUA) treatment specifically for COVID-19: bamlanivimab. A second antibody, etesevimab, followed soon after to be administered together with bamlanivimab. The company also discovered that an existing Lilly medicine, baricitinib had the potential to treat COVID-19. From the outset, Lilly's goal was to work with global health systems to guarantee equitable access to COVID-19 medicines no matter where the patients who need them live. Treatment allocation was based on unmet medical needs globally. To enable affordability, Lilly's intent was for patients to have no out-of-pocket costs for its antibody treatments, wherever possible. Additionally, the company used tiered pricing models based on a country's ability to pay. Lilly also donated COVID-19 therapies to Direct Relief, enabling the humanitarian organization to provide therapies at no cost to low- and lower-middle-income countries most heavily affected by the pandemic. Lilly donated baricitinib to the Indian government through Direct Relief while simultaneously working with in-country pharmaceutical companies to execute royalty-free voluntary licensing agreements to accelerate the manufacturing and distribution of the medicine in India during the pandemic.

Additionally, manufacturers have voluntarily acted to provide their vaccines at reduced prices for less-resourced economies. AstraZeneca committed to sell on a not-for-profit basis during the pandemic and supplied more than 248 million doses to COVAX in 2021. Johnson & Johnson similarly pledged to provide its vaccine at a not-for-profit price for emergency pandemic use and worked with the EU to donate doses to COVAX and with the US government to supply doses for the Humanitarian Buffer, providing immunizations to tens of millions of people in areas beyond the reach of national health authorities.

In January 2021, Pfizer and BioNTech agreed to supply COVAX with 40 million doses of their vaccine. As their manufacturing scaled up, in May 2021 the companies pledged to provide 1 billion doses, 40% of their total production, to low- and middle-income countries and at least 1 billion in 2022.

IP laws have underpinned collaboration between biopharmaceutical innovators and governments, universities, and other research partners to speed progress on hundreds of potential COVID 19 diagnostics, therapeutics, and vaccines. IP has given companies the confidence to conclude more than 330 voluntary technology transfer agreements to expand delivery of COVID-19 vaccines and therapeutics through voluntary partnerships between industrialized and developing country manufacturers because it assures collaborators that their technologies can be securely shared and effective and safe vaccines can be produced. Developers continue pursuing R&D to respond to this pandemic, with 17 vaccines, 68 treatments and 25 antivirals in late-stage clinical development as of mid-January 2022.⁶²

“Manufacturing antibody medicines is incredibly complex and transferring the technology takes many months, as well as

significant resources and skill. Unfortunately, it is not as simple as putting a recipe on the internet and committing to not sue other companies during a pandemic.”⁶³

Moderna's Global Public Health Strategy

In March 2022, Moderna announced its global public health strategy through four new initiatives.

First, Moderna is announcing a commitment to expand its global public health portfolio to 15 vaccine programs targeting priority pathogens that threaten global health, advancing these vaccines into clinical studies by 2025.

Second, to accelerate research with the aim of advancing additional vaccines, Moderna is launching a new program, **mRNA Access**, that will open the company's preclinical manufacturing capabilities and research and development expertise to global partners and offer researchers use of Moderna's mRNA technology to explore new vaccines against emerging or neglected infectious disease.

Third, Moderna is expanding its patent pledge to never enforce COVID-19 patents for manufacturers in or for the Gavi COVAX AMC for 92 low- and middle-income countries.

Fourth, Moderna announced that, with the assistance of the U.S. government, it has entered into a Memorandum of Understanding with the Government of the Republic of Kenya to establish an mRNA manufacturing facility there. Moderna is building this facility in Africa with the goal of producing up to 500 million doses of vaccines each year at the 50 µg dose level. The company anticipates investing up to \$500 million in this new facility, which is expected to include drug substance manufacturing with the opportunity for fill/finish and packaging capabilities at the site.⁶⁴

5. Global Upstream Supply Chains Disruptions Put Production and Distribution at Risk

The lack of multiple, globally sourced components delayed pharmaceutical distribution throughout the pandemic. Shortages of raw materials and intermediate products made worse by trade restrictions and competition for and among vendors resulted in inefficient allocation of available supply, leaving most developers less capable of rapidly testing, manufacturing, and delivering COVID-19 vaccines and therapeutics. Proposed investments to expand manufacturing capacity must also build capacity for sufficient and rapid supply of critical commodities and raw materials.

“When nearly every country is affected at once, it creates pressures on global response systems and weak global supply chains.”⁶⁵

During COVID-19, manufacturers – of personal protective equipment (PPE), diagnostics, treatments, and vaccines – has faced global supply chain challenges, mainly due to a lack of surge capacity to meet massive worldwide need, but also driven in part by a lack of standardization and heterogeneity in supply chain infrastructure^{66,67} and by the complexity of the inputs required. Materials are sourced around the world, and production capacity for everything from active pharmaceutical ingredients (API) to bioreactor bags to vials and stoppers was not initially sufficient to handle massive escalation of demand for R&D and manufacturing. Currently, the single most significant constraint for vaccine producers is the worldwide shortage of raw materials, consumables, and equipment. Globally, existing production and stocks of input materials are committed to the manufacture COVID-19 vaccines, capping the number of vaccines that can be produced. Trade restrictions (see Lesson 8) exacerbated scarcity and added significant burden and uncertainty for manufacturers planning both global manufacturing scale-up and global dose distribution.

An issue that plagued many large-scale production of vaccines on all platforms during the COVID 19 pandemic was the short supply of key reagents, which are used in chemical analysis. This issue should be mitigated by strengthening supply chains for all relevant reagents and by keeping trade open. One developer’s delay in securing emergency use authorization was due to the limited resources available to produce the vaccine.⁶⁸

Biological manufacturers in general and mAbs manufacturers in particular were significantly affected by interruptions to supply chains for commodities and raw materials at the start of the COVID-19 pandemic. Particular elements of mRNA vaccines, like lipid nanoparticles and specialized reagents, had never been manufactured at scale, a new magnitude of challenge to ramping up global supply. The lack of even a single component of a product can grind development and manufacture to a halt. The unavailability of very

basic components, such as vials and stoppers, meant that developers experienced undue delays in getting products to people. The competition for and among vendors resulted in suboptimal allocation of supply, leaving all developers less capable of delivering rapidly.

“We’re running 24/7. So, if for one shift ... if that day, there’s one raw material missing we cannot start making products, and that capacity will be lost forever because we cannot make it up.”

– Stéphane Bancel, Moderna⁶⁹

Top exporters of items needed in the production, distribution, and administration of vaccines, 2018

Need	Top Exporters and Share of Global Exports		
Dry Ice	Netherlands 15.4%	Israel 12%	United States 8.8%
Adjuvants	Mexico 11.4%	China 11.1%	Turkey 9.1%
Preservatives	Germany 17.2%	Argentina 13%	India 12%
Stabilizers	France 36.4%	China 13.3%	Germany 12.5%
Antibiotics	China 23.1%	Switzerland 17%	Italy 9.4%
Needles	United States 21.4%	Ireland 13.5%	Mexico 11.3%
Syringes	United States 14.5%	China 11.2%	Germany 9.6%
Vials	China 17%	Germany 13%	Italy 8.7%
Stoppers	Germany 17%	China 11.1%	Poland 6.7%
Freezers	China 67%	Italy 3.5%	Romania 3.5%
Vaccine Carriers	United States 17.7%	Germany 14.2%	Mexico 11.9%
Cold Boxes	China 14.7%	Germany 12.6%	France 6.9%

Source: Organisation for Economic Co-operation and Development (OECD).⁷⁰

Supply limitations and barriers to the exchange of goods delayed the testing and manufacture of COVID-19 vaccines and therapeutics. Proposed investments to expand manufacturing capacity must also build the capacity for sufficient and rapid supply of critical commodities and raw materials, with the entire enterprise protected by open trade policies.

One Manufacturer's Supply Chain Challenges

One top-10 biopharmaceutical company reported the complexities of managing the various pieces of its supply chain:

An average product — from procurement of raw materials through production — may use approximately 800 different ingredients, components, and materials.

These 800 different items are procured globally, usually across approximately 150 vendors.

Ingredient scarcity or disrupted supply chains strain a manufacturer's ability to make a product.

Makers of neutralizing antibodies, vaccines, and other therapeutics (which experienced increased demand due to so many people being hospitalized) all compete for some common materials, including:

- media for cell culture to produce active ingredients,
- high-performance chromatography resins for product purification,
- vials and components (needles, stoppers, etc.) for drug product filling,
- high-performance filters for sterility assurance.

These materials are custom, regulated, and often proprietary. They are not “off the shelf” items that can easily be sourced elsewhere.

Standardization is an important lever to address the input supply chain challenges in combination with efforts to pre-emptively map inputs and, if possible, increase supply. Standardizing certain consumables when manufacturing is dispersed across a number of sites can help streamline production. However, standardization can also exacerbate demand spikes for the same set of inputs.⁷¹ Because manufacturing platforms and individual production processes differ widely across industry, standardizing consumables is complex and extremely challenging. The introduction of new materials or components into a licensed manufacturing process takes time and resources because it requires technical evaluation, data generation, and regulatory approvals. Not all inputs lend themselves well to standardization – for example, biological inputs may not be as straightforward to standardize as equipment. Further, newer vaccine platforms, such as

DNA and RNA, have required a rapid scale up of new inputs not previously procured at commercial scale,⁷² adding complexity to the ability to pre-emptively standardize.

6. An Established Procurement Mechanism for Low-Income Countries Is Vital

COVAX was not sufficiently funded or organized quickly enough to secure advance purchase agreements for doses on a par with high-income country purchasers. When a pandemic is declared, sufficient, dedicated, and sustainable financing must be available immediately to procure goods for countries with limited or no capacity to finance their own pandemic purchases. Technical assistance must also be quickly provided to speed response implementation.

Equitable and early access to PPE, diagnostics, surveillance tools, treatments, and vaccines globally to prioritize those most at risk is a critical challenge during any pandemic. The establishment of the COVAX Facility for COVID-19 vaccines was “a breathtakingly important initiative”⁷³ and a huge step towards equitable access for lower-income countries, building on capabilities and competencies of existing alliances and infrastructure. But COVAX was not sufficiently funded or set up in time to secure advance purchase agreements for doses on a par with high-income country procurers. Additionally, its initially expansive remit – to procure vaccines for any country that wanted assistance – and prescriptive allocation mechanisms, while grounded in the principles of equity and fairness, proved politically unsustainable for many member states, which proceeded to make deals with manufacturers bilaterally or regionally.⁷⁴

The world can't wait for a solution to be built once a problem has already arrived

Since 2000, Gavi, the Vaccine Alliance has helped vaccinate nearly 900 million children in the world's poorest countries, working in close partnership with WHO, UNICEF, the World Bank, and the Bill & Melinda Gates Foundation, as well as governments and industry, among others. This unique alliance served as a solid foundation for the COVAX Facility, a coalition of international organizations managing procurement and allocation of COVID-19 vaccines for all countries and all populations. COVAX was without precedent. A hard lesson learned has been that the optimum time to test this ambitious pooled purchase facility was perhaps not in the midst of a global pandemic. By the time COVAX was initially capitalized in 2020, high-income countries had pre-purchased nearly all candidate vaccine doses, conditional on their authorization for emergency use by one or more stringent regulatory authorities. Similarly, in October 2020, the World Bank approved financing of \$12 billion for countries' vaccine acquisition and distribution (increased to \$20 billion in 2021).⁷⁵ But the supply of doses had largely been allocated by that point, leaving developing countries unable to make bilateral advance purchase agreements. “If the COVAX saga has shown anything, it is that the world

can't afford to wait for a solution to be built once a problem has already arrived. There must be a tool standing ready—funded and organized and able to spring into action—the moment a new health crisis emerges.”⁷⁶

When a pandemic is declared, sufficient dedicated and sustainable financing and technical assistance must be available immediately to countries with limited or no capacity to finance their own pandemic purchases and deployment activities. This will support early procurement and country readiness to absorb and deploy diagnostics, treatments, and vaccines.

Sharing doses between countries has helped advance COVID-19 vaccine equity, but it is not a solution to ensure lower-income countries are not left behind in the future. Wealthy nations had earlier access to vaccines not because of their ability to produce them, but because they had the financial capacity to procure vaccines at volume and the infrastructure to implement vaccination programs for age groups beyond infancy (see more on this in Lesson 9 Delivery Infrastructure). Despite these challenges, COVAX has been able to support the delivery of more than 1 billion doses as of mid-January 2022 – because Gavi can make advance market commitments (not purchases) before products gain WHO authorization, either through an EUL or prequalification (PQ). Its counterparts for therapeutics, the Global Fund and Unitaid, reportedly cannot, along with the World Bank. Unless this is corrected ahead of the next pandemic, interventions for those in the poorest countries may again be in jeopardy.

Proposals from the G20 and the global community for regional or centralized procurers for LICs in pandemics, with distinct mandates and geographic responsibilities, and transparent mechanisms for sustainable funding and equitable allocation are encouraging but need to secure full political support and long-term funding. A commitment by all nations not to restrict pandemic health-product-related exports and imports is also critical, especially at times when demand exceeds supplies.

"It's hard to imagine any organization built on the fly in the midst of a public-health crisis overcoming centuries of entrenched issues in global health. It's not COVAX's fault that some countries simply don't have the public-health infrastructure required to store, distribute and manufacture vaccines, nor that centuries of inequality have left some countries able to vaccinate their populations many times over while others cannot afford to sign a single contract."⁷⁷

Starting now and going forward, stakeholders need to develop draft procurement agreement provisions that detail their respective responsibilities. This should involve

visibility and clarity on volume requirements, procurement timelines and processes, and anti-corruption measures. The draft provisions may also include advance market commitments and/or responsible stockpiling. No-fault compensation (NFC) systems and liability protections are also essential prerequisites for rapid procurement and deployment under emergency conditions. (For more on the importance of NFC systems, see Lesson 10 Vaccine Confidence.)

7. Regulatory Agility and Convergence Guard Safety and Speed Access

COVID-19 vaccines and therapeutics were developed in record time thanks in no small part to the extraordinary degree of collaboration between industry and national and regional regulatory authorities. The collaborative consultations – between industry and regulators as well as among regulators – saved lives by managing speed, efficacy, and safety. If COVID-19 regulatory agilities lapse, however – for pandemic-potential vaccines and medicines and for others – the promise of scientific advancements and technology to speed development, production, and access to vaccines and therapeutics will not be realized.

For COVID-19 products, early guidance and “rolling reviews” from FDA, EMA, WHO, and the central coordinating role of the International Coalition of Medicines Regulatory Authorities (ICMRA) helped align industry around a common set of expectations for efficacy and data needed for emergency use, drove efficient and non-duplicative clinical trials, and enabled industry’s effective COVID-19 response.

“During the pandemic, we have watched the rapid deployment of clinical trials, the introduction of new and repurposed treatments, and now the development and use of new vaccines, many based on innovative and ground-breaking technological platforms. Throughout these processes, the role of regulatory authorities as independent and science-based institutions has proven more critical than ever.”

– Jarbas Barbosa, PAHO Assistant Director⁷⁸

Yet the wide diversity of regulatory processes, procedures, and expectations worldwide impede improvements to manufacturing processes and products and delay access and uptake of life-saving medicines and vaccines in pandemics and between them. Divergent data requirements and other non-uniform requests, such as country-specific requirements, labelling, packaging, and dynamic expiry dates, have increased the regulatory burden for manufacturers and their supply chains, and have posed challenges for vaccines donation. At this point in the pandemic, manufacturers may have three or more different labels for the same product, complicating dose sharing efforts.

For instance, in the WHO SEARO region, one country required 20 EUA applications for a single COVID-19 vaccine because it was produced from multiple sites (for both drug substance and drug product), imposing significant costs on the manufacturer and creating delays in access. Broader and more transparent use of mutual recognition of approvals, reliance on the approvals of other national regulatory authorities (NRAs), and work-sharing between NRAs would reduce complexity, lighten the regulatory burden throughout the supply chain, and promote convergence of regulatory requirements and expectations. It would also facilitate just-in-time delivery of doses and dose sharing. In this pandemic, divergent product labels and packaging have slowed or prevented doses being shifted from one country/region to another. That's inefficient, and puts people in harm's way.

Continuity of Operations for Conditions Other than COVID-19

With all the progress made against SARS-CoV-2, we risk losing sight of critical continuity of operational efforts that ensured research, development, manufacture, and delivery of essential medicines and vaccines for conditions other than COVID-19. During the pandemic, biopharmaceutical companies have been operating and manufacturing in an environment with disrupted supply chains. Lockdowns, movement restrictions, and stay-at home recommendations redirected health resources to the pandemic's front lines and away from new and ongoing clinical research for non-COVID-19 treatments. Because of demands for urgent clinical research on COVID-related products, patient enrolment in new non-COVID clinical trials and access to existing clinical research sites were limited, though, over time, some have returned to nearly pre-pandemic levels. During an outbreak, stringent regulatory processes remain essential to ensure the safety, quality, and effectiveness of all medicines and vaccines, and to facilitate ongoing clinical research. New technologies like remote monitoring helped improve recruitment of volunteers, clinical trials conduct, monitoring and data capture.

Ideally, in a pandemic, there would be worldwide agreement among regulators, WHO, and others about common clinical trial protocols, regulatory requirements, and "presentation" – that is, product packaging, inserts, labels, etc. – to drive a one-world approach to trials, evaluation, and product presentation. As a more modest proposal, pivotal NRAs should reach prior agreement on the regulatory agilities to be used in a pandemic for the development of new vaccines and medicines. For example, EMA's "pandemic preparedness vaccine marketing authorization" (informally called a mock-up) has enabled ongoing dossier updates and rapid review and approval of pandemic influenza vaccines. Similarly, pre-pandemic approval of common elements of manufacturing platforms, with pathogen-specific data being reviewed at the time of the pandemic, would speed development. These regulatory improvements allow manufacturers to make informed and streamlined decisions around clinical trial designs and data packages, dossier submissions, and product packaging and labelling, as well as risk-appropriate changes to facilities and manufacturing processes to better ensure an adequate supply of quality medicines and vaccines. Continued international facilitation through ICMRA and regional networks is also important. Global regulatory capacity varies widely. "Especially in

emergencies, better resourced regulatory authorities must remove barriers to offering timely support and securely sharing their full documents – such as scientific assessments and inspection reports – with less resourced authorities to support and inform their decision making.”⁷⁹

The collaborative consultation – between industry and regulators as well as among regulators – and regulatory agilities should be preserved and enhanced for pandemic-potential vaccines and medicines, as well as for other life threatening diseases. Absent ongoing regulatory innovation, the promise of scientific advancements and technology to speed development, production, and access to vaccines and therapeutics will not be realized. Achieving the G7’s global 100-day ambition will demand increased regulatory capacity and innovation in regulatory science. Industry will continue to work with regulators and clinical trial partners to speed development as much as possible while rigorously guarding safety.

The Importance of Pharmacovigilance

In a pandemic, vaccines and medicines are deployed globally, and the ability to review the benefit-risk profile of products as new data on potential adverse effects become available requires well-functioning global and national pharmacovigilance systems. Timely and accurate flow of safety data between health authorities, NRAs, and manufacturers enables early signal detection and prompt implementation of risk management strategies. According to WHO, these systems are not in place in many LMICs. This gap must be addressed and will have important population health benefits that go well beyond the pandemic – for example, in boosting vaccine confidence.

There is no concerted effort, so far, to address the immense regulatory burden, both on industry and national authorities, of the unprecedented review and pharmacovigilance challenges faced with COVID-19 vaccines. Countries are generally facing the same safety signals and concerns, requiring similar global data to assess and reach evidence-based decisions – duplicating these efforts to gather and analyse data can only serve to bog down the system. More can and should be done to foster the development of mechanisms and systems to facilitate regulatory collaboration on post-marketing safety surveillance, including work and information sharing, to promote better informed risk-based allocation of regulatory and scientific resources and to facilitate the wider exchange of information.

8. Vaccine Nationalism Imperils Everyone

The first obligation of any government is to ensure the safety of its people. But narrow understandings of that duty have led to the rise of "vaccine nationalism." Policies like export restrictions and vaccine hoarding, regardless of global public health need, have intensified and likely prolonged the COVID-19 pandemic. Refining the concept of "national health security" in a global context will be essential before the next pandemic.

“Vaccinating the world is not only a moral obligation to protect our neighbors, it also serves our self-interest by protecting our security, health, and economy.”⁸⁰

Negative economic impacts of vaccine nationalism could cost the global economy up to \$1.2 trillion USD annually. An estimated \$25 billion USD would supply low-income countries with vaccines. The US, the UK, the EU, and other high-income countries combined could lose about \$119 billion a year if the poorest countries go without vaccines. If high-income countries simply contributed the funds, there could be a benefit-to-cost ratio of 1 to 4.8. For every \$1 spent, high-income countries would get back about \$4.80.⁸¹ Two Nobel-winning economists, Abhijit Banerjee and Esther Duflo, have sharply criticised high-income countries' actions: “Early in the pandemic, wealthy countries did not mobilize enough of their resources – such as vaccines, protective gear, and oxygen – to help developing states. The result has been inadequate access to treatments, millions of unnecessary deaths, depressingly few inoculations, and a sequence of dangerous new variants. Silly as it sounds, the world may have sleepwalked into this disaster, not because anyone wanted it, but because nobody – particularly the United States and Europe – got around to exercising the leadership needed to stop it.”⁸²

Trade restrictions imposed by governments acting to protect their perceived interests have impeded the flow of pandemic-essential goods across borders, affecting both raw materials and commodities, as well as drug samples and finished products. Between January 2020 and the beginning of April 2021, countries took more than 260 actions banning or limiting the export of certain products for COVID-19-related reasons. More than 70 countries imposed export curbs on personal protective equipment and medical supplies.⁸³ For example, the US invoked the Defense Production Act, which prioritises US crisis response, hobbling Merck KGaA's ability to meet demand for supplies, including sterile fermentation bags and filters for vaccine manufacturers elsewhere.⁵ The EU implemented a regulation to monitor and limit the export of COVID-19 vaccines, using that

⁵ Burger, L, and P Weiss. "Supply Fears Lead Eu Vaccine Industry to Seek Home Comforts." Reuters, September 17, 2021. <https://www.reuters.com/business/healthcare-pharmaceuticals/supply-fears-lead-eu-vaccine-industry-seek-home-comforts-2021-09-17/>.

to block the shipment of 250,000 doses produced by AstraZeneca to Australia.⁸⁴ South Africa's government threatened to stop exports of J&J's vaccine to Europe. At a time when companies most needed to dedicate time and resources to increasing global supply, these restrictions disrupted supply chains and distribution routes, produced delays and additional costs, and increased the risk of supply shortages during the pandemic. Additionally, onerous travel restrictions prevented skilled workers from in-person, on-site tech transfer, further constraining production.

The Effects of India's Export Bans on COVAX

In 2020, the Bill & Melinda Gates Foundation, along with Gavi, signed a deal with the Serum Institute of India to ensure that 100 million vaccine doses would be available for low- and middle-income countries during the first half of 2021; they later expanded the agreement to cover an additional 100 million doses. AstraZeneca signed a ground-breaking agreement with Serum Institute to manufacture 1 billion doses of its Covishield vaccine for LMICs. But in the midst of its first COVID-19 wave in the Spring of 2021, India imposed a ban on vaccine exports, sharply curtailing supply to COVAX, and upending immunization plans for 91 low-and lower-middle income countries. India also banned exports of the antiviral remdesivir and its active pharmaceutical ingredients. The vaccine ban wasn't lifted until November 2021.

The heads of the IMF and the WTO have noted: "Taken collectively, export restrictions can be **dangerously counterproductive**. What makes sense in an isolated emergency can be severely damaging in a global crisis. Such measures disrupt supply chains, depress production, and misdirect scarce, critical products and workers away from where they are most needed. Other governments counter with their own restrictions. **The result is to prolong and exacerbate the health and economic crisis — with the most serious effects likely on the poorer and more vulnerable countries.**"⁸⁵

"A crisis without borders cannot be resolved by putting barriers between us. And yet, this is exactly the first reflex that many European countries had. This simply makes no sense. Because there is not one single Member State that can meet its own needs when it comes to vital medical supplies and equipment. Not one."

– EU Commission President Ursula von der Leyen⁸⁶

Work is happening to address these challenges: The COVAX marketplace⁸⁷ was created to improve the free flow of supplies through allocation and reallocation platforms. The WTO collated a working list of critical inputs⁸⁸ with the goal of pre-emptively addressing trade barriers, and the Asian Development Bank developed a supply chain mapping tool⁸⁹ that could help pre-empt potential input bottlenecks and/or identify opportunities for

standardization. These efforts are welcomed, and industry is committed to work with partners to mitigate supply chain risks. An enabling environment of established, pandemic-ready regulatory agreements, trade policies and codified risk-sharing mechanisms will strengthen global preparedness.

With distributed manufacturing, trade restrictions could pose a double constraint, by impeding the flow of both upstream and downstream goods. The COVID-19 pandemic has shown that multi-source supply chains across trusted partners refraining from trade restrictions can allow for redundancies that enable manufacturers to facilitate coordination, ramp up production efficiently and adapt to unanticipated spikes in demand. Planning for expanded manufacturing capacity more evenly distributed around the world should consider mechanisms to enable sufficient and rapid supply of critical commodities and raw materials. There should be global agreement that during pandemics member states will not impose trade restrictions on medical countermeasures or their components. Industry has welcomed participating in discussions with the WTO, IMF, and others to ensure global agreement ahead of the next pandemic that the free flow of goods across borders does not thwart equitable access to life-saving medicines and vaccines.

The irreducible truth of a pandemic is that we're all in it together, and no one is safe until we all are safe.⁹⁰ Refining the concept of “national health security” will be essential ahead of the next pandemic.

Vaccine inequity is a “stain on our global soul,” one of the “greatest policy failures of our times” and “a huge moral lapse on the part of the world.”

– Gordon Brown, former UK Prime Minister⁹¹

9. Delivery Infrastructure Must Be Strengthened

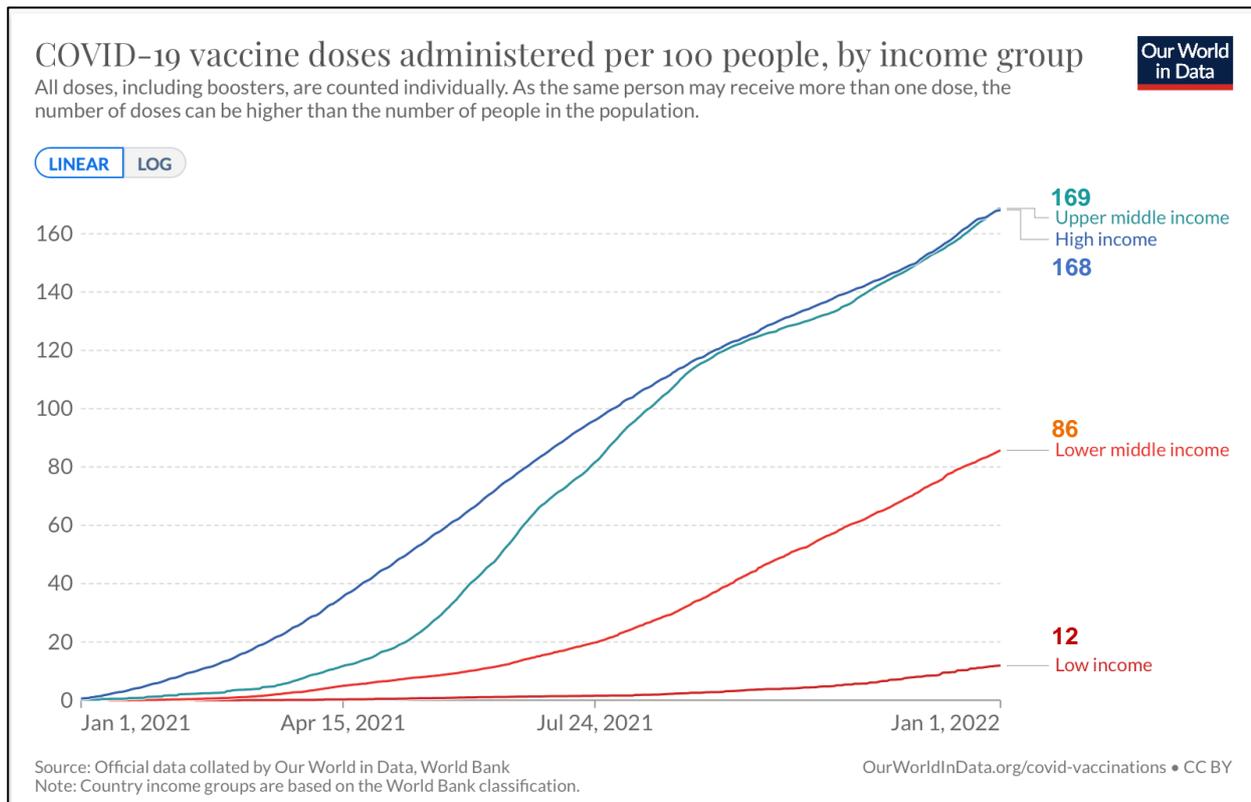
By late 2021, the world's vaccine supply was no longer constrained. Yet too many people in lower-income countries still lack access to COVID-19 vaccines and treatments. The pandemic has once again demonstrated the imperative of strengthening national health systems and ensuring universal health coverage for everyone, everywhere. All stakeholders – governments, civil society, manufacturers, and others – have a collective responsibility to ensure equitable access to vaccines and treatment starting now, in this pandemic, and to build the necessary infrastructure supporting countries' ability to deliver needed vaccines and medicines ahead of the next one. Strong national health systems and global health security are two sides of the same coin.

As of early January, more than 11 billion COVID-19 vaccine doses had been manufactured and most had been administered in nearly every country around the world. By mid-January, COVAX had delivered its one-billionth dose – a cause for celebration and reflection. But, overall, the reach of doses has been highly uneven, with nearly all of them in high-income countries (see Figure 2, below). For much of 2021, this lopsided result was due to insufficient supply and vaccine nationalism (see Lesson 8), **but by late 2021, the world transitioned from being supply constrained to being demand driven – and access and uptake is limited by vaccination capacity in many low-income countries.**

“2020 was about supply insecurity and a challenge in supply. Right now [in November 2021] we’re just flipping in most countries to issues on demand, and that’s going to be where we are certainly going into 2022.”

– Seth Berkley, Gavi CEO⁹²

Figure 2: COVID-19 Vaccinations by Income Group, January 1, 2021—January 1, 2022



Source: Our World in Data <https://ourworldindata.org/covid-vaccinations>: UMIC = 168.68; HIC = 168.15; LMIC = 85.72; and LIC = 11.89

COVID-19 has shown just how fragmented and underfunded health systems are worldwide⁹³ and especially in developing countries. The capacity for healthcare delivery is diverse across LMICs. It has been increasing, but on average it is estimated that the poorest countries will need to double or even triple their current vaccination rates to deliver the supply forecast for 2022. Among the challenges for COVID-19 prevention in low and lower-middle income countries: “diagnostic testing; personal protective equipment; good epidemiological data; logistical systems to vaccinate all segments of society; and systems for reporting adverse events after vaccination. Social, political, and religious unrest can also complicate all prevention efforts.”⁹⁴

The COVID-19 pandemic has highlighted the challenges of transporting and distributing vaccines with unusual temperature requirements (ultra-cold chain). The capacity to handle vaccines varies between and within countries — for example, in smaller hospitals, pharmacies, and rural areas — and requires investments for freezers, equipment (e.g., dry ice), and trained staff. Visibility into a country’s level of preparedness allows manufacturers to prepare for distribution and to support local authorities in vaccines and treatment deployment; knowing where, how, how many, and how quickly products are needed and tracking any changes in real-time is vital to getting them to the right place at

the right time in the right quantity and in the right storage conditions. Consolidated distribution would be more efficient. Delivering small volumes to multiple countries imposes costs on manufacturers and every other component of the supply chain and increases the total amount of time and effort needed to turn vaccines into vaccinations.

The reality on the ground in far too many low-income countries is weak health systems with limited infrastructure, technology, and funding. The majority of health systems in LMICs had little to no experience vaccinating adults before the pandemic, and their health facilities and workforce were quickly overwhelmed by the surge in COVID-19 patients needing treatment. A 2020 review of adult immunization programs among WHO member states found that just 62% reported having any immunization programs – the most common of which was influenza vaccination, reported by 59% of countries.⁹⁵ The most recent data from 44 OECD countries shows influenza vaccination rates for older adults (aged 65 and older) ranging from a low of 6% to a high of 86%, with only half of the countries reporting a vaccination rate of 50% or more.

Couple those challenges with global mis- and dis-information on vaccines spread through social media, and the outcome is low vaccine uptake – along with negative consequences for other health problems, as resources are redirected, threatening HIV, tuberculosis, and malaria prevention and treatment and maternal and child health, and other programs. Patients with non-communicable diseases have had worse outcomes from COVID-19 than healthy patients, underscoring the need for high-quality primary care. Strong health systems with reliable primary care and mass immunization structures in place to vaccinate all age-groups will be better prepared in the event of outbreaks and thereby help prevent them becoming pandemics. Effective immunization programs can also lay the groundwork for delivering other interventions, such as mAbs, which are transfused. COVID-19 has resulted in historically high levels of adult immunization, which prior to the pandemic were stubbornly low in nearly all geographies. The progress made in increasing adult vaccination uptake should be maintained and strengthened going forward, which will be important to support the geographically dispersed vaccine manufacturing now underway.

Implementation Hurdles: Global to Local Challenges

The world's institutions were unprepared for SARS-CoV-2. COVAX has struggled to fulfil its ambitious mission, and its challenges have effects on the ground in the poorest countries, even in those that have made strides in health system strengthening, like South Africa and Nigeria.

Facing sluggish demand for vaccination, South Africa asked for pause in dose deliveries in November 2021.⁹⁶

In December, Nepal halted COVID-19 vaccinations for children due to a lack of syringes.⁹⁷

The Nigerian government faced criticism after destroying 1 million doses donated from Germany – but the doses were due to expire within a month of delivery.⁹⁸ Not only is that not an effective public health strategy, it has negative knock-on effects by reducing people's trust

and confidence in their governments and increases vaccine hesitancy as social media rumours circulate about why doses were destroyed.

In Zambia, where 7% of people are vaccinated, the government is managing supplies from COVAX, China, and the African Union – five different vaccines, each with different dosing regimens, storage requirements, and vial volumes. This has created a huge administrative burden for a health system operating on a shoestring. There is no budget, for example, for staff to make reminder calls about second shots. Of 840 people who received their first AstraZeneca shot in April, only 179 returned in July 2021.⁹⁹

In a joint statement, COVAX and the African Union and Africa CDC were clear: “Countries need predictable and reliable supply. Having to plan at short notice and ensure uptake of doses with short shelf lives exponentially magnifies the logistical burden on health systems that are already stretched. Furthermore, ad hoc supply of this kind utilizes capacity – human resources, infrastructure, cold chain – that could be directed towards long-term successful and sustainable rollout. It also dramatically increases the risks of expiry once doses with already short shelf-lives arrive in country, which may have long-term repercussions for vaccine confidence.”¹⁰⁰

“Universal health coverage and health security are two sides of the same coin.”

– Dr Tedros Adhanom Ghebreyesus, Director-General of the World Health Organization¹⁰¹

10. Vaccine Confidence Is Critical for Success

Ending the pandemic demands that public confidence in COVID-19 vaccines and the systems that deliver them be high and sustained. Vaccines won't work if people won't take them. Concerted, cross-sector action to build public trust is critical now and will need to be maintained long after the pandemic has ended. Strong pharmacovigilance and no-fault-compensation systems contribute to improved confidence.

Vaccines won't work if people won't take them. Confidence in vaccines is about trust – in governments, in vaccines themselves, and in the systems that deliver them:

People must trust that government regulators and manufacturers aren't compromising safety or efficacy standards to get vaccines authorized.

They need to feel confident that public health authorities and health care professionals who recommend and deliver vaccines are doing so based on science and evidence.

They need to have accurate information on vaccines and hear consistent messages from health providers, government officials, and others who affect public opinion.

They need to feel confident that manufacturers are driven to meet health needs and developing and producing high quality, effective medicines and vaccines.

And they need to feel confident that, if they are vaccinated and have a serious adverse event, they will be taken care of and compensated.

“To ensure the high levels of vaccine uptake needed to help end this pandemic, we need true cross-sectoral input to build trust across the various relationships – from scientists and health authorities to business partners and communities.

As we look ahead to preparedness for future pandemics, now is the time to think about building foundational trust to support vaccine confidence for the future.”

– Heidi Larson, Founding Director of the Vaccine Confidence Project at the London School of Hygiene & Tropical Medicine¹⁰²

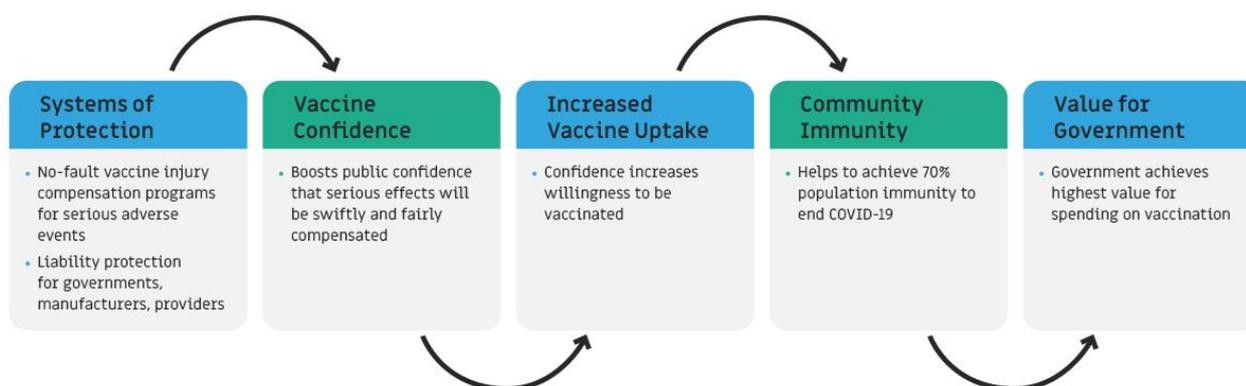
“Public engagement and effective communication through clear, transparent messaging will play a central role in building confidence in the COVID-19 vaccines.”¹⁰³ An emerging body of evidence shows that anti-vaccination campaigns on social media and by some alternative system medical practitioners negatively affect vaccine confidence,¹⁰⁴ and that organized and deliberate disinformation campaigns by unfriendly governments are substantially reducing vaccine confidence and coverage.¹⁰⁵

Confidence is further eroded when political leaders publicly question vaccine safety or efficacy without evidence. On the same day the European Medicines Agency approved the AstraZeneca vaccine for all ages in the EU, French president Emmanuel Macron asserted it was “quasi-ineffective” for people older than 65. Following his comments in January, France’s Health Authority made an official recommendation that the vaccine should not be used for people over 65, saying more studies were needed before it was rolled out to older age groups, and then this position was reversed in March.¹⁰⁶ Other European countries took a similar position: Germany, Austria, Sweden, Norway, Denmark, Netherlands, Spain, and Poland recommend it only for people under 65, and Italy and Belgium for those under 55.¹⁰⁷ After France and Germany temporarily halted use of the AstraZeneca vaccine over similar blood clotting issues in March, public scepticism increased precipitously. But in the UK, where use of the vaccine was limited by age, rather than paused entirely, trust held relatively steady.¹⁰⁸ Similarly, in the US, CDC, and FDA imposed and then lifted a “pause” on delivery of the Johnson & Johnson vaccine,¹⁰⁹ with immediate and persistent effects on vaccine confidence¹¹⁰ and trust¹¹¹ – even though it demonstrated that the pharmacovigilance system was working. These actions had negative repercussions beyond national boundaries: For example, the Democratic Republic of the Congo 1.7 million doses of AstraZeneca’s vaccine through COVAX in early March. But the government paused its rollout after France and Germany suspended use. After the European Medicines Agency concluded the vaccine’s overall benefit outweighs the rare risks associated, DRC launched its vaccination campaign on April 19, but had to return 1.3 million doses to COVAX and UNICEF after determining it would not be able to administer them before they expired in June.¹¹²

Strong pharmacovigilance systems to report adverse event and detect adverse effects are essential to ensure policy recommendations are data-driven and evidence-informed, and to boosting public confidence in vaccine safety and efficacy. Lessons learned on communicating about potential vaccine risks could support the formation of evidence-driven guidelines for communication on potential adverse effects of vaccines identified through a robust, international surveillance system. Ahead of the next pandemic, these systems and guidelines on how emerging risks should be evaluated, managed, and communicated, must be refined and reinforced.

No-fault vaccine injury compensation programs can boost people’s confidence in being vaccinated¹¹³ and in their governments. They are a tangible example of the immunization social contract: Governments ask people to be vaccinated not only for their own health but also for the health of the larger community. In return, those vaccinated know they’ll be taken care of in the rare instance of a serious adverse effect. That’s only fair, and it’s the right thing for governments to do.

Figure 3: The Logic of Systems of Protection



The development of the world's first international NFC system for COVID-19 vaccines by COVAX is an historic achievement, and the program will play a crucial role in advancing the prompt, equitable, and responsible administration of COVID-19 vaccines. We recognize the immense challenges COVAX faced in designing the program and appreciate that it incorporates many of the critical design elements associated with highly effective NFC systems.

COVID-19 Drove the Creation of Ground-breaking Multi-Country No-Fault Compensation Systems

At the outset of the pandemic, only 25 countries had some form of liability protection and injury compensation system in place, and nearly all were in high-income countries.

In February 2021, COVAX announced the world's first international injury compensation program for 92 of the world's poorest countries. It has since been followed by a similar system developed under the auspices of the African Vaccine Acquisition Trust (AVAT) for member governments in Africa and affiliated member states in the Caribbean.

"The No-Fault Compensation fund is a massive boost for COVAX's goal of equitable global access to vaccines: by providing a robust, transparent and independent mechanism to settle serious adverse events it helps those in countries who might have such effects, manufacturers to roll out vaccines to countries faster, and is a key benefit for lower-income governments procuring vaccines through the Gavi COVAX AMC," said Dr. Seth Berkley, CEO of Gavi.¹¹⁴

At the close of 2021, people in 147 countries were protected by a no-fault compensation system in large part specifically implemented for and only covering COVID-19 vaccines. **This positive advancement for public health should be sustained after COVID-19 for routine immunization programs and to ensure the world is ready for the next pandemic.**

ADDITIONAL INFORMATION

Lesson 1: Pathogen Sharing

Public Health Implications of the Nagoya Protocol

<https://www.ifpma.org/subtopics/public-health-implications-of-the-implementation-of-the-nagoya-protocol/>

Pandemic Influenza

<https://www.ifpma.org/tag/pandemic-influenza>

Lesson 2: Partnerships

Innovative Partnerships

https://www.ifpma.org/wp-content/uploads/2021/12/IFPMA_Industrys-collaborations-on-COVID-vaccines-and-therapeutics_20.12.2021.pdf

Policy Perspectives on Pandemic Preparedness

https://www.ifpma.org/wp-content/uploads/2021/10/IFPMA_Preparing_society_against_future_pandemics_Full_Report.pdf

Lesson 3: Manufacturing

COVID-19 Vaccine Scale Up

<https://www.ifpma.org/resource-centre/momentum-of-covid-19-vaccine-manufacturing-production-scale-up-is-now-sufficient-for-step-change-in-distribution-and-opens-way-for-urgent-political-leadership-and-country-preparedness/>

The Complex Journey of a Vaccine

<https://www.ifpma.org/resource-centre/the-complex-journey-of-a-vaccine/>

Enabling Manufacturing During the Pandemic

<https://www.ifpma.org/resource-centre/biopharmaceutical-industry-statement-on-icmra-workshop-on-enabling-manufacturing-capacity-in-the-covid-19-pandemic/>

Lesson 4: Intellectual Property and Innovation

IP

<https://www.ifpma.org/subtopics/ip-2>

Technology Transfer

https://www.ifpma.org/wp-content/uploads/2021/12/IFPMA_Tech-Transfer_A-collaborative-approach-to-improve-global-health_Position-Paper.pdf

Sustainable Innovation

<https://www.ifpma.org/subtopics/innovation-ecosystem/?parentid=258>

Value of Innovation

<https://www.ifpma.org/subtopics/value-of-innovation/?parentid=258>

Lesson 5: Supply Chain

Global Health and Trade

<https://www.ifpma.org/wp-content/uploads/2021/10/WTO-Twelfth-Ministerial-Conference-A-Critical-Opportunity-to-Strengthen-the-Global-Trade-and-Health-Agenda.pdf>

Supply Chain Efficiency

<https://www.ifpma.org/subtopics/supply-chain-2/?parentid=265>

Lesson 6: Equitable Procurement

5 Steps to Advance COVID-19 Vaccine Equity

<https://www.ifpma.org/wp-content/uploads/2021/05/News-Release-Five-steps-to-urgently-advance-COVID-19-vaccine-equity-19-May-2021.pdf>

Lesson 7: Regulatory Agility

Regulatory System Strengthening and Convergence

<https://www.ifpma.org/subtopics/regulatory-system-strengthening-harmonization-ich/?parentid=265>

COVID019 Regulatory Principles

https://www.ifpma.org/wp-content/uploads/2021/05/IFPMA_COVID-19_Regulatory_Guiding_Principles_11May2021.pdf

Pharmacovigilance

<https://www.ifpma.org/subtopics/pharmacovigilance/?parentid=265>

Quality, Safety, and Efficacy

<https://www.ifpma.org/subtopics/quality-safety-and-efficacy/?parentid=265>

Lesson 8: Vaccine Nationalism

Global Industry Commitments to address the COVID-19 pandemic

https://www.ifpma.org/wp-content/uploads/2020/03/IFPMA_Commitment_COVID-19.pdf

Vaccines Policy Principles

<https://www.ifpma.org/resource-centre/ifpma-policy-principles-on-covid-19-vaccines-initiative/>

Lesson 9: Delivery Infrastructure

BIO-DCVMN-IFPMA COVID-19 Press Briefing: 16 December 2021 (Video)

<https://www.ifpma.org/resource-centre/bio-dcvmn-ifpma-covid-19-press-briefing-16-december-2021-video>

Addressing Barriers to Vaccine Equity

<https://www.ifpma.org/resource-centre/as-covid-19-vaccine-output-estimated-to-reach-over-12-billion-by-year-end-and-24-billion-by-mid-2022-innovative-vaccine-manufacturers-renew-commitment-to-support-g20-efforts-to-address-remaining-barriers>

Lesson 10: Vaccine Confidence

An Urgent Public Health Issue

<https://www.ifpma.org/subtopics/vaccination-confidence/>

Building Trust in COVID-19 Vaccines

<https://www.ifpma.org/global-health-matters/the-road-to-building-trust-in-covid-19-vaccines>

A New Approach

https://www.ifpma.org/wp-content/uploads/2019/03/IFPMA-Vaccines-TLS_Rebuilding-Confidence-in-Vaccines.pdf

REFERENCES

- ¹ Saville, Melanie, Jakob P Cramer, Matthew Downham, Adam Hacker, Nicole Lurie, Lieven Van der Veken, Mike Whelan, and Richard Hatchett. 2022. "Delivering Pandemic Vaccines in 100 Days — What Will It Take?" *New England Journal of Medicine*, 1–4. <https://doi.org/DOI:10.1056/NEJMp2202669>.
- ² Bok, Karin, Sandra Sitar, Barney S Graham, and John R Mascola. 2021. "Accelerated COVID-19 Vaccine Development: Milestones, Lessons, and Prospects." *Immunity* 54 (August): 2021. <https://reader.elsevier.com/reader/sd/pii/S1074761321003034?token=E5F44F61B625F8624010BFD643DB88167E724976C0A00781133C6F460C2C091EA59537D8F096833F299F990371E23535&originRegion=us-east-1&originCreation=20220107180330>.
- ³ AstraZeneca. 2020. "AstraZeneca's COVID-19 Vaccine Authorised for Emergency Supply in the UK," December 30, 2020. <https://www.astrazeneca.com/media-centre/press-releases/2020/astrazenecas-covid-19-vaccine-authorised-in-uk.html>.
- ⁴ Moderna. 2022. "Moderna's Work on our COVID-19 Vaccine." <https://www.modernatx.com/modernas-work-potential-vaccine-against-covid-19>
- ⁵ UK Research and Innovation. 2021. "The Imperial vaccine." <https://www.ukri.org/our-work/tackling-the-impact-of-covid-19/vaccines-and-treatments/imperial-covid-19-vaccine-trial-expands-to-additional-sites/>.
- ⁶ Imperial College Longdon. 2020. "Imperial researchers in race to develop a coronavirus vaccine." <https://www.imperial.ac.uk/news/195055/imperial-researchers-race-develop-coronavirus-vaccine/>.
- ⁷ New York Times. 2022. "Coronavirus Vaccine Tracker." <https://www.nytimes.com/interactive/2020/science/coronavirus-vaccine-tracker.html>.
- ⁸ GISAID. 2022. <https://www.gisaid.org>.
- ⁹ World Health Organization. 2017. "Comments by the World Health Organization on the Draft Fact-Finding and Scoping Study "The Emergence and Growth of Digital Sequence Information in Research and Development: Implications for the Conservation and Sustainable Use of Biodiversity, and Fair And Equitable Benefit Sharing, Dated 9 November 2017." https://www.who.int/docs/default-source/documents/nagoya-protocol/whocommentscbddsi.pdf?sfvrsn=8e3c64f1_2.
- ¹⁰ Druedahl, Louise C., Timo Minssen, and W. Nicholson Price. 2021. "Collaboration in Times of Crisis: A Study on COVID-19 Vaccine R&D Partnerships." *Vaccine* 39 (42): 6291–95.
- ¹¹ <https://thehill.com/opinion/healthcare/589734-covid-is-here-for-the-long-haul-we-need-a-variant-proof-vaccine>
- ¹² US Government Accountability Office. 2021. "Operation Warp Speed: Accelerated COVID-19 Vaccine Development Status and Efforts to Address Manufacturing Challenges." Washington, DC. <https://www.gao.gov/products/gao-21-319>.
- ¹³ US Government Accountability Office. 2020. "COVID-19: Federal Efforts Accelerate Vaccine and Therapeutic Development, but More Transparency Needed on Emergency Use Authorizations." Washington, DC. <https://www.gao.gov/assets/gao-21-207.pdf>.
- ¹⁴ Slaoui, Moncef, and Matthew Hepburn. 2020. "Developing Safe and Effective Covid Vaccines -- Operation Warp Speed's Strategy and Approach." *New England Journal of Medicine* 383 (18): 1701–3. <https://www.nejm.org/doi/pdf/10.1056/NEJMp2027405?articleTools=true>.
- ¹⁵ US Government Accountability Office. 2020. "COVID-19: Federal Efforts Accelerate Vaccine and Therapeutic Development, but More Transparency Needed on Emergency Use Authorizations." Washington, DC. <https://www.gao.gov/assets/gao-21-207.pdf>.

¹⁶ Slaoui. 2020.

¹⁷ US Government Accountability Office. 2021. "Operation Warp Speed: Accelerated COVID-19 Vaccine Development Status and Efforts to Address Manufacturing Challenges." Washington, DC. <https://www.gao.gov/products/gao-21-319>.

¹⁸ Pfizer. 2020. "An Open Letter from Pfizer Chairman and CEO Albert Bourla." <https://www.pfizer.com/news/articles/an-open-letter-from-pfizer-chairman-and-ceo-albert-bourla>.

¹⁹ Pfizer, BioNTech. 2018. "BioNTech Signs Collaboration Agreement with Pfizer to Develop mRNA-based Vaccines for Prevention of Influenza." https://biontech.de/sites/default/files/2019-08/20180816_BioNTech-Signs-Collaboration-Agreement-with-Pfizer.pdf.

²⁰ Pfizer. 2021. "Zipline, Pfizer and BioNTech Collaboration Paves the Way for Automated, On-Demand Delivery of First mRNA COVID-19 Vaccines in Ghana." <https://www.pfizer.com/news/press-release/press-release-detail/zipline-pfizer-and-biontech-collaboration-paves-way>.

²¹ <https://www.ox.ac.uk/news/2020-04-30-oxford-university-announces-landmark-partnership-astrazeneca-development-and>

²² AstraZeneca. 2020. AstraZeneca takes next steps towards broad and equitable access to Oxford University's potential COVID-19 vaccine." Press release; June 4, 2020. <https://www.astrazeneca.com/media-centre/articles/2020/astrazeneca-takes-next-steps-towards-broad-and-equitable-access-to-oxford-universitys-potential-covid-19-vaccine.html>.

²³ <https://portal.fiocruz.br/en/news/covid-19-vaccine-fiocruz-discloses-its-technological-order-agreement-astrazeneca>.

²⁴ <https://www.seqirus.com/news/csl-covid-19-vaccine-agreements-with-australian-government>.

²⁵ <https://www.gov.uk/government/news/thailand-joins-forces-with-astrazeneca-on-covid-19-vaccine-manufacturing--2>.

²⁶ <https://www.reuters.com/article/us-health-coronavirus-southkorea-astraze/south-koreas-sk-bioscience-in-deal-with-astrazeneca-on-vaccine-idUSKCN24M0ZF>.

²⁷ <https://www.astrazeneca.com/media-centre/articles/2020/advancing-our-discovery-of-novel-coronavirus-neutralising-antibodies-against-covid-19.html>.

²⁸ <https://www.astrazeneca.com/media-centre/press-releases/2021/evusheld-long-acting-antibody-combination-authorized-for-emergency-use-in-the-us-for-pre-exposure-prophylaxis-prevention-of-covid-19.html>.

²⁹ <https://ir.novavax.com/2020-08-06-Novavax-and-Serum-Institute-of-India-Announce-Development-and-Commercial-Collaboration>.

³⁰ <https://ir.novavax.com/2020-08-07-Novavax-and-Takeda-Announce-Collaboration-for-Novavax-COVID-19-Vaccine-Candidate-in-Japan>.

³¹ Whitfill, Travis. 2021. "A Likely New Treatment for COVID-19 Was Made Possible by Government-Funded Innovation." Stat, October 5, 2021. <https://www.statnews.com/2021/10/05/government-funding-backed-molnupiravir-possible-new-covid-19-treatment/>.

³² Aspen Holdings. 2020. "Aspen Announces Agreement with Johnson & Johnson to Manufacture Investigational COVID-19 Vaccine Candidate," November 2, 2020. <https://www.aspenpharma.com/2020/11/02/aspen-announces-agreement-with-johnson-johnson-to-manufacture-investigational-covid-19-vaccine-candidate/>.

³³ Sanofi. 2021. "Our Response to COVID-19." <https://www.sanofi.us/en/about-us/our-stories/our-response-to-covid-19>.

-
- ³⁴ Roche. 2020. "Roche and Regeneron collaborate to significantly increase global supply of REGN-COV2 investigational antibody combination for COVID-19." <https://www.roche.com/de/media/releases/med-cor-2020-08-19>.
- ³⁵ Merck. 2021. "Why we're excited to partner on Johnson & Johnson's COVID-19 vaccine." <https://www.merck.com/stories/why-were-excited-to-partner-on-johnson-and-johnsons-covid-19-vaccine/>.
- ³⁶ GSK, Vir. 2021. "GSK and Vir Biotechnology announce Joint Procurement Agreement with European Commission for COVID-19 treatment, sotrovimab." <https://www.gsk.com/en-gb/media/press-releases/gsk-and-vir-biotechnology-announce-joint-procurement-agreement-with-european-commission-for-covid-19-treatment-sotrovimab/>.
- ³⁷ GSK, Vir. 2021. "GSK and Vir Biotechnology announce United States government agreements to purchase sotrovimab, a COVID-19 treatment." <https://www.gsk.com/en-gb/media/press-releases/gsk-and-vir-biotechnology-announce-united-states-government-agreements-to-purchase-sotrovimab-a-covid-19-treatment/>.
- ³⁸ Han S. Clinical vaccine development. *Clin Exp Vaccine Res.* 2015;4(1):46–53. doi:10.7774/cevr.2015.4.1.46
- ³⁹ Global Health Centre. 2021. COVID-19 Vaccines R&D Investments. Graduate Institute of International and Development Studies. <https://www.knowledgeportal.org/covid19-r-d-funding>.
- ⁴⁰ Swaminathan, Soumya, Bernard Pecoul, Hisham Abdullah, Christos Christou, Glenda Gray, Carel Jsselmuiden, Marie Paule Kieny, et al. 2022. "Reboot Biomedical R&D in the Global Public Interest." *Nature*. <https://www.nature.com/articles/d41586-022-00324-y>.
- ⁴¹ The Independent Panel for Pandemic Preparedness and Response. 2020. "COVID-19: Make it the Last Pandemic." https://theindependentpanel.org/wp-content/uploads/2021/05/COVID-19-Make-it-the-Last-Pandemic_final.pdf.
- ⁴² Druedahl, Louise C., Timo Minssen, and W. Nicholson Price. 2021. "Collaboration in Times of Crisis: A Study on COVID-19 Vaccine R&D Partnerships." *Vaccine* 39 (42): 6291–95. <https://doi.org/10.1016/j.vaccine.2021.08.101>.
- ⁴³ The Pandemic Preparedness Partnership. 2021. "100 Days Mission to Respond to Future Pandemic Threats." https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/992762/100_Days_Mission_to_respond_to_future_pandemic_threats_3_.pdf
- ⁴⁴ The Independent Panel for Pandemic Preparedness and Response. 2020.
- ⁴⁵ Multilateral Leaders Task Force on COVID-19. 2021. "International organizations, vaccine manufacturers take stock of COVID-19 vaccine roll out, share views for 2022." 10 November 2021. <https://www.who.int/news/item/10-11-2021-international-organizations-vaccine-manufacturers-take-stock-of-covid-19-vaccine-roll-out-share-views-for-2022>.
- ⁴⁶ US Government Accountability Office. 2020. "COVID-19: Federal Efforts Accelerate Vaccine and Therapeutic Development, but More Transparency Needed on Emergency Use Authorizations." Washington, DC. <https://www.gao.gov/assets/gao-21-207.pdf>.
- ⁴⁷ Aspen Holdings. 2020. "Aspen Announces Agreement with Johnson & Johnson to Manufacture Investigational COVID-19 Vaccine Candidate," November 2, 2020. <https://www.aspenpharma.com/2020/11/02/aspen-announces-agreement-with-johnson-johnson-to-manufacture-investigational-covid-19-vaccine-candidate/>.
- ⁴⁸ Pfizer Inc. 2021. "Pfizer and BioNTech Announce Collaboration With Biovac to Manufacture and Distribute COVID-19 Vaccine Doses Within Africa." Pfizer Inc., July 21, 2021. <https://investors.pfizer.com/investor-news/press-release-details/2021/Pfizer-and-BioNTech-Announce-Collaboration-With-Biovac-to-Manufacture-and-Distribute-COVID-19-Vaccine-Doses-Within-Africa/default.aspx>.
-

-
- ⁴⁹ LaHucik, Kyle. 2021. "BioNTech to start building mRNA vaccine manufacturing plant in Africa in mid-2022." <https://www.fiercepharma.com/manufacturing/biontech-to-build-mrna-vaccine-manufacturing-plant-africa-mid-2022-plans-finalized>.
- ⁵⁰ Jlmenez, Darcy. 2021. "Moderna to Build \$ 500m Vaccine Manufacturing Facility in Africa." *Pharmaceutical Technology*, October 7, 2021. <https://www.aspenpharma.com/2020/11/02/aspenn-announces-agreement-with-johnson-johnson-to-manufacture-investigational-covid-19-vaccine-candidate/>.
- ⁵¹ Jerving, Sara. 2021. "Pfizer Outlines Challenges in Localizing Vaccine Manufacturing." *Devex*, December 7, 2021. <https://www.devex.com/news/pfizer-outlines-challenges-in-localizing-vaccine-manufacturing-102273>.
- ⁵² World Health Organization. (2015). *The Global Action Plan for influenza vaccines: report of the tenth meeting of the Advisory Group of the WHO Global Action Plan for Influenza Vaccines*. World Health Organization. <https://apps.who.int/iris/handle/10665/182733>.
- ⁵³ Rajinder Suri, Chief Executive Officer, Developing Countries Vaccine Manufacturers' Network (DCVMN), *BIO, DCVMN, IFPMA Media Briefing*, 23 April 2021.
- ⁵⁴ Jeong, Andrew. 2021. "U.S. cancels multimillion-dollar deal with coronavirus vaccine maker whose plant ruined Johnson & Johnson doses." *Washington Post*, 5 November 2021. <https://www.washingtonpost.com/business/2021/11/05/coronavirus-vaccine-emergent-biosolutions-cancel/>.
- ⁵⁵ Reuters. 2021. "Canada clears import of J&J COVID-19 vaccine doses made at Emergent plant." <https://www.reuters.com/business/healthcare-pharmaceuticals/canada-allows-import-jj-covid-19-vaccine-doses-made-emergent-facility-2021-11-24/>.
- ⁵⁶ Ball, Philip. 2021. "The Lightning-Fast Quest for COVID Vaccines-- and What It Means for Other Diseases." *Nature* 589: 16–18. <https://doi.org/10.1038/d41586-020-03626-1>.
- ⁵⁷ Food and Drug Administration. 2022. "Current Good Manufacturing Practice (CGMP) Regulations." <https://www.fda.gov/drugs/pharmaceutical-quality-resources/current-good-manufacturing-practice-cgmp-regulations>.
- ⁵⁸ Barosso, José Manuel. 2021. "Intellectual Property and COVID-19 Vaccines." <https://www.gavi.org/vaccineswork/intellectual-property-and-covid-19-vaccines>.
- ⁵⁹ Brant, Jennifer and Mark F. Schultz. 2021. "Unprecedented: The Rapid Innovation Response to COVID-19 and the Role of Intellectual Property." https://377da495-a7a0-44e0-a16f-dde7e79abeae.filesusr.com/ugd/159979_71b651acbd27478baeeb22f6eddf9f24.pdf.
- ⁶⁰ Polity. 2021. "Even if Covid-19 vaccine IP is waived, Africa does not have the capacity to produce at scale – expert." <https://www.polity.org.za/article/even-if-covid-19-vaccine-ip-is-waived-africa-does-not-have-the-capacity-to-produce-at-scale-expert-2021-05-05>.
- ⁶¹ Medicines Patent Pool. 2021. "Licensing for Public Health." <https://medicinespatentpool.org/what-we-do/licensing-for-public-health>.
- ⁶² Biotechnology Innovation Organization (BIO). COVID-19 Therapeutic Development Tracker. <https://www.bio.org/policy/human-health/vaccines-biodefense/coronavirus/pipeline-tracker>. Accessed January 18, 2022.
- ⁶³ Usher, Ann Danaiya. 2020. "South Africa and India Push for COVID-19 Patents Ban." *Lancet* 396 (December 5): 1790–91. <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC7831528/pdf/main.pdf>.
- ⁶⁴ Moderna, Inc. 2022. "Moderna Announces Its Global Public Health Strategy." 7 March 2022. <https://www.biospace.com/article/releases/moderna-announces-its-global-public-health-strategy/>.
-

-
- ⁶⁵ Nuzzo, Jennifer B., and Lawrence O. Gostin. 2022. "The First 2 Years of COVID-19: Lessons to Improve Preparedness for the Next Pandemic." *JAMA* January 6 (online): 6–7. <https://doi.org/10.1001/jama.2021.24394>.
- ⁶⁶ Hatchett, R, M Saville, M Downham, T Cueni, L Bigger, P Arthur, R Suri, SD Prasad, and RB Hansen. "Towards Vaccinating the World: Landscape of Current COVID-19 Supply Chain and Manufacturing Capacity, Potential Challenges, Initial Responses, and Possible "Solution Space" - a Discussion Document." March 9, 2021. https://www.ifpma.org/wp-content/uploads/2021/03/Summit_Landscape_Discussion_Document.pdf.
- ⁶⁷ Brown, CP, and TJ Bollyky. 2021. "How COVID-19 Vaccine Supply Chains Emerged in the Midst of a Pandemic." Peterson Institute for International Economics, August. <https://www.piie.com/publications/working-papers/how-covid-19-vaccine-supply-chains-emerged-midst-pandemic>.
- ⁶⁸ Castaneda, R. "Novavax COVID-19 Vaccine Booster: Safety and Manufacturing Questions Remain." *Clinical Trials Arena*, September 2, 2021. <https://www.clinicaltrialsarena.com/analysis/novavax-covid-19-vaccine-booster/>.
- ⁶⁹ Johnson, Carolyn Y. 2021. "Companies Scramble to Expand Coronavirus Vaccine Supply." *The Washington Post*, January 14, 2021. <https://www.washingtonpost.com/health/2021/01/14/covid-vaccine-supply/>.
- ⁷⁰ OECD. 2021. "Using trade to fight COVID-19: Manufacturing and distributing vaccines." https://read.oecd-ilibrary.org/view/?ref=1060_1060354-4a355ojd&title=Using-trade-to-fight-COVID-19-Manufacturing-and-distributing-vaccines
- ⁷¹ Brown, CP, and C Rogers. 2021. "The Us Did Not Ban Exports of Vaccine Supplies. But More Help Is Needed.", Peterson Institute for International Economics, June 7, 2021. <https://www.piie.com/blogs/trade-and-investment-policy-watch/us-did-not-ban-exports-vaccine-supplies-more-help-needed>.
- ⁷² Schmidt, C. "New COVID Vaccines Need Absurd Amounts of Material and Labor." *Scientific American*, January 4, 2021. <https://www.scientificamerican.com/article/new-covid-vaccines-need-absurd-amounts-of-material-and-labor1/>.
- ⁷³ Ducharme, Jamie. 2021. "COVAX Was a Great Idea, But Is Now 500 Million Doses Short of Its Vaccine Distribution Goals. What Went Wrong?" *Time*, September 9, 2021. <https://time.com/6096172/covax-vaccines-what-went-wrong/>.
- ⁷⁴ Goldhill, Olivia, Rosa Furneaux, and Madlen Davies. 2021. "'Naively Ambitious': How COVAX Failed on Its Promise to Vaccinate the World." *STAT*, October 8, 2021. <https://www.statnews.com/2021/10/08/how-covax-failed-on-its-promise-to-vaccinate-the-world/>.
- ⁷⁵ The World Bank. 2022. "World Bank Support for Country Access to COVID-19 Vaccines." <https://www.worldbank.org/en/who-we-are/news/coronavirus-covid19/world-bank-support-for-country-access-to-covid-19-vaccines>.
- ⁷⁶ Ducharme, Jamie. 2021. "COVAX Was a Great Idea, But Is Now 500 Million Doses Short of Its Vaccine Distribution Goals. What Went Wrong?" *Time*, September 9, 2021. <https://time.com/6096172/covax-vaccines-what-went-wrong/>.
- ⁷⁷ Ducharme. 2021.
- ⁷⁸ PAHO. 2021. "PAHO report: COVID-19 highlights need for strengthening national regulatory authorities in Latin America and the Caribbean." <https://www.paho.org/en/news/26-4-2021-paho-report-covid-19-highlights-need-strengthening-national-regulatory-authorities>.
- ⁷⁹ Mak, Tippi K., John C.W. Lim, Prapassorn Thanaphollert, Gugu N. Mahlangu, Emer Cooke, and Murray M. Lumpkin. 2020. "Global Regulatory Agility during Covid-19 and Other Health Emergencies." *The BMJ* 369 (April): 1–2. <https://doi.org/10.1136/bmj.m1575>.
-

-
- ⁸⁰ Katz, Ingrid T., Rebecca Weintraub, Linda-Gail Bekker, and Allan M. Brandt. 2021. "From Vaccine Nationalism to Vaccine Equity — Finding a Path Forward." *New England Journal of Medicine* 384 (14): 1281–83.
<https://www.nejm.org/doi/pdf/10.1056/NEJMp2103614?articleTools=true>.
- ⁸¹ Hafner, Marco, Erez Yerushalmi, Clement Fays, Eliane Dufresne, and Christian Van Stolk. 2020. "COVID-19 and the Cost of Vaccine Nationalism." *COVID-19 and the Cost of Vaccine Nationalism*.
<https://doi.org/10.7249/rra769-1>.
- ⁸² Banerjee, Abhijit and Esther Duflo. 2022. "How to Prevent COVID's Next Comeback." *Foreign Affairs*, 21 January 2022.
- ⁸³ Fu, Jianguan, and Joseph A. McMahon. 2019. "The Global Scramble for PPE Amid COVID-19: Lessons from the EU Export Restrictions and Import Facilitation Through Regulatory Cooperation on PPE." *Asian Journal of WTO & International Health Law and Policy* 16 (1): 25–58.
https://papers.ssrn.com/sol3/papers.cfm?abstract_id=3815761.
- ⁸⁴ Agence France Presse. "EU Extends COVID Vaccine Export Controls." September 30, 2021.
<https://www.barrons.com/amp/news/eu-extends-covid-vaccine-export-controls-01633014908>.
- ⁸⁵ World Trade Organization. "IMF and WTO Heads Call for Lifting Trade Restrictions on Medical Supplies and Food." April 24, 2020.
https://www.wto.org/english/news_e/news20_e/igo_15apr20_e.htm.
- ⁸⁶ European Commission. 2020. "Speech by President von der Leyen at the European Parliament Plenary on the European coordinated response to the COVID-19 outbreak." March 26, 2020.
https://ec.europa.eu/commission/presscorner/detail/en/speech_20_532.
- ⁸⁷ Coalition for Epidemic Preparedness Innovations. "The Covax Marketplace." 2021.
<https://cepi.net/the-covax-marketplace/>.
- ⁸⁸ COVID-19 Vaccine Supply Chain and Regulatory Transparency Symposium. "Joint Indicative List of Critical COVID-19 Vaccine Inputs for Consultation, Version 1.0." July 7, 2021.
- ⁸⁹ Asian Development Bank. "Supply Chain Maps for Pandemic-Fighting Products [Database]."
<https://www.adb.org/multimedia/scf/#/>.
- ⁹⁰ Gilbert, Sarah, and Richard Hatchett. 2021. "No One Is Safe until We Are All Safe." *Science Translational Medicine* 13 (614): 2021. <https://doi.org/10.1126/scitranslmed.abl9900>.
- ⁹¹ Cowburn, Ashley. 2021. "Gordon Brown: Failure to distribute vaccines to poorer countries 'stain on our soul.'" *Independent*, 23 December 2021.
<https://www.independent.co.uk/news/uk/politics/gordon-brown-vaccines-covid-who-b1981251.html>.
- ⁹² CSIS. November 15, 2021. "Online Event: "COVAX Past, Present, and Future: A Conversation with Dr. Seth Berkley.""
- ⁹³ Lal, Arush, Ngozi A. Erondy, David L. Heymann, Githinji Gitahi, and Robert Yates. 2021. "Fragmented Health Systems in COVID-19: Rectifying the Misalignment between Global Health Security and Universal Health Coverage." *The Lancet* 397 (10268): 61–67.
[https://doi.org/10.1016/S0140-6736\(20\)32228-5](https://doi.org/10.1016/S0140-6736(20)32228-5).
- ⁹⁴ Kim, Jerome H., Peter Hotez, Carolina Batista, Onder Ergonul, J. Peter Figueroa, Sarah Gilbert, Mayda Gursel, et al. 2021. "Operation Warp Speed: Implications for Global Vaccine Security." *The Lancet Global Health* 9 (7): e1017–21. [https://doi.org/10.1016/S2214-109X\(21\)00140-6](https://doi.org/10.1016/S2214-109X(21)00140-6).
- ⁹⁵ Williams, Sarah R., Amanda J. Driscoll, Hanna M. LeBuhn, Wilbur H. Chen, Kathleen M. Neuzil, and Justin R. Ortiz. 2020. "National Routine Adult Immunization Programs among World Health Organization Member States: An Assessment of Health Systems to Deploy Future SARS-CoV-2 Vaccines." *MedRxiv* 6 (165): 1–13.
<https://www.medrxiv.org/content/10.1101/2020.10.16.20213967v2.full.pdf>.
-

-
- ⁹⁶ Mukherjee, Promit. 2021. "South Africa delays COVID vaccine deliveries as inoculations slow." Reuters, 24 November 2021. <https://www.reuters.com/world/africa/exclusive-south-africa-delays-covid-vaccine-deliveries-inoculations-slow-2021-11-24/>.
- ⁹⁷ Sharma, Bhadra. 2021. "Nepal halts COVID vaccinations in children because of a lack of syringes." New York Times, 27 December 2021. <https://www.nytimes.com/2021/12/27/world/nepal-halts-covid-vaccinations-in-children-because-of-a-lack-of-syringes.html>.
- ⁹⁸ Eboh, Camillus. 2021. "Nigeria destroys 1 mln donated AstraZeneca vaccines with short shelf life." Reuters, 22 December 2021. <https://www.reuters.com/world/africa/nigeria-destroys-1-mln-donated-astrazeneca-vaccines-with-short-shelf-life-2021-12-22/>.
- ⁹⁹ Nolen, Stephanie. 2021. "As Vaccines Trickle Into Africa, Zambia's Challenges Highlight Other Obstacles." New York Times, 11 December 2021. <https://www.nytimes.com/2021/12/11/health/covid-vaccine-africa.html>.
- ¹⁰⁰ WHO. 2021. "Joint Statement on Dose Donations of COVID-19 Vaccines to African Countries." <https://www.who.int/news/item/29-11-2021-joint-statement-on-dose-donations-of-covid-19-vaccines-to-african-countries>.
- ¹⁰¹ WHO. 2018. "Managing epidemics: key facts about major deadly diseases." <https://apps.who.int/iris/handle/10665/272442>
- ¹⁰² UK Government. 2021. "Summit to build global confidence in vaccines to be convened by the UK Government." <https://www.g7uk.org/summit-to-build-global-confidence-in-vaccines-to-be-convened-by-the-uk-government/>.
- ¹⁰³ National Academies of Sciences, Engineering, and Medicine 2021. Strategies for Building Confidence in the COVID-19 Vaccines. Washington, DC: The National Academies Press. <https://doi.org/10.17226/26068>.
- ¹⁰⁴ Nair, Anoop T., Kesavan Rajasekharan Nayar, Shaffi Fazaludeen Koya, Minu Abraham, Jinbert Lordson, Chitra Grace, Sreekutty Sreekumar, et al. 2021. "Social Media, Vaccine Hesitancy and Trust Deficit in Immunization Programs: A Qualitative Enquiry in Malappuram District of Kerala, India." Health Research Policy and Systems 19 (Suppl 2): 1–8. <https://doi.org/10.1186/s12961-021-00698-x>.
- ¹⁰⁵ Wilson, Steven Lloyd, and Charles Wiysonge. 2020. "Social Media and Vaccine Hesitancy." BMJ Global Health 5 (10): 1–7. <https://doi.org/10.1136/bmjgh-2020-004206>.
- ¹⁰⁶ <https://www.bbc.co.uk/news/world-europe-56242617>
- ¹⁰⁷ BBC News. 2021. COVID-19: Fact-checking Macron's over-65s claim about the Oxford-AstraZeneca vaccine. <https://www.bbc.com/news/55919245>.
- ¹⁰⁸ Law, Tara. 2021. Will Trust in the Johnson & Johnson Vaccine Recover? Europe's AstraZeneca Experience Suggests Not. Time, April 20. <https://time.com/5956221/johnson-covid-19-trust-europe/>.
- ¹⁰⁹ FDA, CDC. 2021. FDA and CDC Lift Recommended Pause on Johnson & Johnson (Janssen) COVID-19 Vaccine Use Following Thorough Safety Review. <https://www.fda.gov/news-events/press-announcements/fda-and-cdc-lift-recommended-pause-johnson-johnson-janssen-covid-19-vaccine-use-following-thorough>
- ¹¹⁰ CNBC. 2021. Confidence in the safety of the J&J vaccine is low following US pause, Kaiser survey shows. <https://www.cnbc.com/2021/05/07/confidence-in-the-safety-of-the-jj-vaccine-is-low-following-us-pause-kaiser-survey-shows.html>.
- ¹¹¹ Sato, Mia. 2021. The J&J vaccine is back. Next comes trust. MIT Technology Review, April 29. <https://www.technologyreview.com/2021/04/29/1024205/jj-johnson-and-johnson-vaccine-trust/>.
-

¹¹² Jerving, Sara. 2021. "DRC to return 1.3M COVAX vaccine doses before expiry." DEVEX News, 29 April 2021. <https://www.devex.com/news/drc-to-return-1-3m-covax-vaccine-doses-before-expiry-99792>.

¹¹³ WHO. 2019. Global Advisory Committee on Vaccine Safety, 5-6 December 2018. Weekly Epidemiological Record 4 (94): 45-52. <https://www.who.int/publications/i/item/10665279829>.

¹¹⁴ WHO. 2021. "No-fault compensation programme for COVID-19 vaccines is a world first." <https://www.who.int/news/item/22-02-2021-no-fault-compensation-programme-for-covid-19-vaccines-is-a-world-first>.



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