KEY POINTS

- Limited vaccine supply, logistics challenges, the lack of funding and staff resources for vaccination, and vaccine hesitancy have delayed widespread vaccination.
- Many high-income economies have started vaccination, purchasing plenty of shots in advance to cover entire populations; but low- and middle-income economies might have to wait until 2022 or even 2023 to vaccinate a majority of their populations.
- Logistics support is vital to successful immunization programs but many developing Asian economies have difficulty acquiring temperature-controlled supply chains.
- National vaccination strategies and policies must enable regulatory decision-making to authorize, distribute, and create a safe marketplace for vaccines.
- Digital immunization information systems and vaccine certificates can help economies return to normal.
- International cooperation can help bring safe, efficient, and effective solutions through capacity-building, policy and advocacy, and financing, while national efforts should be made to mitigate vaccine hesitancy and raise vaccine uptake.

Getting Ready for the COVID-19 Vaccine Rollout

Vaccines for the coronavirus disease (COVID-19) offer hope for better containing the pandemic, which had infected more than 108 million people and killed more than 2 million as of 15 February 2021 since COVID-19 was first reported in December 2019. The pandemic and stringent containment measures have also pushed many economies into recession, with particularly grave impact on vulnerable and marginalized populations. For example, 114 million jobs were lost globally in 2020, with 5% more among women than men and 8.7% more among younger workers than older (International Labour Organization [ILO] 2020). School closures affected about 1.6 billion school-age children globally with more than 1 billion children in developing countries falling behind in education.¹ Hard-won gains in poverty reduction are being reversed, with global poverty estimated to have increased in 2020 for the first time in 20 years (Lakner et al. 2021).

About 1 year into the pandemic, vaccines have been developed and are now gradually being rolled out. While around 80 countries had started rolling out vaccines as of 15 February 2021, vaccination has been slower than expected. Only about 15 doses were administered per 100 people even in the leading region, North America, while Asia and the Pacific is lagging, with less than 2 doses administered per 100 people, led by India, Indonesia, the PRC, and Singapore (Figure 1). Many factors, including limited vaccine supply, logistics challenges, lack of funding and staff resources for vaccination, and vaccine hesitancy hamper efforts to immunize a meaningful share of populations quickly and effectively to stop the pandemic.

A large COVID-19 vaccination campaign is particularly challenging in developing economies in Asia and the Pacific. COVID-19 vaccines are new and some need to be kept in ultra-low temperature freezers for storage and distribution. Many countries' existing immunization programs may not be ready for these new vaccines and require new guidance, including adapting current programs to allow large vaccination programs for adults and elderly people. More importantly, developing economies face various challenges in designing and implementing effective vaccination policies and strategies. Successful implementation of a vaccination strategy also requires transport, storage, and logistics infrastructure; capacity in health facilities; sufficient medical personnel; safety monitoring; and strong public awareness and advocacy campaigns.

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¹ UNICEF. Education and COVID-19. <https://data.unicef.org/topic/education/covid-19/>.

Figure 1: COVID-19 Vaccine Doses Administered per 100 People, 15 February 2021

Source: Bloomberg. Covid-19 Tracker. <https://www.bloomberg.com/graphics/covid-vaccine-tracker-global-distribution/> (accessed 15 February 2021).

This policy brief discusses the state of play in vaccine procurement and distribution in Asia and the Pacific, as well as the challenges posed in distribution and logistics, including vaccine storage and cold chain management. Policy implications follow, including the role of global and regional cooperation toward procuring and delivering safe, effective, and affordable vaccines to all.

STATUS OF COVID-19 VACCINE DEVELOPMENT

The speed of COVID-19 vaccine development has been unprecedented, thanks to advanced science and technology, multilateral and national government support, industry effort, and the public who volunteered to join vaccine trials.² As of 15 February 2021, 11 COVID-19 vaccines were authorized for

use by at least 1 economy, 80 in clinical trials, and more than 170 under preclinical trials (Figure 2 and Table 1).³ Among the authorized vaccines, those developed by Pfizer/BioNTech, Oxford/AstraZeneca, and Moderna have been authorized for early or emergency use in around 40–60 economies, while other authorized vaccines are only in a relatively small number of economies yet. So far in the region, 19 economies have authorized at least one of these vaccines, but the number of national approvals for available vaccines is expected to increase.

Some economies in the region are also trying to develop or produce their own vaccines. The PRC has developed two vaccines authorized outside the PRC. India is cultivating its indigenous vaccine, called Covaxin, which gained restricted emergency use approval in the country; this could significantly meet its own vaccine demand. Taipei, China is also developing three of its own vaccine candidates with one in the early stage of clinical trials,

² COVAX is the vaccine's pillar under the Access to COVID-19 Tools (ACT) Accelerator, the global collaboration platform launched by the World Health Organization (WHO) and partners to address the pandemic (the ACT pillars include diagnostics, treatment, vaccines, and health system strengthening). COVAX is co-led by WHO, Gavi, and the Coalition for Epidemic Preparedness Innovations (CEPI). Its aim is to accelerate the development and manufacture of COVID-19 vaccines (up to 2 billion by the end of 2021), and to guarantee fair and equitable access for every country in the world under the COVAX Facility. Gavi and CEPI are international organizations with public-private stakeholders that aim to develop vaccines (CEPI) and give equal access to them (Gavi) (see GAVI.org and, CEPI.net for more information).

³ A vaccine must be authorized before it is administered. Typically, national regulatory authorities (NRAs) approve a vaccine for use in the domestic market. WHO recognizes some NRAs performing a high level of regulatory oversight as stringent regulatory authorities (SRAs) including those in Australia, Canada, the European Union, Switzerland, the United Kingdom, and the United States. WHO's Emergency Use Listing (EUL) also assesses the quality, safety and efficacy of COVID-19 vaccines and is a prerequisite for vaccine supply under COVAX Facility. Decisions by SRAs and WHO are widely accepted internationally, helping NRAs in many developing countries to expedite the approval processes (WHO 2020d).

and the other two have proceeded to Phase II (Ming-hsuan and Liu 2021). Singapore's Arcturus is in Phase II trial (Arcturus Therapeutics 2020). Nanocovax, Viet Nam's own vaccine, is currently in Phase 1/2 trial, with another one about to enter Phase 1 in February, and another two under development

(Thuy and Tuan 2021). Kazakhstan is committed to having its own vaccine, Quazcovid, which is about to enter Phase III (Eurasianet 2021). Thailand is also expecting to start human trials of its vaccine candidate, Chula-Cov19, in April (Chulalongkorn University 2021).

Figure 2: Status of COVID-19 Vaccine Development, 15 February 2021

Sources: COVID-19 Vaccine Tracker. <https://covid19.trackvaccines.org> (accessed 15 February 2021); World Health Organization. Draft Landscape and Tracker of COVID-19 Candidate Vaccines. <https://www.who.int/publications/m/item/draft-landscape-of-covid-19-candidate-vaccines> (accessed 15 February 2021).

Table 1: Authorized COVID-19 Vaccines, 15 February 2021

Developer (Economy)	Vaccine Name	Economies where National Authorization is Granted		WHO Emergency Use Listing	Doses Required	Storage Temperature	Efficacy in Trial
		Total number	Asia and Pacific Region				
Pfizer/BioNTech (US/GER)	BNT162b2	57	HKG, MON, NZL, PHI, SIN	Granted	2 (3 weeks apart)	-70°C	95%
Moderna (US)	mRNA-1273	37	MON	-	2 (4 weeks)	2-8°C	95%
Gamaleya (RUS)	Sputnik V	20	MON, MYA, PAK, TKM	-	2 (3 weeks)	-18°C	91%
FBRI (RUS)	EpiVacCorona	1	-	-	2 (3 weeks)	2-8°C	Not available
Oxford/AstraZeneca (UK)	AZD1222	46	IND, KOR, MON, PAK, PHI, THA, VIE	Granted	2 (4 weeks)	2-8°C	Up to 90%
Serum Institute of India (IND)	Covishield	9	BAN, IND, MLD, NEP, SRI	Granted	2 (4 weeks)	2-8°C	Up to 90%
Bharat Biotech (IND)	Covaxin	1	IND	-	2 (3 weeks)	2-8°C	60%-70%
Sinopharm (PRC)	BBIBP-CorV	13	CAM, PRC, PAK	-	2 (3 weeks)	2-8°C	86%
Sinopharm (PRC)	Not available	2	PRC	-	2 (2 weeks)	2-8°C	Not available
Sinovac (PRC)	CoronaVac	7	PRC, INO	-	2 (2 weeks)	2-8°C	50.38%
CanSino (PRC)	Ad5-nCoV	2	PRC	-	1	2-8°C	Not available

BAN = Bangladesh; CAM = Cambodia; EUL = Emergency Use Listing; GER = Germany; HKG = Hong Kong, China; IND = India; INO = Indonesia; KOR = Republic of Korea; MLD = Maldives; MON = Mongolia; MYA = Myanmar; NEP = Nepal; NZL = New Zealand; PAK = Pakistan; PHI = Philippines; PRC = People's Republic of China; RUS = Russian Federation; SIN = Singapore; SRI = Sri Lanka; THA = Thailand; TKM = Turkmenistan; UK = United Kingdom; US = United States; VIE = Viet Nam; WHO = World Health Organization.

Note: Includes early, limited, or emergency use; Covishield is the same formulation as the Oxford/AstraZeneca vaccine (AZD1222) and AstraZeneca reached a licensing agreement with the Serum Institute of India in June 2020.

Sources: COVID-19 Vaccine Tracker. <https://covid19.trackvaccines.org>; New York Times. Coronavirus Vaccine Tracker. <https://www.nytimes.com/interactive/2020/science/coronavirus-vaccine-tracker.html#bharat> (accessed 15 February 2021).

VACCINE PROCUREMENT AND DISTRIBUTION IN ASIA AND THE PACIFIC

As of 15 February, the planned production for the authorized vaccines covers about half of the world population under a two-dose regime in 2021—8.4 billion doses (3.8 billion and 4.6 billion doses in the first and second half of 2021, respectively). For 2022 and 2023 the situation might improve, as 9.6 billion doses are supposed to become available annually (Figure 3). More importantly, for now, access to vaccines is not evenly distributed across and within countries.

Vaccine availability remains a significant risk to early and even recovery paths around the world. As of 15 February, around 80% of global population is covered by advance vaccine purchases, but the coverage rates vary significantly by income group (Figure 4a).

Figure 3: COVID-19 Vaccine Production Capacity
(billion doses; for authorized vaccines only)

Q= quarter, H= half.

Source: Asian Development Bank (ADB) based on United Nations Children's Fund COVID-19 Vaccine Market Dashboard (accessed 15 February 2021).

High-income economies have secured doses enough to cover 185% of their populations, while COVAX has stepped up vaccine acquisition for low- and low-middle-income economies. It is expected that 2.3 billion doses of vaccines could be provided through the COVAX Facility in 2021 (Gavi 2021).

The total vaccine supplies secured by lower income economies or COVAX AMC-eligible economies including an expected 1.8 billion COVAX-supplied doses would cover around 50% of their populations, excluding India which is the world's largest vaccine manufacturer and one of the leading countries in vaccine acquisition.⁴ COVAX's vaccine supplies alone account for a half of those covered in the lower income group. Meanwhile, upper-middle-income economies have secured vaccines enough to cover 36% of their populations.

In Asia and the Pacific, many economies have formalized vaccine supply deals or are under bilateral negotiations with vaccine makers and multilateral entities. However, apart from a few high-income economies, most have less than the full coverage of their populations (Figure 4b). The percentage of people covered under COVID-19 vaccine contracts in the region rises from 50% to 60% when COVAX's supply is included. The region also lags in the rollout of vaccinations, as Bangladesh, India, Indonesia, Maldives, Myanmar, Nepal, Pakistan, the PRC, Singapore, and Sri Lanka were the only countries in the region that had started inoculation as of 15 February 2021.

Recently, many developed economies started vaccination for high-risk groups, aiming to extend it to the general public by the first or second quarter of 2022. In contrast, low-income economies initially relying heavily on COVAX may have to wait until 2022 or even 2023 to vaccinate a majority of their populations (EIU 2021a; EIU 2021b). Challenges persist in an effort to inoculate a large enough number of people in many developing economies in Asia and the Pacific due to supply constraints, poor infrastructure, and insufficient numbers of health-care workers.

Strengthening regional cooperation can help low-income economies gain access to vaccines. For example, Oceania has included several Pacific islands in its immunization coverage. New Zealand secured enough doses to cover its own population and several small island states such as the Cook Islands, Niue, Samoa, Tonga, and Tuvalu. Australia, on the other hand, committed foreign funding for vaccine rollout in the Pacific (Hopgood 2020; Indo-Pacific Centre for Health Security 2020).

⁴ In June 2020, Gavi launched the Gavi COVAX Advance Market Commitment for COVID-19 Vaccines. This is a new financing mechanism whereby donors commit funds to guarantee the purchase of vaccines once they have been successfully developed. It aims to incentivize vaccine developers to invest in research and development and production, while ensuring access for developing countries. Proposed earlier by Michael Kremer, the concept gained momentum in his papers and opinion pieces in major newspapers (Kremer and Glennerster 2004; Kremer, Levin, and Snyder 2020). As of 3 February, the COVAX Facility expects to distribute 175 million doses of the Pfizer/BioNTech vaccine and the Oxford/AstraZeneca vaccine to 37 countries in the region by the first and second quarters of 2021 (Gavi 2021).

Figure 4: People Covered by Vaccines, 15 February 2021

Notes: Based on publicly disclosed information; Number of people covered takes into account the number of doses (mostly two) required by each vaccine; Vaccines in India includes those under manufacturing deals that may be exported to other countries. * includes 92 COVAX Advance Market Commitment (AMC) eligible economies including 11 upper-middle-income economies which are also eligible for the International Development Association (IDA) support. COVAX's supply to upper-middle and high-income economies are based on those that submitted non-binding confirmations of intent to participate in the COVAX Facility as of 15 December 2020. COVAX supply includes 2.3 billion doses of vaccines to be provided in 2021 only. COVAX's supply to the Asia and Pacific region covers WHO's South-East Asia Region and Western Pacific Region only, thus Afghanistan, Pakistan, and the countries in Central Asia are not included.

Source: Asian Development Bank based on Bloomberg Vaccine Tracker. <https://www.bloomberg.com/graphics/covid-vaccine-tracker-global-distribution/> (accessed 15 February 2021). World Bank. GNI per capita, Atlas method (current \$). <https://data.worldbank.org/indicator/NY.GNP.PCAP.CD> (accessed 25 January 2021). GAVI. 3 Feb 2021. <https://www.gavi.org/news/media-room/covax-publishes-first-interim-distribution-forecast>, GAVI. 29 Jan 2021. <https://www.gavi.org/vaccineswork/covax-supply-forecast-reveals-where-when-covid-19-vaccines-will-be-delivered>. GAVI. 15 Dec 2020. https://www.gavi.org/sites/default/files/covid/pr/COVAX_CA_COIP_List_COVAX_PR_15-12.pdf

Given the supply shortage in the near term, many countries are prioritizing certain population groups for vaccination. While countries have their own criteria and different vaccination priorities, many have prioritized vaccinations of essential workers, including health-care workers and high-risk populations with underlying medical conditions (Wang et al. 2020). Indonesia, which launched its massive COVID-19 vaccination program on 14 January 2021, was an exception. It began the vaccination campaign with frontline health workers, then moved to vaccinate under-60s, as this is the age group that is most productive and most likely infected without symptoms. The government hopes that vaccinating this group first will facilitate economic recovery, while waiting for more clinical results on the safety of the vaccines being deployed in the country, especially for the elderly.

To improve immunization coverage, challenges include

- developing and implementing vaccination strategies and policies for reaching the last mile,
- supporting evidence-based decision-making to introduce new vaccines,
- adapting immunization systems to deliver new vaccines effectively and including older age groups and residents in remote areas,

- using the data to improve performance of the immunization programs and the quality of monitoring and evaluation in immunization, and
- exploring financing options for low-income countries and populations (Duclos et al. 2009).

COLD CHAINS FOR COVID-19 VACCINES

What Is the Cold Chain and Why Is It Important?

Vaccines are sensitive to temperatures, some to heat and some to freezing. Some are sensitive to light. Exposure to such elements can greatly affect the potency of the vaccines, and once potency is lost, it can no longer be recovered. Proper storage and handling are therefore crucial.

The cold chain is a type of supply chain that preserves consistent cold temperatures. This ensures that the quality and safety of products are maintained from the origin, throughout the distribution chain, and to the patient (Figure 5). For vaccines, this involves keeping ideal temperatures—usually between 2°C and 8°C—to ensure their efficacy and safety. Apart from the delivery from the manufacturers to the countries across borders, the cold

Figure 5: Flows and Main Components of Vaccine Cold Chain

Sources: Reproduced by the Asian Development Bank based on *Medium* (2020); World Health Organization (2015).

chain is also applicable in rolling out the vaccines within countries. Storage temperature requirements thus need to be met at every step of the way.

Each level of the vaccine cold chain system requires different equipment, from storage to transport. Along with proper refrigeration, components of the vaccine itself include glass containers, syringes, vials, and other secondary packaging. In general, freezer rooms, freezers, refrigerators, and cold boxes are needed to deploy vaccines. These are ideally found at both the national and the provincial or district level. Meanwhile, at the peripheral level (health facilities), refrigeration, cooling components, and cold boxes are utilized. In addition, vaccine carriers may be utilized, depending on the needs of the vaccine.

For transport and logistics, refrigerated trucks may be required to keep vaccines in colder temperatures. In addition, more innovative means of transport such as drones and electronic vehicles may be needed to reach difficult areas. Other equipment such as temperature monitors (vaccine vial monitors, electronic temperature loggers, or electronic freeze indicators) may also be needed to ensure that vaccine vials are kept in proper condition.

OVERVIEW OF COLD CHAIN MARKETS

The pharmaceutical industry utilizes cold chain services for storage and distribution to maintain the efficacy of refrigerated drugs and pharmaceuticals. Drugs and pharmaceuticals account for 10% of the cold chain logistics market in Asia and the Pacific and is valued at around \$6.2 billion, which will likely increase in the future due to increasing demand in temperature-controlled vaccines and medicines for treatments (Figure 6). By country, Japan hosts most players among international logistics companies, logging a revenue of \$716 million equivalent to a share of 12%. India trails with 10%, followed closely by Indonesia (9%).

Types of Cold Chains

Traditional cold chain. This is also called the refrigerated chain. Temperatures range between 2°C and 8°C, which is the usual temperature range of a refrigerator. Several vaccine candidates in the pipeline can be distributed using traditional cold chains.

Frozen chain. Frozen chains must maintain a temperature of -20°C, which is typical of freezers and may already be in use to transport other frozen products or medical materials such as organs and tissues. Among the currently approved COVID-19 vaccines, Sputnik V requires a temperature of -18°C.

Figure 6: Asia and Pacific Cold Chain Logistics in Drugs and Pharmaceuticals, 2018
(revenue \$ million, %)

Source: Allied Market Research (2019).

Ultra-cold chain. Ultra-cold chains, also called deep freeze, are those whose temperatures are -70°C or lower. Some vaccines, such as Pfizer/BioNtech's COVID-19 vaccine and Merck's Ebola vaccine, require such low temperatures to remain effective. Ultra-cold chains pose significant challenges for developing countries as they often have very limited capacity to handle such low cold chain temperatures.

Controlled temperature chain. The controlled temperature chain (CTC) or extended controlled temperature condition is a different approach to vaccine management. This allows vaccines to be kept at temperatures outside of the refrigerated chain for a limited period. Conditions for this are controlled and monitored with respect to the stability of the vaccine's antigens. Utilizing the CTC usually involves taking the vaccine into ambient temperatures of less than 40°C for a specified period just before administration. However, vaccines to be approved for use under the CTC must undergo an approval process by the appropriate regulatory authorities and World Health Organization (WHO) prequalification (WHO 2016). Table 2 compares the different types of cold chains.

Snapshot of Vaccine and Cold Storage Supply Chains Based on Trade Flows

International trade will play a vital role in the distribution of vaccines, as the production of vaccines and vaccine carriers is concentrated in certain economies. To have a better understanding of cross-border trade flows of vaccines, Figure 7 presents the trade linkages of human medicine and vaccine carriers in 2019. The European Union (EU) and the United States (US) are the main suppliers of the vaccines and vaccine carriers. In 2019, the top exporters of vaccines in Asia were India, which accounted for 2.6% of global exports (\$773 million), the Republic of Korea (0.5%, \$143 million), and the PRC (0.4%, 113 million). These were followed by two Association of Southeast Asian Nations (ASEAN) economies: Indonesia (0.3%, \$96 million), and Singapore (0.2%, \$70 million).

A few ASEAN economies are exploring collaboration with foreign vaccine developers to produce vaccines for domestic use, given their large manufacturing capacity. In Indonesia, state-owned Bio Farma is working with Sinovac, a PRC vaccine developer, to conduct trials and produce vaccines, which can meet the demand from the entire ASEAN region (mClinica 2020).

Table 2: Comparison of Types of Cold Chain

	Traditional Cold Chain	Frozen Chain	Ultra-Cold Chain (or Deep Freeze)	(Extended) Controlled Temperature Chain
Temperature range	2° to 8°C	-20° to -15°C	-80° to -70°C	2° to 8°C for initial storage and permits storage up to 40°C for at least 3 days prior to use
Monitors needed	Yes; vaccine vial monitors	Yes; vaccine vial monitors	Yes; vaccine vial monitors	Yes; vaccine vial monitors and peak temperature threshold indicators
Approval requirements for use under specified chain	None	None	None	Must meet requirements stipulated by WHO

WHO = World Health Organization.

Notes: As per WHO, not all vaccines are admissible for use under CTC. Four conditions should be met for use under CTC: (i) the vaccine must undergo and pass stability testing; (ii) regulatory authorities must license the vaccine for CTC use, and there should be a label specifying the conditions of use; (iii) the vaccine must be prequalified by WHO; and (iv) the government where the vaccine will be used should give consent in advance.

Sources: WHO. Health Product and Policy Standards: Controlled Temperature Chain (CTC). <https://www.who.int/teams/health-product-and-policy-standards/standards-and-specifications/ctc/> (accessed 16 December 2020); WHO. 2017. Biologicals: Extended Controlled Temperature Conditions. <https://www.who.int/biologicals/areas/vaccines/ectc/en/> (accessed 16 December 2020).

Figure 7: Global Trade Networks of Vaccine and Cold Storage Products, 2019

a. HS 300220 Vaccines (for human medicine)

b. HS 901890 Vaccine Carriers (medical, surgical or dental instruments and appliances; not elsewhere classified)

AUS = Australia; BEL = Belgium; CAN = Canada; EU = European Union; FRA = France; HKG = Hong Kong, China; IND = India; INO = Indonesia; IRE = Ireland; JPN = Japan; KOR = Republic of Korea; MAL = Malaysia; MEX = Mexico; PRC = People's Republic of China; RoW = Rest of the World; SIN = Singapore; USA = United States.

Notes: The size of the nodes represents the economy's total export of the concerned commodity group. The thickness of the lines represents the value of the flow of goods between economies. Some lines show the share of exports to the total global exports of the commodity group. For clarity, only exports with high values are represented by the lines.

Source: Asian Development Bank calculations using data from United Nations. Commodity Trade Database. <https://comtrade.un.org> (accessed 25 November 2020).

Some Asian economies also produce vaccine carriers such as Japan, Malaysia, the PRC, and Singapore, albeit minimal compared with the EU and US production. For cold boxes, Hong Kong, China; the Republic of Korea; Malaysia; the PRC; and Thailand are among the top producers in Asia. For refrigerators and freezers, the PRC is the top supplier in Asia.

LOGISTICS ISSUES AND CHALLENGES IN COLD CHAINS

Logistics support is integral to the success of immunization programs. A well-managed logistics system leads to efficient vaccine rollout and ensures the quality of the immunization program. Three key areas of logistics support should include

(i) vaccine management and monitoring, (ii) cold chain management, and (iii) immunization safety.⁵ Many low-income countries face difficulty in meeting immunization program requirements due to stagnant vaccine delivery systems brought by challenging contextual factors. WHO estimates that more than 50% of vaccines may be wasted globally every year because of temperature control, logistics, and shipment-related issues (Box 1).

Different types of COVID-19 vaccines will need different handling and storage requirements and have to answer to different quality and regulatory requirements. Some types of refrigerants, such as dry ice, are classified as dangerous goods and its allowed quantities in flights can further limit vaccine shipment. The availability of transport infrastructure, facilities for distribution and disposal, and equipment and trained staff to handle time- and temperature-sensitive vaccines should be considered (DHL 2020; IATA 2020).

⁵ WHO. Vaccine Management and Logistics Support. https://www.who.int/immunization/programmes_systems/supply_chain/resources/tools/en/.

Box 1: Vaccine Wastage

Wastage usually happens in two areas: in-country transport and vaccine administration at health centers. Most portable vaccine containers in use today simply do not have the ability to keep sufficiently cold temperatures beyond 12 hours, especially when exposed to extremely hot weather. Transportation from a district health depot to immunization sites on motorcycle, boat, or bicycle is time-consuming and hinders active monitoring of temperatures. Core challenges at health centers that lead to wastage include insufficient cold chain capacity, unsafe technology, slow adoption of better equipment, and inadequate temperature monitoring and maintenance systems.^a

Vaccine wastage is usually evaluated separately from immunization coverage rates, and its measurement is vital in forecasting the number of doses needed. Historically, the World Health Organization has identified two types of vaccine wastage: (i) closed, and (ii) open vial wastage. Closed vial wastage results from improper cold chain and inventory management, such as missing or discarded inventory, breakage, freezing, or exposure to heat. Effective vaccine management should only have a wastage of 1% per storage facility. On the other hand, open vial wastage stems from health worker practices such as discarding unused doses from multi-dose vials (WHO 2005).^b

^a Ashok, Brison, and LeTallec (2017); ^b WHO (2005).

Source: Ashok, A., M. Brison, Y. LeTallec. 2017. Improving Cold Chain Systems: Challenges and Solutions. *Vaccine*. 35 (17). pp. 2217–2223. <https://doi.org/10.1016/j.vaccine.2016.08.045>; WHO. 2005. Monitoring Vaccine Wastage at Country Level: Guidelines for Programme Managers. https://apps.who.int/iris/bitstream/handle/10665/68463/WHO_VB_03.18.Rev.1_eng.pdf?sequence=1&isAllowed=y (accessed January 2021).

Low Air Transport Capacity

Closed airports and lack of flights can be additional bottlenecks amid the COVID-19 pandemic. The International Air Transport Association (IATA) stated that “8,000 cargo jumbo jets would be needed to deliver a single dose to the world’s 7.8 billion people, compared with the roughly 400 that are still flying” (Mancini 2020). Current air transport capacity is thus far below the minimum required to address the transport demands of COVID-19 vaccines. Furthermore, the global route network has dropped dramatically from pre-COVID-19’s 22,000 city pairs (IATA 2020). In March and April 2020, when strict restrictions were in place, the United Nations Children’s Fund (UNICEF) sought alternative options, such as chartering its own planes to deliver vaccines.

Security and Border Management

Vaccines are highly valuable commodities, so both physical and cybersecurity measures must be in place. This includes arrangements to ensure that shipments remain secure from tampering and theft for all points in the supply chain (DHL 2020; IATA 2020). Authorities should also be on the lookout for illicit trade of falsified COVID-19 products, including fake vaccines, especially as lucrative products are susceptible to falsification (WTO 2020). Processes may be in place already, but the huge volume of vaccine shipments will need early planning to ensure that they are scalable.

Distribution of a new vaccine means additional requirements at the border from customs and public health authorities to eradicate illicit trade of counterfeit medical goods. Preparation for requirements and varying trade regulations for different countries take up precious time in distribution. There should be coordinated, swift, transparent, and tractable processes at the border. Well-coordinated and timely regulatory approvals, inspection, and clearance by customs and health authorities will be essential. Priorities for border processes should include introducing fast-track procedures for overflight and landing permits for operations carrying the COVID-19 vaccine and

considering tariff relief to facilitate the movement of the vaccine. Ample temporary cold storage at the border is also needed to accommodate the anticipated surge of these, discussed below.

Inadequate Level of Temperature-Controlled Supply Chains

Temperature-controlled supply chains in the region are limited, making it hard to accommodate the vaccine’s various temperature requirements. UNICEF estimates that the poorest countries across the world would need additional funding of \$133 million to support in-country vaccine logistics and cold chain equipment (UNICEF 2020).

Under the scenario of more stringent temperature requirements as low as -80°C , the majority of countries in the region are expected to face significant logistical challenges. Only six economies, with a combined population of 1.6 billion (Australia; Hong Kong, China; Japan; New Zealand; the PRC; and the Republic of Korea) are relatively well prepared (score of 4 or higher) for ultra-cold chain logistics (Figure 8).

For conventional cold chain, the region’s preparedness significantly improves, with 14 countries and 3.6 billion people considered ready. But preparedness in most of the countries in Central Asia and the Pacific remains very low. Several developing economies in East Asia, South Asia, and Southeast Asia also lack logistics capacity, even for the vaccines that can be stored at $2-8^{\circ}\text{C}$.

Improper Handling of Vaccines and Lack of Information

Losses resulting from mishandling of vaccines during storage and in transit through various stages in the cold chain are substantial. In most countries with immunization programs, breakdowns in refrigeration during the transport and storage of vaccines in remote rural areas or at the regional and national central stores

Figure 8: Measure of Preparedness for Cold Chain Logistics in Asia and Pacific Economies

PRC = People's Republic of China.

Notes: Scenario 1: Stringent temperature requirements (as low as -80°C); Scenario 2: Conventional temperature requirements ($+2$ – 8°C); Measure of preparedness = 1 (lowest) to 5 (highest).

Source: Asian Development Bank based on DHL (2020).

have led to great losses of vaccine. The losses are often caused by poor temperature management; low levels of technology; and insufficient skills, knowledge, and management capacity.

Cold chains can be easily broken in developing countries, especially those close to the equator, as ambient temperatures there significantly exceed 8°C . In Cameroon, for example, a survey in 2015 found that only roughly half of vaccines that needed refrigeration were monitored in 81% of health-care facilities (Yakum et al. 2015). One study in a city in India also cited that some urban health centers employed poor practices in handling vaccines, such as ill maintenance of temperature logs and storage of items other than vaccines in ice-lined refrigerators. In addition, over a third of vaccines worldwide were exposed to freezing temperatures, which could affect the efficacy of those vaccines sensitive to freezing. Information drives to improve storage conditions may be lacking, as a 2013 study in western India's Surat City revealed that a significant proportion of vaccinators lacked knowledge in proper vaccine storage and handling such as required temperatures and defrosting (Naik, Rupani, and Bansal 2013). Earlier studies already pointed out that qualified and vigilant personnel is a critical requirement for successful cold chain management, together with efficient and reliable equipment (Guinebault 1986).

Vaccination in the Rural Areas and the Last Mile

The toughest challenge in vaccine distribution is the delivery to a country's farthest-flung areas. An estimated 25% of vaccines are lost, as the "gnarly last mile" challenges the limits of existing health infrastructure and cold chain (SciDev.Net 2020). For example, only 10% of health-care facilities in the world's poorest countries have a reliable electricity supply (World Economic Forum 2018). Health workers are also faced with poor infrastructure and a lack of proper transportation, which reduces the frequency of outreach visits to these areas. Establishing well-functioning cold chains is a heavy burden for developing Asia, where more than a half of the population resides in remote and rural areas. Such last-mile challenges can cause vaccinations in rural and remote areas in Asia to be less effective and inefficient.

Success of vaccination campaigns indeed depends on how to effectively reach out to people residing in rural areas. For the Diphtheria-Tetanus-Pertussis and Poliomyelitis vaccines, data show that vaccination coverage rates decline as the share of rural area population increases (Figure 9). Economies where more than half of the population resides in cities exhibit significantly higher coverage rates than those with high rural population shares. Box 2 provides country-specific examples of challenges in delivering vaccines to rural areas.

Figure 9: Vaccination Coverage Rates and Rural Population

Note: Dots represent economies. The samples cover 44 Asian economies for the Diphtheria-Tetanus-Pertussis vaccine and 36 Asian economies for the Poliomyelitis vaccine in 2019; y axis represents the coverage rate for the first dose of the corresponding vaccine in the panel. Population data for Taipei, China; the Cook Islands; and Niue are for 2020 from the United Nations Department of Economic and Social Affairs (UNDESA). The rest are from the World Bank, World Development Indicators, with 2019 as the latest data. No UNICEF data are available for Hong Kong, China; and Taipei, China.

Sources: Asian Development Bank calculations using immunization data from United Nations Children's Fund. <https://data.unicef.org/topic/child-health/immunization/> (accessed January 2021); UNDESA. Urban and Rural Populations. <https://population.un.org/wup/Download/> (accessed January 2021); and World Bank. World Development Indicators. Rural Population. <https://datacatalog.worldbank.org/public-licenses#cc-by> (accessed January 2021).

Box 2: Vaccine Distribution to Rural and Remote Areas in Select Asian Countries

In the Lao People's Democratic Republic, Sychareun et al. (2019) show that rural areas have higher dropout rates in vaccine campaigns than urban areas.^a Supply-side challenges include vaccine shortages, lack of funds, poor data, and cold chain management. Moreover, health workers have reported having to use their own transportation to transfer cold boxes, usually a motorbike, and have difficulties balancing the box. This is one reason why outreach programs do not go beyond main village centers.

India's Universal Immunization Program, which provides free immunization across the country, can be limited by nonparticipation of a misinformed clientele as well as difficulty in reaching isolated communities. Moreover, the percentage of immunized children decreases as the area becomes more rural. Around 8% of the program's vaccines are still wasted due to expiry and problems surrounding the cold chain.^b In rural India, cold storage facilities are reportedly only able to store about a month's supply of vaccine and only a third of them have been found to function properly.^c

In Pakistan where 7 in 10 people live in rural areas, about 40% of children below age five, especially in poor and rural areas, are not immunized or are under-immunized. Butt et al. (2020) find that aside from lower demand because of cultural resistance, the health infrastructure was limited, especially in rural areas.^d Further, they report that the immunization centers were not equally distributed throughout the country and the schedule of immunization was scarce. Other experts report that there was no proper cold-chain monitoring and equipment maintenance as well as inadequate provision for a back-up power source to keep the integrity of the cold chain.^e

In the Philippines, it is difficult to access rural and remote communities due to unpredictable weather, security concerns, and poor infrastructure. Inadequate provision of transportation has seen health-care workers resort to hiring private motorcycles and pump boats to deliver and administer vaccines. Refrigerators in health centers in rural areas are subject to intermittent power supply with no back-up power source. Vaccine wastage also occurs owing to a lack of skilled personnel.

Sources: ^a Sychareun et al. (2019); ^b Banerjee et al. (2010); Gurani (2018); Hasman and Noble (2016); Pawar (2020); ^c Prinja et al. (2010); ^d Butt et al. (2020); ^e Masud and Navaratne (2011).

POLICY IMPLICATIONS

With the arrival of COVID-19 vaccines, efforts to end the pandemic need to shift into a higher gear. Even as a number of advanced economies are rolling out their vaccination programs, country readiness for COVID-19 vaccine introduction varies considerably. Lack of funds, logistics and infrastructure, medical facility and staff preparedness, and public awareness and acceptance are major challenges in many developing economies to effective distribution and administration of vaccines. Redoubling of efforts is needed to support planning and coordination of vaccine acquisition, distribution, storage, and delivery in developing economies with global and regional cooperation. Further reforms to quickly assess and address weaknesses in their health systems will also strengthen resilience to future pandemics.

Strategic planning and coordination. Even before vaccines become readily available, developing countries need to develop strategic plans for safe and effective vaccine deployment and vaccination. Introduction of new vaccines requires a complex and multilayered decision-making process involving diverse groups including public health officials and professionals, national public health agencies, governments, and multilateral organizations at different steps. With the historic rollouts ahead, it needs a whole-of-society approach engaging not only the health sector, but also all relevant groups that are critical for a successful vaccine rollout, such as armed forces, religious leaders, and school teachers.

National vaccination strategies and policies should be in place for proper regulatory decision-making to increase acceptance and uptake of vaccines. Given the shortage of near-term supplies, countries need to consider who should be vaccinated first and how to distribute vaccines in a timely and fair manner, with close attention to protecting the most vulnerable populations. For instance, some experts note that urban areas are more prone to spread of the virus than rural areas, while older populations are at higher risk of serious illness than young people. Support from international organizations and expert groups will be particularly important for informed decision-making. Countries also need to develop effective monitoring and evaluation frameworks to track implementation of vaccination programs.

Advanced planning and early preparation are critical. Developing countries need to assess the capacity of their national health systems to identify and address any gaps in preparedness of medical facilities, medical and protective equipment, and workforce skills.

They need to plan deployment of vaccines with different storage and transportation needs and to consider how to deliver safe and affordable vaccines for target populations. And they need to establish clear public communication strategies on the benefits and risks of vaccines to build public trust. Finally, in addition to organizing the first round of COVID-19 vaccinations, economies should also consider significantly strengthening their health systems to prepare for repeated large vaccination campaigns in the future as pandemics are likely to reoccur.

Most countries suffer from a chronic shortage of health care workers. Vaccinating a large part of the population in a short period of time requires deploying a significant share of health care workers for this purpose as well as mobilizing additional human resources for support. One option to mobilize staffing sources could be to retrain workers from ailing sectors, such as tourism, to help with basic tasks during the vaccination campaign. For example, in Singapore flight attendants have been redeployed to help hospital care teams in low-risk wards (Ng 2020).

Regulatory systems to facilitate vaccine procurement and access. Weak and fragmented regulatory systems may cause delays in authorization and increase the cost of scaling up new health technologies.⁶ Harmonized policies, regulations, and guidelines for institutions and personnel are needed to handle the distribution and provide education and training for effective vaccination. The possibility of mutual recognition agreements to vaccine authorization can perhaps be explored to accelerate safe vaccine procurement and distribution.⁷ Another option, which is already chosen by several developing countries in Asia, is to follow WHO Emergency Use Listing or the approval of regulatory bodies in developed countries, such as the European Medicines Agency or the US Food and Drug Administration (FDA). However, this still requires that national regulatory agencies have strong post-market surveillance capacity to monitor vaccine effectiveness and possible adverse side effects.

Regulatory authorities can collaborate and share information more effectively across borders. For instance, the African Vaccine Regulatory Forum, created by WHO in 2006, acts as a regional mechanism to promote human resources capacity, best practices, common technical requirements, and the efficiency and transparency of regulatory processes for medical products directed toward diseases endemic to the continent.⁸ A similar platform could be explored for Asia and the Pacific to build capacity, develop technical expertise, and harmonize standards to lower the costs of access and expedite approvals.⁹

⁶ In Africa, 10–20-year delays in the rollout of hepatitis B, rotavirus, and other vaccines have been attributed to weak and fragmented regulatory systems that caused approval delays and increased the cost of scaling up new health technologies (Borse and Ngemera 2020).

⁷ For instance, the US FDA has the authority to enter into agreements to recognize drug inspections conducted by foreign regulatory authorities (see [fda.gov](https://www.fda.gov)). The US FDA and the EU have been collaborating since 2014 under a mutual recognition agreement enabling the FDA to recognize inspectorates in various countries and conduct fewer inspections.

⁸ See African Vaccine Regulatory Forum. <https://www.afro.who.int/health-topics/immunization/avaref>.

⁹ In Asia, COVID-19 has become an opportunity for cooperation among national regulators and vaccine manufacturers. Members of WHO South-East Asia Region, conducted a two-day virtual meeting to discuss the COVID-19 vaccine, where they also highlighted the importance of high-quality, complete, and timely COVID-19 surveillance data on all risk groups. Member countries are now finalizing national development and vaccination plans for COVID-19 to further strengthen regulatory preparedness (WHO 2020b).

There have been efforts to harmonize the pharmaceutical regulatory landscape in the ASEAN region, including the ASEAN Pharmaceutical Product Working Group, South-East Asia Regulatory Network, and ASEAN Joint Assessment Coordination Group. Further effort to strengthen data sharing, mutual acceptance and recognition of manufacturing practices, drug registration, inspection, and evaluation would improve efficiency and transparency of regulatory decision-making.

Globally, WHO is also working with governments on setting common standards for vaccination documentation and adopting digital tools for verifying COVID-19 test results and vaccination certificates to facilitate monitoring of national COVID-19 vaccination programs and supporting national implementation of International Health Regulations and their updates.¹⁰ More immediately, the development of digital verification of COVID-19 health status can help economies to reopen and manage the potential risks of cross-border transmission. This will also help improve interoperability of digital immunization information systems.

Cold chain, logistics, and infrastructure. Vaccines should be kept within a specifically designed temperature range from production to use to preserve quality and efficacy. Concern is increasing about potential errors in the vaccine cold chain, especially as some early arrivals such as the Pfizer vaccine require ultra-cold conditions for storage and transportation.

Stringent storage and transportation requirements are not new to the progressing COVID-19 vaccine. Vaccination campaigns against Ebola faced similar challenges, but they were delivered successfully following development at unprecedented speed with the help of technology and cooperation across the board (Box 3). Yet many developing countries suffer from insufficient cold chain capacity. Moreover, inadequate infrastructure, such as unstable electricity and power supply or poor road conditions, may cause breakdowns in the cold chain.

While poor infrastructure and local logistical hurdles must be addressed, resolution of many related issues would require long-term policy commitments and, in the near term, expanding the current vaccination cold chain system may simply not be feasible. Instead, national and multinational efforts should focus on strengthening local capacity and enforcing proper cold chain management practices. Countries should have effective vaccine regulation policies and systems in place for monitoring vaccine distribution to maintain product integrity and reduce wastage. Supply chain managers and a trained workforce are also needed to optimize the system and service its components. This includes (i) demand planning; (ii) real-time, end-to-end cold-chain temperature, shock, and moisture monitoring; (iii) post-vaccination tracking to efficiently plan for second dosage and recurring vaccine applications; (iv) limiting vaccine counterfeiting, tampering, contamination, and theft; and (v) managing last-mile delivery (KPMG 2020). Rural areas experiencing unstable

Box 3: Lessons from the Ebola Vaccine

Since its outbreak in 2014, the Ebola virus killed more than 11,000 and infected 28,000 people in West Africa by 2016. It saw the first human trials of a vaccine, Everbo, against the disease, which allowed the development and global acceptance of that vaccine. The vaccine was developed by Merck thanks to unprecedented global cooperation and technology.

Global cooperation through World Health Organization (WHO) leadership was launched to mobilize expertise and funding toward the vaccine. This included national governments (such as African countries, Canada, and the United States [US]); national medical agencies (Public Health Agency of Canada, the US National Institutes of Health, Centers for Disease Control and Protection, and US Biomedical Advanced Research and Development Authority); nongovernment organizations (Doctors Without Borders); global health agencies (WHO, Wellcome Trust, Gavi); as well as universities and private companies. Each had a role to play in conducting preclinical and clinical trials, funding research and development, disseminating good manufacturing practices,

and scaling up manufacturing and vaccine deployment. This global coordination was also required to establish protocols and standards for regulators that helped to accelerate product development and distribution.

Technology also played an important role, especially in storage and distribution. Similar to COVID-19 vaccines, Everbo also required ultra-cold storage equipment to maintain its potency, at about -70°C . The Arktek super-thermos can maintain these temperatures up to a week without an external power source. Arktek was used in administering the vaccine to about 400,000 people in the Democratic Republic of Congo. This suggests that the COVID-19 vaccine can be successfully deployed in tropical developing economies. Moreover, innovative clinical trials helped to hasten development to 5 years, from Phase 1 trials in 2014 to approval in 2019, much faster than the typical 10–15-year timeline and without compromising safety. Global coordination toward harmonized standards also hastened data collection and analysis.

Source: Rigby (2020), Wolf et al. (2020).

¹⁰ WHO Smart Vaccination Certificate Working Group. <https://www.who.int/groups/smart-vaccination-certificate-working-group>.

electricity may need additional diesel generators to power fridges and voltage stabilizers to reduce the depreciation rate of cold chain devices (INCLIN 2014).

While large vaccination programs against COVID-19 present an unprecedented challenge, they will not be the last. Over the past decades, many innovations and new technologies in the vaccine supply chain and logistics systems have improved storage and temperature monitoring. These include temperature-sensitive vaccine vial monitors and better equipment to store and transport vaccines, such as high-performance refrigeration equipment, vaccine cold-boxes and carriers, and improved methods to record and communicate temperatures. However, more substantial investment in time and resources needs to be made in the coming years and decades to improve vaccine supply and logistics systems around the world.

Continuous improvements in vaccine supply and logistics systems with innovation and investment can ensure better responses to the next epidemics and enhance the quality of national immunization programs. The role of the private sector is particularly important for greater innovation and investment in this regard. To do so, public-private partnerships should be built where appropriate by identifying projects that can involve the private sector and exploring innovative funding mechanisms. Also, especially in developing countries, support from global and regional partners, governments, and multilateral institutions would be critical for improving vaccine supply systems and successful implementation of immunization programs with new vaccines.

Training and compliance. As described above, managing the immunization logistics and vaccine supply chain is not simple. Properly designed cold chain management policies and procedures would be a must, but underlying safe storage and handling of vaccine are well-trained personnel and strict adherence to management requirements and guidelines. As the new vaccines are being introduced, responsible personnel, including technicians in charge of maintenance and medical staff, must be trained for different handling requirements. Training is also required for new monitoring methods and devices to maintain appropriate temperature at all times. Public awareness is also important for increased attention to safe handling of vaccines.

WHO recognizes poor compliance with temperature monitoring requirements as a major problem hampering proper management of vaccine supply chains at all levels in over 45 countries. Guidelines should describe proper storage methods and temperatures, offer temperature-monitoring practices, and recommend steps for maintaining and evaluating temperature controls. Better compliance can be accomplished by putting appropriate regulations and penalties in place and providing adequate supervision and necessary oversight.

Open trade policies and trade facilitation. While tariff rates on pharmaceuticals declined from a global average of 4.9% in 2001 to 3.4% in 2018, many countries still impose tariffs higher than 10%, such as India, Nepal, and Pakistan (Stevens and Banik 2020). Such tariffs amount to higher prices and fewer immunizations. The pandemic has highlighted the need to abolish tariffs on medicines, vaccines, and essential medical equipment for populations and economies to recover quickly.

Trade facilitation plays a key role in cross-border trade to address bottlenecks and keep trade flowing during the pandemic, particularly for essential food and medicine. Countries that allow for an efficient entry of goods will be able to reduce wastage of vaccines at borders, improving vaccination outcomes (Helble and Shepherd 2017). During the early stages of the pandemic, personal protective equipment was in high demand, and many countries responded by setting up “green lanes” for expedited clearing and tariff exemptions. Such lessons should carry over to COVID-19 vaccines.

The pandemic is also highlighting the importance of paperless trade to speed up clearance and avoid potential contagion from paper-based documentation. Several developing economies have limited infrastructure and capacity for such systems, however. In addition, regional cooperation is essential to harmonize customs standards and promote interoperability.

International cooperation for effective, efficient, and safe solutions. Multilateral development banks such as the Asian Development Bank (ADB) play a key role in facilitating regional and international approaches to addressing the pandemic. ADB’s Asia Pacific Vaccine Access Facility (APVAX) relies on a regional framework given the risks for cross-border outbreaks (Box 4). ADB has been working with other international agencies to facilitate vaccine procurement and distribution to its developing member countries under the COVAX Facility. As part of knowledge support, ADB launched a supply chain mapping tool to assist governments and producers of essential medical equipment with exhaustive information on suppliers at various stages of the supply chain, including cold chains.¹¹

COVAX serves as the global platform for supporting the research and manufacturing of candidate vaccines, including negotiating their prices for access for both advanced and developing economies. It is coordinated by WHO, GAVI, and CEPI. As of January 2021, 29 Asian developing countries are part of COVAX. ADB is also working with UNICEF, which is the lead global organization for freight, logistics, and storage of COVID-19 vaccines on behalf of the COVAX Facility.

Global and regional partners can make interventions in three major areas to support vaccine procurement and deployment in low- to middle-income developing countries: (i) evidence and

¹¹ More information on the supply chain maps can be found at ADB. Supply Chain Maps for Pandemic-Fighting Products. <https://www.adb.org/multimedia/scf/#/>.

Box 4: ADB's Initiatives for Vaccine Procurement and Distribution

To assist in vaccine procurement and distribution for its developing member countries, the Asian Development Bank (ADB) launched the Asia Pacific Vaccine Access Facility (APVAX) in December 2020 with a budget of \$9 billion. APVAX provides a comprehensive framework and funding source to promote fast, safe, effective, and equitable access to vaccines. Its two components are as follows:

- (i) The rapid response component which provides support for critical vaccine diagnostics and procurement, as well as transporting vaccines to countries; and
- (ii) The project investment component, which supports investments in systems for effective distribution and administration, such as cold-chain storage facilities and domestic transport, including capacity building and surveillance.

In addition, ADB assists many subregional programs to support the pandemic responses and post-pandemic recovery. For example, ADB has approved a \$3.5 million project to address health threats in the Central Asia Regional Economic Cooperation region, which includes support for immediate and medium-term health cooperation against COVID-19. ADB also supported the Greater Mekong Subregion to develop its COVID-19 Response and Recovery Plan 2021–2023 aimed at combating the pandemic and accelerating the subregion's recovery. In the Pacific, additional funding for vaccine procurement is considered for effective coverage of new vaccine projects.

ADB is also providing a \$500 million Vaccine Import Facility through guarantees and insurance under its Trade and Supply Chain Finance Program to reduce payment risks and facilitate vaccine imports. The private sector will play a key role in getting vaccines and related inputs to developing member countries. ADB is working with vaccine manufacturers for potential financing needs in

expanding production and acquiring local licensing rights from global producers, including manufacturers of vaccine inputs such as glass vials and syringes. ADB is also working with governments in setting up public-private partnerships for access to or purchase of private sector warehouses and cold storage space. ADB's nonsovereign financing has been designed to address financing needs in the entire vaccine delivery value chain.

As countries need to prepare health system assessments and comprehensive readiness plans prior to implementing vaccine administration, ADB also allocated \$20 million in November 2020 for technical assistance grants for its developing member countries. The technical assistance supports readiness plans toward access, deployment, delivery, and monitoring vaccines for safe and effective administration. For instance, ADB assisted Georgia in mobilizing experts and developing its national plan to address regulatory and institutional aspects of vaccine deployment, including cold-chain and logistical requirements during the rollout to immunize 1.7 million citizens. In the Philippines, while the government has developed a vaccine road map to vaccinate 60%–75% of the population, ADB has allocated \$25 million to help the government make advance payments to manufacturers.

In conjunction with these initiatives, ADB is working with international partners in implementing APVAX, including the World Health Organization (WHO), United Nations Children's Fund, COVAX, Gavi, the Vaccine Alliance (GAVI), the World Bank, and others. ADB's financing under APVAX should meet one of the three criteria for eligibility: (i) vaccines are selected and procured through the COVAX platform; (ii) vaccine manufacturer is prequalified by WHO; and (iii) the vaccine is authorized by a stringent regulatory authority (SRA) for manufacture in an SRA country (or SRA-authorized for manufacture in a non-SRA country).^a

^a Countries that join COVAX gain access to prequalified vaccines. If acceptable to the receiving country, emergency use listing by WHO may be acceptable on an exceptional basis. As of 13 December 2020, WHO had listed the Pfizer/BioNTech vaccine for emergency use (WHO 2020a). An SRA is any one of a current list of 35 national regulatory authorities deemed by WHO to meet the highest regulatory standards. Australia and Japan are the only SRAs in the Asia and Pacific region.

Sources: ADB (2020), ADB (2021a), and ADB (2021b).

capacity building, (ii) policy and advocacy, and (iii) financing. A regionally coordinated health policy can facilitate the uptake of new vaccines and support informed decision-making in the national vaccination program, thus reducing vaccination gaps across and within countries in Asia and the Pacific. Advance market commitments and front-loading of vaccine funding have shown potential for accelerating new vaccine introduction. A regional approach in vaccine procurement and deployment also has strong merits in helping shape national strategic plans and preparing vaccination programs in low-income developing countries. This is to improve harmonization in vaccine safety and efficacy standards in vaccine introduction, to promote

coordination and effective information exchange in vaccine distribution, and to ensure equitable access to the limited resources needed for effective immunization coverage that can end the pandemic. In particular, a regional approach to build the harmonized regulatory framework for vaccine approval may reduce time for vaccine delivery and allow regional pooling of medical, technological, and administrative human resources. Finally, regional partners can coordinate the exchange of knowledge, information, and best practices to improve vaccination rates and reach the common goal of adequate immunization coverage more efficiently and effectively.

National efforts to address vaccine hesitancy and raise vaccine uptake. This includes targeted, clear, and credible communication from trusted sources as well as safe, familiar, and convenient locations for vaccine access. Inadequate knowledge of the general population, uncertainty over efficacy and safety of vaccines, as well as prevalence of misleading information accessible in various social media can contribute to people's reluctance and harm immunization efforts.¹² In this context, it is important to underscore the importance of leadership. Transparent and open

communication and guidance can significantly increase the uptake of vaccines. In low-income developing countries, financial and nonfinancial incentives coupled with regular delivery of services can be more cost-effective in improving the immunization rate and increase the uptake of preventive health-care services (Banerjee et al. 2010). Herd immunity would be achieved more efficiently by addressing the factors that drive people's behavior toward the vaccines, including an enabling environment, social influences, and motivation (WHO 2020c).

¹² Globally, it is estimated that 68.4% of the global population is willing to receive COVID-19 vaccination. This is estimated at over 70% on average in Asia and the Pacific (Wang et al. 2020).

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