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‘None are safe until all are safe’: COVID-19 vaccine rollout in low- and middle-income countries

Despite persistent supply issues, in-country delivery and demand for COVID-19 vaccines is likely to be the next challenge for LMICs.

by Stephen Hall, Leah Kaplow, Ying Sunny Sun, and Tania Zulu Holt

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High-income countries (HICs) around the world have been deploying mass COVID-19 vaccination programs at varying speeds since December 2020. As of April 19, 2021, more than 500 million people worldwide had received at least one dose, a majority of HICs had administered at least one dose to over 20 percent of their populations, and a few outliers had provided at least one dose to well over 50 percent.[1]

But in low- and middle-income countries (LMICs), the situation looks quite different. A large number of LMICs were yet to administer an initial dose to 1 percent of their populations as of April 19,[2] presenting a risk not only to their residents but also to global progress in preventing the spread of potential variants. As the global initiative on COVID-19 Vaccines Global Access (COVAX) stated: "With a fast-moving pandemic, no one is safe, unless everyone is safe."[3]

In early March, COVAX announced the expectation to make some 1.8 billion doses available to Advanced Market Commitment countries by the end of 2021, corresponding to coverage of roughly 28 percent of those countries' populations.[4] Outside of COVAX, some LMIC regions and countries have secured additional doses through agreements with specific manufacturers.[5] Now, the challenge is how to scale access, manage uncertainty amid new streams of information (for example, vaccine efficacy against variants or evolving safety profiles), and ensure vaccines distributed can effectively reach their target populations.

Globally, sizable attention has been paid to supply challenges for LMICs. Much less time and resources have been dedicated to in-country delivery of and demand for vaccines, which may quickly become the bottleneck as supply ramps up. Five critical factors LMICs can consider when designing rollout programs for COVID-19 vaccination include:

1. *Robust and efficient central nerve centers are critical* to drive target-setting made by policy makers, scenario planning, roadmap development, and decision making; oversee implementation; manage uncertainty; and conduct performance management of in-country vaccine rollout.

2. *Specific and robust in-country delivery strategies can drive effective rollout,* taking into account unique challenges and opportunities to ensure the availability, administration, accessibility, acceptability, and affordability of the vaccines, as well as the system's accountability for rollout effectiveness.

3. *Agile strategies can adapt to evolving (and sometimes unpredictable) supply and demand dynamics.* Even though the idea of having significant supply in LMICs may seem like a remote scenario in the near term, countries need to actively plan for scaled supply so that their absorptive capacity does not become the bottleneck.

4. *LMICs may be able to leverage existing strengths from past experiences with immunization campaigns and outbreak response, while being mindful of ways in which COVID-19 vaccine rollout strategies could potentially disrupt ongoing immunization programs.* LMICs are facing a secondary health crisis, compounded by the pandemic, having seen major disruptions in routine immunization (with 2020 coverage levels dropping to those not seen since the 1990s)[6] as well as in other health services (with increasing health burdens and excess deaths across major disease categories throughout the pandemic, in many cases exceeding deaths from COVID-19).[7]

5. *COVID-19 vaccination strategies can go beyond a one-time, siloed approach.* Efforts can intentionally build health system capacity and resiliency, strengthening traditional immunization efforts or other health services, such as through investments in delivery infrastructure, demand-creation activities, and new digital systems.

National and global healthcare stakeholders considering these five factors can develop actions to help more citizens receive the COVID-19 vaccine more effectively.

Critical strategic decisions for LMIC rollout of COVID-19 vaccines

Large amounts of funding are being dedicated to the procurement of COVID-19 vaccines for LMICs (although doses procured to date are still not sufficient to cover LMIC populations), but far less is being invested in planning for and implementing in-country rollout. COVAX's recent reports indicate a cost for in-country vaccine rollout of roughly $1.5 per dose in order to deliver vaccines to cover the first 20 percent of populations, not including the cost of the healthcare workforce. Of this, COVAX has estimated that approximately $1 per dose would need to come from sources other than COVAX (for example, domestic, bilateral, or multilateral sources) at an estimated total of $1.3 billion.[8] COVAX already expects to provide more than 20 percent population coverage by the end of 2021, and many LMICs have sourced additional doses through regional and bilateral deals, so the total rollout funding requirement for 2021 alone could be substantially higher than this. Although the World Bank's $12 billion lending programs could theoretically be leveraged for vaccine delivery activities, it is yet unknown whether countries will choose to use this financing mechanism.[9]

LMICs tend to have less well-resourced vaccination delivery systems to begin with, with more limited access to warehousing, cold-chain equipment, distribution capacity, dedicated staff, and needed information technology systems. Furthermore, LMICs will need to reach uniquely hard-to-serve populations, which can include:

— *Informal economies.* Large portions of LMIC economies are informal, including many workers with high exposure risk (for example, street vendors) or those employed by small and medium-size enterprises. These workers can be much more challenging to reach than those who work for larger, more formal employers in HICs.

— *Rural communities.* Many LMICs have substantial rural populations (LMIC urbanization rates are around 51 percent, and only 33 percent in low-income countries, compared with 66 percent in upper-middle income countries (UMICs) and 81 percent in HICs).[10] Rural populations can be much harder to reach (both logistically—limited infrastructure, transportation difficulties—and because of poor health coverage) and present serious efficiency obstacles for a mass vaccination program, including limited ability to host a single vaccination site that can reach a substantial population, vaccine utilization problems for multidose vials that need to be fully used in a short period of time, and follow-up challenges for those requiring a second dose. These challenges may require more labor-intensive vaccination outreach, which can be problematic for multidose vials that need to be fully used in a short period of time. Vaccine administration may be harder in rural communities, especially to ensure second dose provision.

— *Transient populations and humanitarian situations.* LMICs tend to face greater numbers of transient and hard-to-identify populations in humanitarian contexts, whether refugees, migrants, or mobile workers. These groups may be challenging to identify and access outside of formal settings (for example, in refugee camps).

The ACT-Accelerator and its partners have developed tools for country diagnostics and planning.[11] As a compliment to that, we focus on major design considerations for national programs for COVID-19 vaccine rollout.

Setting up robust and effective central nerve centers

Given the complexity and challenges associated with these components, countries have seen benefits from developing nerve centers to set a singular strategy and manage across activities. Countries across income bands have faced challenges with a lack of role coordination between multiple government entities and other stakeholders. As a result, these countries may experience a duplication of efforts as well as a failure to consider the holistic set of activities

and resources required. Given the complexity and challenges associated with vaccine rollout, many countries have seen benefits from developing nerve centers to set a singular strategy and manage across activities. As a result, these countries may experience a duplication of efforts as well as a failure to consider the holistic set of activities and resources required.

LMICs can look to successful emergency operations center (EOC) examples, such as those developed in Nigeria to combat polio. In "Eradicating Polio in Nigeria" we describe one such effort, highlighting critical success factors for high-performing EOCs, including taking a "command center" approach that drives extensive collaboration; leveraging dedicated cross-functional talent; consistently iterating the approach based on regular synthesis of fast-paced analytics; ensuring extensive and early buy-in with senior stakeholders to enable rapid decision making; and conducting intensive program management with clear targets, debottlenecking processes, and rigorous tracking and monitoring.

Some LMICs may already have such structures that can be leveraged for COVID-19 vaccination rollout. Others may find it critical to rapidly develop EOCs, and can take comfort knowing how valuable they may be beyond the COVID-19 response: a previous report, "Acting now to strengthen Africa's health systems" details how EOCs, once set up, have been effectively used to pivot and respond to new outbreaks in real time in sub-Saharan Africa.

In addition to centrally directed planning and coordination, locally driven approaches can also be effective. A microplanning model has been deployed in a number of countries,[12] where a central body, such as a Ministry of Health, sets eligibility principles and makes allocation decisions while outsourcing other decision making (for example, site identification, demand generation) to regional or local stakeholders. Local knowledge may be invaluable to inform decision making in centralized systems; how much decision making itself is devolved may depend on how much new infrastructure (which may be allocated and funded centrally) is required for effective rollout.

Developing an end-to-end tactical rollout plan across delivery components

Overall, COVID-19 vaccine delivery should consider several components (see exhibit). A number of critical factors can be considered for each component of the rollout strategy, with specific implications for LMICs:

Availability

LMICs are considering multiple potential levers to access additional doses. Countries will need to determine which levers to pursue, with what speed, and in what proportion. Each source has different considerations, including financing (some are at least partially funded, others require countries to self-finance), access to diverse products, availability of sophisticated intermediaries to pool/negotiate on a country's behalf, and expected timing of procurement tranches. In all likelihood, many LMICs will take a portfolio approach, combining levers to suit their needs. These levers include:

— *Additional COVAX doses.* It is possible (but not certain) that the COVAX mechanism will increase the volumes it can secure for LMICs beyond the current allocation announcement. It is not yet clear how likely this is to occur or by when, or how much LMICs would be asked to co-fund.

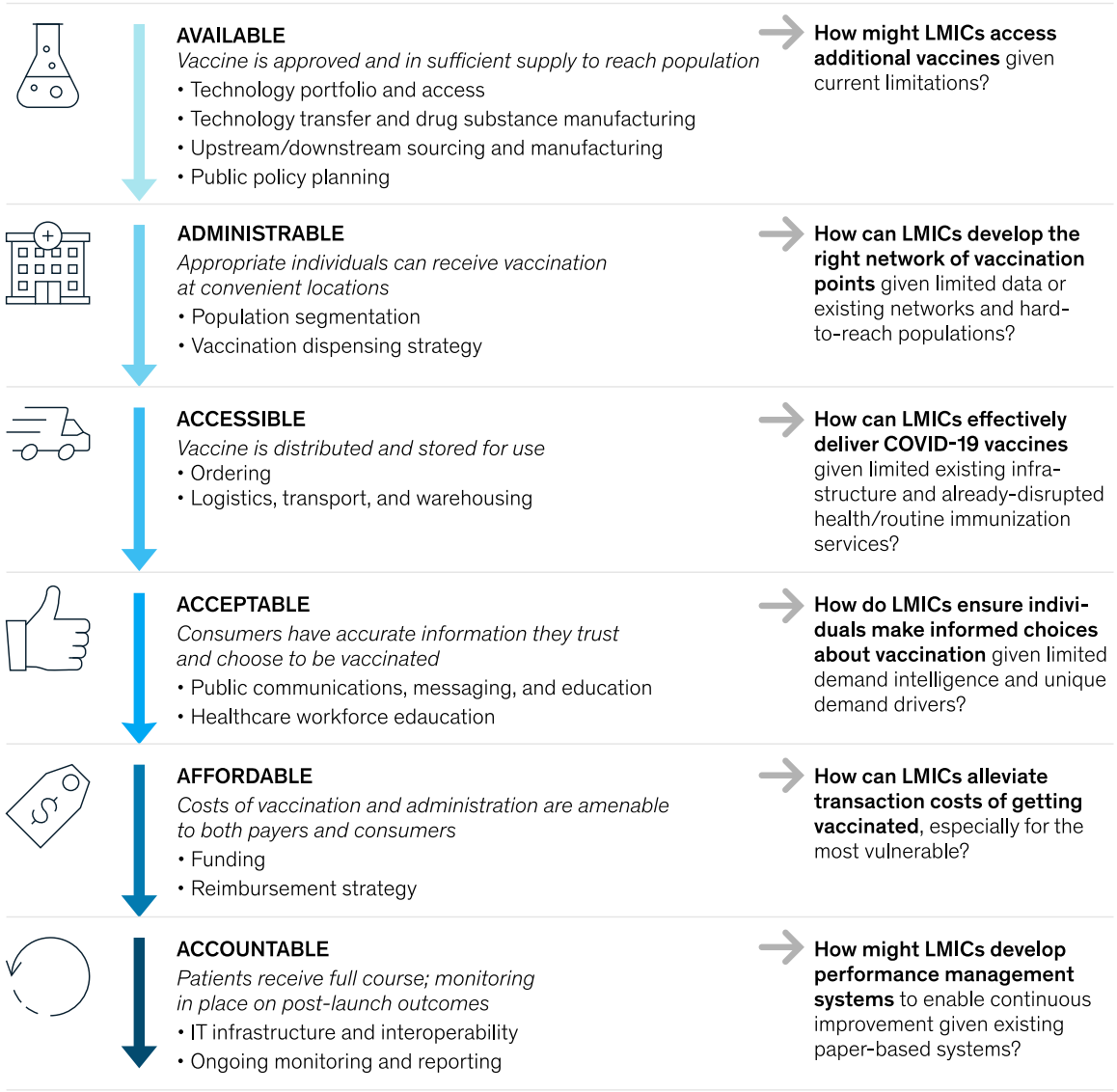
— *Regionally coordinated pooled procurement.* In a few cases, regional bodies have secured large volumes of doses to support the countries in their remit. For example, in March 2021, the African Union announced that it had secured up to 400 million doses.[13]

— *Bilateral deals.* Countries, including some LMICs, have already begun bilateral deals directly with manufacturers. Additional capacity for LMICs may become available over time, potentially driven by increasing demand saturation in HICs, deployment of new COVID-19 manufacturing facilities to ramp up supply (which may include manufacturing in LMIC regions, such as Aspen in South Africa),[14] and potential approval of new COVID-19 vaccines.

Exhibit

To date the bulk of attention and support has been focused on vaccine *access*; ultimately, the bottleneck to coverage may come from *in-country delivery*.

Requirements and critical considerations for effective vaccine roll-out



— *Donations from over-supplied countries.* Although most HICs are still limiting vaccination eligibility as supply (and delivery infrastructure) continues to increase, HICs overall appear to have secured more doses than they might ultimately need, under current manufacturing expectations.[15] Some have already indicated that they plan to contribute excess doses to LMICs,[16] through COVAX or directly, although realizing these donations may take some time.

As described above, countries may benefit from preparing for a range of supply scenarios. This is likely to include ensuring the proper regulatory

steps are taken to approve proven products; some countries have aligned national COVID-19 vaccine decision making with either stringent regulatory authority approvals or regional reliance frameworks that can enable efficient and high-quality regulatory decisions. As availability may change over time, countries could theoretically develop a phased scale-up approach to their distribution strategies based on an availability forecast. In reality, vaccine shipments may be uncertain and unpredictable, necessitating a more agile approach that can allow for successful implementation despite changing availability.

Administration

Administering an initial wave of vaccinations focused on healthcare workers (the approach most governments have taken) can be straightforward, as this group can be easier to identify, inform, and ensure access to a vaccination than the broader population. Many LMICs have not yet needed to deploy new vaccination sites and the limited vaccine volumes available are often being administered through the traditional healthcare system and its facilities. Ramping up thereafter—especially in an equitable way—can be challenging. In many HICs, this ramp-up has usually begun with existing points of care (hospitals, followed by general practitioner/primary care physician offices). HICs have often started by adding new vaccination points in densely populated areas (such as mass vaccination in stadiums or schools). They have then segued to mobile or smaller sites to reach specific or underserved populations. Although this approach has had some equity implications, it has allowed HICs to reach increasing numbers of target populations.

Countries will likely benefit from deploying multiple vaccination channel approaches to successfully reach target populations, balancing the need for efficiency and equity. Some LMICs have strengths to leverage in developing their approach: many have significant experience with campaign-based vaccination programs, (for example, polio) that can be brought to bear.[17] To develop these strategies, countries may deploy the following approaches:

— *Mapping populations to existing infrastructure, leveraging local expertise.* Many countries have complemented official sources (for example, census or other public records) by devolving efforts to local community leaders who can identify the strength of existing facilities as well as the size and location of population clusters for each target group (for example, municipal government staff in Brazil[18] and the healthcare workforce in Costa Rica[19] have driven such efforts). More innovative data sources may also be available, such as mobile data or household geotagging.

— *Designing a temporal network.* Countries can choose to develop best-estimate forecasts of vaccination point capacity required over time, based on when vaccines are expected to arrive and the target populations they are intended for. Combining this with the mapping of populations and existing vaccination points, countries would help identify where different scaled vaccination points are most likely to be required, balancing efficiency (including cost implications) and equity (ensuring vulnerable populations that may be harder to access are reached).

— *Identifying solutions for each area with unmet need.* Countries can select the specific types and locations of sites to be fit-for-purpose with population needs. Many UMICs are also leveraging local community leaders to self-select vaccination points based on specific community contexts and preferences.

Even if an appropriate mix of vaccination sites is developed, HIC experience has shown challenges in managing throughput capacity at these sites, balancing demand across sites, and minimizing waste; LMICs will need to develop systems and processes to address these challenges.

Accessibility

Multiple components are involved in an effective logistics system (various partners have collaborated on comprehensive checklists, as mentioned above). Three major elements of vaccine distribution logistics may prove especially challenging for LMICs:

— *IT/data systems* for appointment-making, to track stock levels of all relevant products, for

vaccination points to place new orders, and for allocation approvals and rebalancing decisions to be made. As HICs have begun COVID-19 vaccine rollout, challenges with the quality and reliability of these systems have arisen, as they are often overloaded by demand or have not built in the decision-making processes required for proper utilization. Furthermore, some HICs have struggled to optimally manage second dose administration, including ensuring stock and appointments are available and that people actually return for their second dose at the appropriate time. LMICs can work to identify common flaws and incorporating solutions based on forecasts.

— *Distributors, warehousing, and storage* often involve multiple supply chain layers, depending on the country's size and complexity. Cold-chain equipment (CCE) may be especially difficult for LMICs. COVID-19 vaccines to date require some level of refrigeration, with some requiring ultra-cold-chain (UCC) storage temperatures. Most LMICs have limited ordinary cold-chain capacity for storage or distribution, let alone UCC capacity.[20] At the last mile, cold-chain capacity can be even more limited (in terms of the lack of available equipment, outdated technology, and limited power for non-solar CCE), creating a problem for vaccine storage at vaccination points.

Why are COVID-19 vaccines different?

COVID-19 vaccinations are different from traditional immunization programs for reasons that include:

— *Much higher volumes and new target populations.* Existing vaccination capabilities are primarily focused on routine immunization, a system at relatively smaller scale and pace (most routine vaccines need to reach a single birth cohort over the course of a year), with a different target demographic (with very few routinely used products targeting adults). Even most LMICs that have experience doing vaccination campaigns to respond to outbreaks (for example, polio, yellow fever) have still never conducted an emergency vaccination program at the scale required for COVID-19.

— *Availability of multiple products.* For most vaccine-preventable diseases, countries deploy a single vaccine. There are certainly a number of cases where an improved product or a new multivalent product has been introduced to replace an existing product, which must then be phased out, but it is unusual to have multiple (especially more than two) vaccines deployed in a single country for the same purpose. Today, many COVAX countries are primarily receiving one vaccine, but many are already expecting to receive multiple COVID-19 vaccines from multiple sources. The system will need to be able to handle this complexity, as the right facilities will need to receive the right vaccines—as well as any vaccine-specific delivery products—and people's specific vaccines will need to be tracked to properly enable second doses (or boosters if ultimately needed).

— *Shifting supply/demand dynamics over time.* Initially, demand may exceed supply at most vaccination points. Throughputs may vary but be reasonably predictable, and countries may deploy so-called "push" distribution approaches (for example, delivering a set amount of product on a schedule, with some supply rebalancing across vaccination points as needed). As more and more people are vaccinated, this dynamic may switch, with supply exceeding demand at many vaccination points. Thus, systems cannot continue pushing down doses on a fixed schedule but can consider how to incorporate clear demand signals into the supply chain.

— *Trained staff* to administer vaccines and vaccination points. As mentioned earlier, existing vaccinator staff may not be able to conduct all COVID-19 vaccination activities without disrupting other critical services. LMICs can develop strategies to maximize the number of staff that are qualified by ensuring that healthcare workers who can administer vaccines are working at the top of their license (that is, ensuring lower-skilled staff handle non-administration steps), and exploring task shifting if appropriate.

Many LMICs have experience with vaccination delivery processes and logistics, with varying degrees (and sophistication) of ordering, tracking, transportation, warehousing, cold-chain, and staffing infrastructure. However, multiple factors are expected to make COVID-19 vaccination logistics far more complex than routine immunization programs (see sidebar, "Why are COVID-19 vaccines different?"), and a recent World Bank report notes that having a well-functioning child immunization system has not thus far been a strong predictor of readiness to roll out COVID-19 vaccines.[21] Furthermore, simply deploying existing vaccination infrastructure for COVID-19 vaccination efforts may be considered with care, given the potential to impact the already high levels of disruption of routine immunization efforts.

In HICs, vaccine delivery activities are often outsourced to the private sector, both before and during COVID-19, from leveraging third-party logistics providers to transport and store vaccines, to contracting private developers for IT systems to track vaccination rollout, to utilizing private pharmacies and healthcare centers to administer vaccines. When managed properly, private involvement in vaccine delivery can improve quality and accountability. Such practices—especially for distribution—are relatively rare in LMICs, often because of cost concerns, reluctance to commit to sustained funding for third-party contractors, a lack of appropriate procurement frameworks (for example, public-private partnership [PPP] frameworks), insufficient capacity to manage private contracts, or low confidence that outsourcing processes will be fair and transparent. Some LMICs have been supported in supply chain outsourcing,[22] with a few examples in Nigeria (where Lagos State outsources its vaccine supply chain)[23] and Senegal (where multiple third-party logistics providers have been contracted to manage delivery of a variety of public health products).[24]

Some countries may explore outsourcing options, which could lead to broader vaccine supply chain innovation, provided the right conditions are met. Some LMICs can be supported through the strengthening of PPP frameworks, affordability costing, efforts to ensure the process is (and is seen as) transparent and justly managed, and procurement/contract management capability-building (including support for performance management). If successful, private sector engagement developed for COVID-19 vaccine delivery could be expanded for broader immunization programs. On the other hand, countries with limited PPP capabilities, private sector options, or support may find it unwieldy to undertake such a transition during an already complex COVID-19 vaccine rollout.

Acceptability

Consumer confidence in COVID-19 vaccines varies by geography and, within countries, by population segments. In LMICs, limited data exists on COVID-19 vaccine acceptability, with even less information on demographic differences, trends over time, or root causes of hesitancy. This stands in sharp contrast to some HICs, where regular surveys are done that allow for micropattern detection.

A survey of more than 15,000 adults in 15 African countries conducted between August and December 2020 indicated that willingness to take COVID-19 vaccines varied from 94 percent in Ethiopia to 59 percent in the Democratic Republic of the Congo. Primary respondent reasons for vaccine hesitancy included a lack of trust in the safety of vaccines and a belief that the COVID-19 threat is exaggerated.[25] Some people in LMICs have a long-standing mistrust of adult vaccinations as a result of problematic clinical trial programs in the past,[26] [27] although vaccine acceptability has generally been stronger for pediatric vaccines.[28] Promisingly, some HICs saw decreases in vaccine hesitancy as COVID-19 vaccinations expanded.[29]

A recent World Bank report notes that less than 30 percent of countries have developed demand-generation strategies to encourage COVID-19 vaccine uptake.[30] LMICs may be able to leverage existing strengths in community engagement and demand generation from previous public health efforts (for example, HIV prevention), including from immunization programs specifically, where strategies have often leveraged deep engagement with trusted local leaders to directly address misinformation, build awareness, and provide information about how to get vaccinated. For example, in India's polio vaccination efforts, a thousands-strong "Social Mobilization Network" (SMNet) was created to communicate to underprivileged communities, engaging local officials and religious leaders, running campaigns in a highly iterative fashion to respond to community needs. SMNet's success was subsequently leveraged to expand its impact to other health areas.[31] For COVID-19, some LMICs (for example, Morocco)[32] have deployed local government staff or local organizations, who have gone door-to-door to inform eligible populations, answer questions, address concerns, and support appointment-making or location-finding efforts. Proper safety protocols should be applied to any in-person community outreach efforts.

LMICs may want to consider how COVID-19 vaccination efforts can be leveraged to increase acceptance and utilization of a broader set of health services, especially for vulnerable groups (for example, to ensure continued childhood immunization) or demographics that historically engage less with the health system (for example, adult men, older generations). Additionally, countries can consider providing information about primary care, or even rapid testing services, while individuals wait in line to be vaccinated.

Affordability

Today, LMIC populations are largely not expecting to be charged for COVID-19 vaccinations. As countries continue vaccination programs (which may include self-financed procurement), it is not yet known whether this will remain the case. For example, some countries might charge more affluent segments, but keep vaccines free of charge for lower-income populations.

LMIC residents can face meaningful opportunity costs and indirect costs to getting vaccinated, such as taking time off from work, securing and paying for transportation to and from vaccination points, waiting in line, and managing childcare. Many may need to take time (and put themselves at some exposure risk) to help relatives and friends get vaccinated. Countries may consider how to reduce personal disruption or cost, such as by encouraging employers to allow employees to "take time" to get vaccinated.

Accountability

The COVID-19 vaccination rollout will need to be closely monitored to ensure the best use of scarce resources; rapidly adapt to changing supply, demand, logistical, and epidemiological circumstances; and continuously improve the approach. The need to ensure that populations requiring a second dose actually receive that second dose further complicates tracking efforts. Today, vaccination tracking and monitoring systems in many LMICs are highly manual—leveraging paper-based ledgers and reports—and delayed, often only reporting centrally every month or every quarter. These manual systems are likely to be insufficient to deal with the rapidly changing supply and demand dynamics of COVID-19 vaccines, which may require frequent load-balancing, reevaluation of site location and infrastructure strategies, and careful monitoring of wastage to inform reduction efforts. Countries may consider a range of system improvements, including lower-tech and lower-cost approaches (for example, simple mobile apps).

Where do we go from here?

Without minimizing the challenge of COVID-19 vaccines for LMICs, stakeholders can also reflect on bright spots. The last time a mass vaccination program was needed in response to a major pandemic was in 2009, with H1N1. Then, the first vaccines arrived in Africa more than 20 weeks after the first (higher-income) countries started vaccinating. By contrast, although most LMICs are receiving COVID-19 vaccines more slowly than HICs, shipments to LMICs have taken place within 12 weeks of introduction in the first HICs.[33] The COVAX Facility has helped to move LMICs closer to parity

with HICs, with initial vaccine shipments reaching 100 countries 42 days after its first international shipment.[34]

As LMICs access larger volumes of doses over time, in-country delivery activities become more critical—and more challenging—as capacity can become stretched, making the next sets of target populations harder to reach. Furthermore, the future may only get more complex: unfolding epidemiological realities (for example, expanded or new variants) may preset novel challenges, and the need for LMICs to vaccinate younger populations to achieve herd immunity[35] means that large new groups will need to be reached once effective pediatric vaccines are approved.

As approaches are developed, LMICs can identify opportunities to strengthen their broader health systems. Agile and robust nerve center capabilities can support response to future outbreaks. Private sector engagement and improved logistics/data systems can help expand supply chain capacity and effectiveness. Novel demand-generation approaches can bring new demographics into the healthcare system and support catch-up efforts for others. Even longer-term strategies, including broader pandemic preparedness tactics or local vaccine manufacturing, can help drive health security for the future. Such strategies can serve the dual purpose of bolstering existing service provision while also improving LMICs' ability to respond to the next public health crisis.

Stephen Hall is a partner in McKinsey's Dubai office; **Leah Kaplow** is a consultant in the Washington, DC, office; **Ying Sunny Sun** is a partner in the Nairobi office; and **Tania Zulu Holt** is a senior partner in the London office.

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Footnotes

[1]"COVID-19 vaccine doses administered," Our World in Data, updated April 19, 2021, ourworldindata.org.
[2]Ibid.
[3]COVAX is a global consortium set up to ensure equitable vaccine distribution. Countries across income brackets can leverage COVAX's procurement mechanism, but the subset of countries at lower income levels are eligible for financial support for procurement. These 92 countries are referred to as COVAX Advance Market Commitment (AMC) countries (see "COVAX: Working for global equitable access to COVID-19 vaccines," World Health Organization, 2021, who.int).
[4]COVAX initially targeted making approximately 1.3 billion doses (corresponding to approximately 20 percent of AMC country populations) by the end of 2021 and has recently increased its aspiration (see "COVAX global supply forecast," Gavi the Vaccine Alliance, April 7, 2021, gavi.org).
[5]Africa: the Africa Union has thus far secured over 400 million doses (see "African Union secures additional 400 million vaccine doses," Africanews, January 28, 2021, africanews.com). India: India does not publicly state the number of doses secured; public aggregators estimate approximately 200 million secured (see Launch and Scale Speedometer, "Tracking COVID-19 vaccine purchases across the globe," Duke Global Health Innovation Center, updated April 16, 2021, launchandscalefaster.org); however, if half of India's locally produced vaccines stayed in the country, this number would reach approximately 1.1 billion as of today's manufacturing capacity forecasts.
[6]In 2019, 84 percent of the world's children received all the vaccines recommended by the World Health Organization—a record high. In 2020, that number fell to around 70 percent, with increases in deaths from measles, diphtheria, and other vaccine-preventable diseases already increasing (see "2020 Goalkeepers report: COVID-19 a global perspective," Bill & Melinda Gates Foundation, September 2020, gatesfoundation.org; Donald McNeil Jr, "Gates offers grim global health report, and some optimism," *New York Times*, updated November 23, 2020, nytimes.com).

[7]In a report published in November 2020, the WHO found a more than 50 percent decline in services in 14 African countries ranging from the provision of skilled birth attendants to the treatment of malaria cases in May, June, and July in 2020. The WHO predicts that a 50 percent disruption to anti-malarial treatment could result in 100,000 additional deaths in 2020. Additionally, the pandemic has led to interrupted treatment for people with HIV/AIDS because services are closed. WHO predicts that if service disruptions continue for longer than six months in the region, they could result in AIDS-related deaths rising to levels not seen since 2008 (see Nita Bhalla, "Africa: COVID-19 could cause a million excess deaths from these 3 diseases," World Economic Forum, January 13, 2021, weforum.org). In early 2021, the WHO estimated that reduced care for tuberculosis (TB) could cause an additional 500,000 TB deaths, setting the world back to TB mortality last seen in 2010 (see "Impact of the COVID-19 pandemic on TB detection and mortality in 2020," World Health Organization, 2021, cdn.who.int). The Global Financing Facility has also published similar figures, which has led to a new initiative, "Reclaim the Gains," to address this secondary health crisis (see "New findings confirm global disruptions in essential health services for women and children from COVID-19," Global Financing Facility, September 18, 2020, globalfinancingfacility.org; "Reclaim the gains," Global Financing Facility, 2021, globalfinancingfacility.org).

[8]Recent COVAX reports have listed "in-country delivery and demand generation costs" for the first 1.3 billion doses ranging from $1.7 billion to $2.2 billion. Funding expected to be provided from COVAX has been described as primarily funding WHO and UNICEF TA activities at the global and country level, as well as catalytic funding to support investment (for example, in CCE). Funding requirements for healthcare workforce required for vaccination activities are estimated at $0.4-1.7 billion, which COVAX expects to be covered by domestic governments budgets. (see *A financing framework for the 2021 ACT-A funding gap*, World Health Organization, December 16, 2020, who.int; Costs of delivering COVID-19 vaccine in 92 AMC countries, World Health Organization, February 8, 2021, who.int; *ACT-Accelerator prioritized strategy* and budget for 2021, World Health Organization, March 12, 2021, who.int).

[9]Key facts: World Bank Group vaccine announcement," World Bank, April 21, 2021, worldbank.org.

[10] United Nations Population Division, World Urbanization Prospects: 2018 Revision, World Bank, data.worldbank.org.

[11]*COVID-19 vaccine introduction readiness assessment tool*, *World Health Organization,* September 21, 2020, *who.int; Guidance on developing a national deployment and vaccination plan for COVID-19 vaccines*, World Health Organization, November 16, 2020, who.int; COVID-19 national deployment and vaccination plan: Submission and review process, World Health Organization, January 29, 2021, who.int.

[12]For Costa Rica, see "Manual de Procedimientos para la ejecución de vacunación contra COVID-19 en los establecimientos de salud de la Caja Costarricense de Seguro Social," Seguro Social Costa Rica, December 2020, cendeisss.sa.cr. For Brazil, see "Plano Nacional de Operacionalização da vacinação contra a COVID-19," Ministro da Saúde, February 15, 2021, gov.br.

[13]"J&J, African Union in deal for up to 400 million COVID-19 shots," Reuters, March 29, 2021, reuters.com.1[4]Christine Vestal, "COVID-19 patients swamp rural hospitals," Pew Charitable Trusts, October 20, 2020, pewtrusts.org.

[14]Janice Kew, "Aspen Pharmacare to deliver J&J vaccines in next three months," Bloomberg, March 12, 2021, bloomberg.com.

[15]Anna Rouw et al., "Global COVID-19 vaccine access: A snapshot of inequality," Kaiser Family Foundation, March 17, 2021, kff.org.

[16]For example, French President Emmanuel Macron has called on Europe and the United States to urgently send up to 5 percent of their coronavirus vaccine supplies to developing nations (see "Covid vaccines: Macron proposes sending 4-5% of doses to poorer nations," BBC News, February 19, 2021, bbc.com). Boris Johnson has pledged to donate most of the UK's surplus vaccine supply to poorer countries once all adults are vaccinated but he has not specified the stage at which the sharing would happen (see "Covid vaccines: Boris Johnson pledges surplus to poorer countries at G7," BBC News, February 19, 2021, bbc.com). Canada will donate surplus vaccines through the COVAX mechanism, but has not communicated a timeline of when it will do so (see Amanda Coletta and Emily Rauhala, "Canada defends decision to draw vaccines from program aimed at low- and middle-income countries," *Washington Post,* February 5, 2021, washingtonpost.com).

[17]Uwagbale Edward-Ekpu, "African countries have an advantage in rolling out Covid-19 vaccines," Quartz Africa, February 19, 2021, qz.com.

[18] "Plano Nacional de Operacionalização da vacinação contra a COVID-19," Ministro da Saúde, February 15, 2021, gov.br.

[19]"Manual de Procedimientos para la ejecución de vacunación contra COVID-19 en los establecimientos de salud de la Caja Costarricense de Seguro Social," Seguro Social Costa Rica, December 2020, cendeisss.sa.cr.

[20]One-fifth of immunization facilities in the world's poorest countries do not have the equipment needed to keep vaccines at optimal temperatures (and some existing equipment may not function properly). In 2014, in a number of Gavi-eligible countries, up to 90 percent of health facilities were not equipped with adequate cold-chain equipment (see "Cold supply for hot demand," Gavi, the Vaccine Alliance, 2020, gavi.org; "Cold chain equipment optimization platform," Gavi, the Vaccine Alliance, December 2020, gavi.org).

[21]"Assessing country readiness for COVID-19 vaccines—First insights from the assessment rollout," World Bank, March 11, 2021, worldbank.org.

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[26]Sarah Boseley, "Key HIV vaccine trial in South Africa ends because of poor results," Guardian, February 3, 2020, theguardian.com; Stephanie Busari and Barbara Wojazer, "French doctors' proposal to test Covid-19 treatment in Africa slammed as 'colonial mentality'," CNN, April 7, 2020, cnn.com; Stephanie Kelly, "Testing drugs on the developing world," Atlantic, February 27, 2013, theatlantic.com.

[27]Ibrahim Garba and Danielle Paquette, "In this Nigerian city, Pfizer fears loom over the vaccine rollout," Washington Post, March 20, 2021, washingtonpost.com.

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[29]For example, according to a recent Ipsos survey, which surveyed 15 countries, there was an overall increase in COVID-19 vaccine intent across the world from December 2020 to February 2021. Since the last survey, the highest uptick in vaccine intent was seen in Italy and Spain (intent increased 28 percentage points), followed by the United Kingdom (an increase of 21 percentage points), which may indicate that acceptability improves as rollouts expand (see "Global attitudes: COVID-19 vaccines," Ipsos, February 9, 2021, ipsos.com).

[30]"Assessing country readiness for COVID-19 vaccines—First insights from the assessment rollout," World Bank, March 11, 2021, worldbank.org.

[31]Nicole Deutsch et al., "Legacy of Polio—Use of India's Social Mobilization Network for strengthening of the Universal Immunization Program in India," Journal of Infectious Diseases, July 2017, Volume 216, pp. S260–6, academic.oup.com.

[32]"Morocco achieves remarkable vaccination rates surpassing some European powers," Agence Marocaine de Presse, March 13, 2021, mapnews.ma.

[33]Report of the WHO Pandemic Influenza A(H1N1) Vaccine Deployment Initiative, World Health Organization, 2012, apps.who.int; "Statement of the Co-Chairs of the 5th Access to COVID-19 Tools Accelerator (ACT-A) Facilitation Council," World Health Organization, March 23, 2021, who.int.

[34]"COVAX reaches over 100 economies, 42 days after first international delivery," World Health Organization, April 8, 2021, who.int.
[35]Although clinical trials are ongoing, most COVID-19 vaccines have not yet been approved or those under age 18. As a result, LMICs may need to vaccinate far higher proportions of their adult populations to achieve herd immunity until a pediatric COVID-19 vaccine arrives. Proportion of country populations under the age of 15: 42 percent (low-income countries) and 30 percent (lower-middle income) compared with 21 percent (upper-middle income) and 16 percent (high income) (see World Bank staff estimates using the World Bank's total population and age/sex distributions of the United Nations Population Division's World Population Prospects: 2019 Revision, data.worldbank.org; John Bonifield, "First children vaccinated in Moderna's Phase 2/3 pediatric Covid-19 vaccine trial, company says," CNN, March 16, 2021, cnn.com).