

Regional Research & Development and Manufacturing Capacity in Low-and Middle-Income Countries

Research report on global initiatives to strengthen R&D and manufacturing capacities of COVID-19 vaccines in low-and middle-income countries, with a focus on Japan and the G7 countries.

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INTRODUCTION

The COVID-19 pandemic revealed stark inequities between developed countries and Low- and Middle-Income Countries (LMICs) in accessing vaccines and other medical technologies. The limited capacity in research and development (R&D) and manufacturing of vaccines within LMICs is one of the many challenges that contributed to this reality. R&D and manufacturing capacities are unevenly centered around higher income countries, particularly the G7 nations, leaving many LMICs to highly depend on wealthy nations, private companies and philanthropic organizations when responding to health emergencies. This was evident during the COVID-19 pandemic. For instance, by June of 2022, there was the highest number of mRNA vaccine patents assigned to the United States (688), followed by China (336) and Germany (332), which accounted for 72% of the global total⁴⁰. Furthermore, in the production of COVID-19 vaccines, African nations only had the capacity to handle the final steps of labeling and packaging products.

In response to this issue, many wealthy countries began supporting initiatives developed by public and private entities to enhance regional R&D and manufacturing capacities of developing medical technologies for health emergencies. This overview will focus on the R&D and manufacturing of COVID-19 vaccines.

R&D CAPACITY AND INITIATIVES IN THE ASIA-PACIFIC REGION

Nations in the Asia-Pacific region has increasingly been positioning themselves as leaders of R&D capacity, with the greatest number of researchers in 2018, mainly led by China, and to a lesser extent, Japan. They also lead the world in other indicators of R&D capacity, such as numbers of vaccine clinical trials and granted patents. The region also accounts for the largest share of global R&D spending, led by China, Japan, and ROK, representing around 40% of global R&D expenditures, followed by North America and the EU¹⁶. In countries with high total R&D spending, the private sector tends to be the largest contributor. For example, in 2018, the business enterprise sector funded 78% of R&D spending in Japan. However, the Japanese Ministry of Health, Labor and Welfare is also a major donor to funds of vaccine and drug R&D for emerging infectious diseases. Therefore, increasing responsibility lies among Asia-Pacific nations to support the capacities of LMICs, in the context of improving the global preparedness for future health emergencies.

PEOPLE'S REPUBLIC OF CHINA

China has been strengthening domestic manufacturing through their "Made in China 2025" strategy⁵⁴ which aims to reduce their reliance on foreign technology imports. Through this initiative, China has become one of the leading vaccine R&D centers, with companies Sinopharm Group Co. Ltd. and Sinovac Biotech Ltd. having become main providers of Chinese vaccines abroad³⁷.

Primarily through the belt-and-road initiative, China has exported 1 billion doses of COVID-19 vaccines between 2020 and 2021⁵⁴. From the beginning of the outbreak to the end of 2022, China has sold 1.8 billion, donated 328 million and delivered 1.6 billion vaccine doses, which have been tracked in China COVID-19 Vaccine Tracker⁸² developed by global health consulting companies Global Health Strategies and Bridge Consulting (Beijing).

Not only is China supplying vaccines, but they have also been developing joint production facilities in LMICs to manufacture Chinese COVID-19 vaccines, as supported by their statement to reject vaccine nationalism and support transferring technology to developing countries at the World Health Summit in 2021⁵⁰. For instance, an Algerian pharmaceutical company Sidal group received training and locally produced Sinovac's vaccines, which was said to be 45% cheaper than imported vaccines¹⁹, although there were reports of hesitancy expressed by the Algerian public to use this Coronavac vaccine⁴¹. Additionally, Indonesia announced a deal to receive technology to produce the AWcorna mRNA vaccine,

co-developed by Chinese Walvax Biotechnology, Suzhou Abogen Biosciences and the Chinese military⁵². Furthermore, as a member of BRICS, China launched the BRICS Vaccine R&D Center⁵¹, a partnership to cooperate in vaccine research, building plants and developing a “BRICS defense line” against pandemics.

As an example of China’s involvement in multilateral initiatives, CEPI established a Representative Office in Shanghai to enhance cooperation with China on COVID-19 vaccine development and future infectious disease threats. For instance, they have been developing partnerships with Sichuan Clover Biopharmaceuticals, Inc. who received technical assistance and collaborated with a US biotech corporation, Dynavax Technologies in 2020¹⁸ to advance the R&D and manufacture COVID-19 vaccines, in which the products are expected to be accessible globally through COVAX¹⁴.

REPUBLIC OF KOREA

The Republic of Korea (ROK) has also been strengthening their vaccine sovereignty, due to the delays they faced in receiving COVID-19 vaccines through COVAX and Pfizer Inc.⁶⁵. In 2021, ROK launched a USD1.9 billion investment plan to become part of the world’s five-largest COVID-19 vaccine manufacturing hubs by 2025⁷. Examples of major pharmaceutical vaccine producers are Samsung Biologics, who have been producing and distributing Moderna’s vaccines⁶⁷, and SK bioscience Co., Ltd, who produced Novavax, a vaccine developed by an American biotechnology company, and developed their own vaccine SKYCovione™³³. With ROK’s advanced private and public capabilities in manufacturing, national efforts claimed to support LMICs by training their infrastructure and workforce in vaccine R&D and manufacturing.

Building on ROK’s national plan, in 2022, they developed the K-Bio Vaccine Fund to support Korean pharmaceutical companies to enhance global competitiveness, with the Korean Government contributing USD76 million²², and ROK has also been enhancing support for multilateral initiatives including the Coalition for Epidemic Preparedness Innovations (CEPI) and the 100 Days Mission⁷². They also coined their ‘glocalization’ project which aims to transfer capacities to countries that lack R&D and manufacturing infrastructure, which is taking place in, for instance, Thailand and Serbia⁶⁸. As for Thailand, SK Bioscience aims to strengthen the Thai Government Pharmaceutical Organization (GPO)’s end-to-end manufacturing practices that can attain WHO pre-qualification⁸¹.

The RIGHT Foundation⁶⁶, a research funding agency that funds R&D through a partnership between the Government of Korea, Korean life science companies and the Bill and Melinda Gates Foundation (BMGF), was launched as a part of ROK’s strategic initiative to enhance the effectiveness and impacts of its Official Development Assistance (ODA) projects and support for LMICs. Their projects cover vaccines including COVID-19, therapeutics and diagnostics. ROK has also been collaborating with the World Health Organization (WHO) to support LMICs as a global vaccine hub¹⁰, and their leading vaccine producer, SK Bioscience, has been working on expanding vaccine manufacturing in Thailand⁶⁹.

SOUTHEAST ASIA

According to the Coalition for People’s Right to Health (CPRH)¹⁷ in the Philippines and People’s Vaccine Alliance Asia, COVID-19 revealed stark gaps in R&D capacity among ASEAN countries, including inequities in access to COVID-19 vaccine and over-reliance on imports of vaccines despite the high number of approved vaccine trials in ASEAN countries (22 in Thailand, 23 in the Philippines and 24 in Indonesia).

This issue is coupled with limitations in regional R&D and manufacturing capacities, access to vaccine technology, dependence on imported raw materials and lack of political and budgetary commitment to vaccine developments. Five out of ten ASEAN countries produce vaccines, namely Myanmar, Indonesia, Singapore, Thailand and Vietnam. For example, Indonesia’s state-owned pharmaceutical company Bio Farma has been aiming to produce a locally produced IndoVac multi-strain COVID-19 vaccine³⁸. Historically, the Philippines and Malaysia used to produce vaccines, but they are no longer considered producing countries.

Furthermore, there is a disjunct between R&D and manufacturing in this region, with some countries relying on public institutions for vaccine research, but rely on the private sector or public-private partnerships for manufacturing. In addition, the COVID-19 pandemic put more limitations in accessing finance and investments, and there are differences between countries that invest in local capacity or self-sufficiency more than others.

However, there are increasing initiatives within this sub-region. Prior to the COVID-19 outbreak, ASEAN countries established a legally binding framework, the ASEAN Vaccine security and self-reliance (AVSSR)⁸. There are current efforts to

strengthen this sub-regional collaboration to improve capacity-building, training, and sharing of best practices for vaccine security. Additionally, Vietnam and Indonesia have been selected as recipients of WHO's technology transfer hub program.

JAPAN'S ROLES

Japan plays a major role in supporting the many global initiatives in strengthening R&D and manufacturing capacities, as revealed by their positions in political forums including the G7 Summits, as well as their significant financial contributions to pharmaceutical industries, international organizations and regional initiatives. Considering that Japan is one of the leaders of global R&D capacity and spending, they also hold great responsibility to center their initiatives around ensuring equitable and sustainable preparedness to health emergencies.

JAPAN'S STANCE

THE G7

The G7 has been building up capacities to effectively and timely respond to emergency health crises including pandemic preparedness. During the 2023 G7 Summit, Japan recognized the need to invest in R&D to strengthen the global capacity to tackle existing threats and rapidly produce Covid-19 technologies⁴⁶ and announced the 'G7 Hiroshima Vision for Equitable Access to Medical Countermeasures⁴⁷', which highlights the need for an end-to-end global ecosystem of medical technologies that includes regional diversification of manufacturing. To realize this, they supported the 100 Days Mission (100DM)⁴⁵ which was coined during the 2021 G7 Summit in the United Kingdom, aimed to develop diagnostics, therapeutics and vaccines within 100 days of the identification of a new pandemic threat. They also leveraged global and regional partnerships to accelerate R&D efforts, including the Global Health Innovative Technology (GHIT) Fund²¹, as well as engagements of the private sector.

THE QUAD VACCINE PARTNERSHIP

In 2020, China launched a global vaccine diplomacy effort, making Chinese companies Sinopharm and Sinovac become the main providers of Chinese COVID-19 vaccines abroad, which led to their pledge to supply one billion doses to African nations and 150 million to ASEAN countries in 2021. In response, the Quadrilateral Security Dialogue (the Quad), including Australia, India, Japan and the United States, formed their Vaccine Partnership. During their Leaders' Summit in 2021, the Quad committed to donating 1.2 billion doses to the Indo-Pacific by the end of 2022, with a focus on strengthening Indian pharmaceutical Biological E Ltd.'s manufacturing capacity⁴⁵.

To support this initiative, Japan, through the Japan International Cooperation Agency (JICA), committed to provide USD41 million plus concessional yen loans⁴⁸. Japanese banks including the Japan Bank of International Cooperation (JBIC) have been expanding their operations by engaging in this initiative, through loans made to the Export-Import Bank of India, which will loan to Indian vaccine manufacturers and healthcare sectors³⁴. By the end of 2021, Biological E Ltd. received funding to increase manufacturing capacity to 75 million doses of Corbevax per month. However, despite receiving continuous financing since 2021, the first doses were only delivered in early 2022.

During the 2021 May Tokyo summit, the Quad celebrated delivering over 670 million COVID-19 vaccine doses, including vaccines delivered through COVAX⁶¹. The Quad partners collectively pledged approximately USD5.2 billion to COVAX AMC and other initiatives including CEPI, and the Bank of Japan committed to a USD100 billion investment to finance the vaccine initiative⁷¹. However, this initiative faced numerous criticisms due to the many obstacles faced⁷⁴. For instance, while Australia, the United States and Japan donated vaccines through bilateral agreements with recipient countries, only India donated vaccines through this initiative. In addition, India began to prioritize domestic supply due to their wave of COVID-19 infections, causing delays in vaccine delivery. Furthermore, Bio-E manufactured Corbevax which could not be donated internationally as it lacked WHO-approval. This failure led to a large stockpile of vaccines, causing Bio-E to sell the rest to J&J.

In 2023, in their Joint Statement⁶², the Quad announced the change in their Vaccine Initiative to a broader Quad Health Security Partnership, despite failing to meet their original goals. While they continue to play a role in pandemic preparedness through meetings on vaccine and R&D cooperation, critics claim that the Quad partnership is solely a

military-focused alliance, without capacity to support the Indo-Pacific on other issues²⁰. Some predict future coordination of the Quad in R&D development with ASEAN countries⁵⁷.

ACCESS AND DELIVERY PARTNERSHIP

Since 2013, the Japanese government has been working in partnership with the United Nations Development Program (UNDP) on the Access and Delivery Partnership (ADP)⁷⁶, in an effort to realize Japan's national Global Health Strategy²⁵ and the 2030 Agenda for Sustainable Development. With the aim to improve access and delivery to health technologies including vaccines, the ADP focuses on strengthening capacities of national health systems and policies. For instance, they jointly developed the Uniting Efforts for Innovation, Access and Delivery⁷⁸, a joint platform that brings together stakeholders to promote cooperation in strategies that advance R&D and access initiatives, particularly focusing on financing.

The GHIT Fund plays a key role in the ADP through investments in innovation and research for developing new health technologies, and connecting Japanese organizations with global actors in R&D initiatives. Furthermore, in May 2022, the Japanese government funded the UNDP workshop in Vietnam to strengthen vaccine access and health systems capacity for Vietnam's response to COVID-19⁷⁷.

BILATERAL AGREEMENTS AND PRIVATE SECTOR

During the seventh Tokyo International Conference on African Development (TICAD) in 2019, the Japanese government endorsed leveraging the private sector to contribute to African development⁴⁹, resulting in multitudes of bilateral agreements with private industries. For example, through JICA, there have been agreements with the African Export-Import Bank (Afrexim), one of the main partners of the African Vaccine Acquisition Trust (AVAT), a framework established by the African Union for the purpose of securing access to COVID-19 vaccines. In 2022, JICA pledged up to USD200 million to respond to COVID-19 in Africa, including developing production and supply bases for medical technologies including vaccine production lines by African private companies, co-financed by Japanese banks³⁶. Furthermore, NEXI (Nippon Export & Investment Insurance), in collaboration with Japanese banks, loaned a total of USD520million to Afreximbank with an expectation of ensuring stable vaccine procurement in Africa through AVAT⁵⁵.

With a lack of transparency in the project details and ongoing situation of the agreements, it is uncertain how such bilateral agreements and loans are contributing to strengthening the regional R&D, manufacturing and related capacities in Africa. Furthermore, it is possible that such bilateral agreements are more business-oriented, as some loan schemes restrict the eligibility of financing to those with affiliation to Japanese companies³⁶.

100 DAYS MISSION

While the world managed to produce COVID-19 vaccines in 326 days after the identification of the pathogen, the 100DM aims to develop vaccines for future pandemics in 100 days. The Japanese G7 presidency in 2023 emphasized the importance of linking this initiative with equity in access, and strengthened, sustainable health systems of LMICs.

National efforts have been leveraged to support the 100DM, including Japan's launch of the Strategic Center of Biomedical Advanced Vaccine Research (SCARDA) with USD1.2 billion of funding over five years, and the United States' Biomedical Advanced Research and Development Authority (BARDA). SCARDA has been developed for vaccine R&D and clinical trial infrastructure with the hope to use the developed technologies for health emergencies beyond COVID-19. In 2023, they agreed to share information on vaccine development and other issues concerning health emergency preparedness, and coordination to support the 100DM¹². As there were opinions that Japan lagged behind other countries in developing COVID-19 vaccines, partly due to the 'siloe'd' research culture and lack of cross-disciplinary collaborations, SCARDA aims to boost national vaccine development capacities⁵⁸.

The International Pandemic Preparedness Secretariat (IPPS) has been established to support the implementation of the 100DM, including by reporting and submitting recommendations to the G7³⁰, key endorsers of the 100DM. The significance of regional manufacturing capacities has been raised in their recommendations, in addition to their 2023 Diagnostics Report³² which highlights FIND's five-year initiative that mentions their support of developing regional manufacturing hubs. Furthermore, in 2023, the IPPS conducted Regional Listening Exercises³¹ to investigate the current level of pandemic preparedness at various regions, and the ways in which the 100 DM could benefit the regions.

With regard to funding, the G7 and G20, particularly Japan, has been playing key roles in supporting the 100DM since its inception, including the pledges of USD125 million from Japan, USD120 million from Norway, USD100 million from the BMGF, and USD100 million from Wellcome Trust²⁸. In 2019, the Dai-ichi Life Insurance Company Ltd. from Japan was a major producer of CEPI's vaccine bonds, and in 2022, Japanese Prime Minister Kishida announced an additional USD300 million pledge towards CEPI for the upcoming five years.

COALITION FOR EPIDEMIC PREPAREDNESS INNOVATIONS (CEPI)

Coalition for Epidemic Preparedness Innovations (CEPI)

Contextual background

There are significant gaps in current markets for medical technologies and health systems, with insufficient incentives for pharmaceuticals to focus on the extent of impact, as well as the timeline of the next emerging infectious disease. This issue was clear during the Ebola outbreak, where there was no vaccine available even though the disease itself has been present since the 1970's.

Inception of CEPI

Launched in 2017, the Coalition focused on emerging infectious diseases and preparing for outbreaks, using the WHO's blueprint. It is currently a global partnership between public, private, philanthropic and civil society organizations.

Mission

- 1) Accelerate the development of vaccines and other health technologies against infectious diseases, enabling equal access to vaccines. Among many issues, CEPI focuses on establishing global manufacturing capacity and preparing clinical trials and laboratory networks.
- 2) CEPI 2.0 was launched during the pandemic to focus on addressing issues that hindered swift and effective development of vaccines during the COVID-19 outbreak, namely the 100DM.

Achievements

Some examples of CEPI's achievements include the development of the world's largest portfolio of vaccine candidates, including shared information by global partners on 25 viral families with potential to infect people. CEPI has also invested in DNA/mRNA vaccine platforms, and co-established COVAX.

How CEPI plays a role in equitable access

CEPI's Equitable Access Framework¹³ guides CEPI in ensuring linkages between the 100DM and equitable access to vaccines, particularly in the Global South. In their framework, they highlight strategies for enabling equity at the systemic level, including efforts to support the resilience of global health architecture and regional R&D and manufacturing, through strategic collaborations and financial investments in technologies and partners with an interest in equity, and through policy and advocacy work.

Their strategic partnerships include Universities and research facilities including ROK's IQVIA, pharmaceuticals including BioNTech and Moderna. In the case of Moderna, CEPI collaborated to find ways to expand their mRNA platform to broader health threats, while ensuring that any licenses developed through this partnership are affordable for LMICs. CEPI has also been working on geo-diversification by investing in strengthening manufacturing capacities among LMICs, through collaborations with, for instance, BioFarma in Indonesia, Aspen in South Africa, and Institut Pasteur de Dakar in Senegal. Additionally, they conduct advocacy towards equitable pandemic preparedness in various arenas such as the G7, G20 and the pandemic accord.

WHO'S mRNA COVID-19 mRNA VACCINE TECHNOLOGY TRANSFER HUB

As one of the most significant initiatives to strengthen regional capacities to produce vaccines, the WHO launched a

COVID-19 mRNA Vaccine Technology Transfer Hub⁷³ in Cape Town, South Africa in 2021 to share the know-how and intellectual property of vaccine production. Supported by the Medicines Patent Pool (MPP), ACT-A/COVAX, the Africa CDC, various universities and heavily funded by G7 nations, the technology transfer hub is a multilateral initiative to develop the manufacturing capacities of mRNA vaccines in LMICs⁸⁰.

Afrigen Biologics and Vaccines Ltd. (Afrigen) in South Africa has been selected to develop and produce COVID-19 vaccines for clinical trials using publicly available information, with support from other South African entities, which are then commercially produced by selected 'spokes,' the first one being Biovac in South Africa. In 2021, the Pan-American Health Organization (PAHO) made agreements to establish additional spokes in Brazil and Argentina⁷⁹.

ASIA PACIFIC'S ROLES IN THE TECHNOLOGY TRANSFER HUB

In Southeast Asia, Indonesia and Vietnam have been receiving training by Afrigen and the International Vaccine Institute to produce mRNA vaccines. Through the training, there is hope to also develop capacity to tackle other diseases; although this would require time and strengthened capacity for distribution.

The ROK signed an agreement with the WHO to establish a Global Training Hub for Biomanufacturing for vaccine and biologics workforces in LMICs³⁹. ROK is offering national training facilities and programs, expanding operations to accommodate more trainees from other countries. They intend to train at least 310 students from 33 LMICs in Africa, Middle East, Asia and ROK and aim to launch a Global Bio Education Campus in 2025.

CONCERNS AROUND THE TECHNOLOGY TRANSFER HUB

As there is no longer a market for COVID-19 vaccines, there are some concerns raised about the effectiveness of this mRNA technology transfer hub. However, the WHO hopes that this process of designing, testing and producing the vaccines will develop technological know-how to make other medical technologies, including an mRNA shot for tuberculosis, a priority of Afrigen⁵⁶.

However, other concerns have also been raised. For instance, while civil society has been mentioned by the WHO and MPP as key stakeholders, and that they can apply for their own technology or Intellectual Property Rights through this mechanism, currently, most partners of this initiative are pharmaceutical industries, and civil society organizations have limited research capacity to meaningfully engage. Civil society engagement is critical in achieving a whole-of-society, sustainable mRNA production ecosystem. There is great opportunity for civil society to engage in the social accountability mechanism, to be included in the governance of programs and demand open and transparent information, and ensure affordability of future products that are developed from this hub.

Additionally, as the technology transfer hub is producing vaccines using Moderna's publicly available sequence, there are concerns over Moderna's ability to sue any outputs of this hub, due to patents granted to Moderna over mRNA vaccines in South Africa (see *the Technical Brief by Medecins Sans Frontieres*⁴²). Such legal uncertainties highlight the looming issue of Intellectual Property Rights as a key barrier to any initiatives listed in this report.

ROLE OF PHARMACEUTICALS

With a flurry of global initiatives to strengthen regional R&D and manufacturing capacities in LMICs, pharmaceutical industries have also taken on several projects of their own. For example, BioNTech, who developed mRNA technology for Pfizer's COVID-19 vaccine, developed 'BioNTainers,' which are vaccine manufacturing factories using shipping containers. With plans to expand to other countries such as Senegal and South Africa, BioNTainers have been delivered to Kigali, Rwanda⁶³, and are expected to produce 50 million doses of mRNA vaccines each year⁹. Additionally, Moderna has announced their first mRNA manufacturing facility in Kenya, with the expectation to supply 500 million doses of COVID-19 vaccines to Africa, using a USD500 million investment⁶⁴.

Several issues have been raised regarding the independent projects by private industries, including the lack of transparency, and uncertainties in its usefulness for upcoming pandemics. For instance, the BioNTainer can only support productions of vaccines. With Rwandan biotech industries' lack of R&D capacities, there are concerns that they are incapable of responding to new pathogens other than COVID-19. Furthermore, there are currently no demands for COVID-19 vaccines, and currently, it seems these initiatives lack plans of developing capacities to produce other products.

REGIONAL INITIATIVES

Alongside the many global initiatives, there have also been increasing regional efforts among LMICs to strengthen their own R&D and manufacturing capacities. For instance, there have been developments in national vaccines in Cuba, and several technology transfer partnerships have been established with industries, for example, in the Latin America and the Caribbean region, AstraZeneca plc. and Sinovac Biotech in Brazil³¹.

However, several technology-transfer partnerships with pharmaceutical industries led to failures. For instance, South Africa's Aspen, who led African efforts to expand vaccine production capacities in Africa, announced their deal of USD30 million from the BMGF and CEPI to produce affordable vaccines for Africa in 2022²⁴. While Aspen managed to package and supply around 180 million doses of J&J vaccines, there was a halt in orders and hence production, putting at risk its 450 million dose production line, which they later used with their deal with Serum Institute of India. This failure, alongside the fact that the agreement only allowed Aspen to conduct the 'fill and finish' of vaccines, exposed the issue of vaccine dependence and limitations in manufacturing capacity. This issue was also exacerbated by the halt in vaccine exports in India in 2021⁷⁴, which hindered the delivery of AstraZeneca vaccines from Serum Institute to Africa.

AFRICA

Africa only produced 1% of the COVID-19 vaccines administered in the continent, making them reliant on imports. With expectations to grow the African vaccine market from around USD1.3 billion to around USD2.4 billion by 2030, the African Union launched the African Vaccine Acquisition Trust (AVAT) in 2020, with the Institut Pasteur de Dakar (IPD)²⁷ in Senegal as a key player in reaching their regional goal. Furthermore, through an initiative called the Partnerships for African Vaccine Manufacturing (PAVM), the Africa Centres for Disease Control and Prevention (CDC) has been working towards a goal to manufacture 60% of the continent's immunization needs by 2040⁵.

While many partnerships and initiatives have launched through the Africa CDC goal, for example, in December 2023, The Africa CDC welcomed the Global Vaccine Alliance (GAVI) for establishing the African Vaccine Manufacturing Accelerator (AVMA) that will finance up to USD1 billion for sustainable vaccine manufacturing industries in the continent³.

INSTITUT PASTEUR DE DAKAR

Institut Pasteur de Dakar (IPD)

Background

The Institut Pasteur has extensive expertise in epidemics, particularly in producing yellow fever vaccines. They are currently one of the key players, and fast-growing institutions for developing R&D and manufacturing capacities in Africa. IPD is frequently endorsed and funded by many donors, particularly the G7, but also international institutions such as CEPI²⁴.

Mission

With expertise in research and innovation; diagnostics, vaccination, nutrition and environment; public health management; and vaccine manufacturing and distribution, IPD aims to promote efficiency, inclusivity and innovation in public health. According to CEO Dr. Amadou A Sall, IPD prioritizes the following:

- 1) **Working in African contexts:** Most networks in which IPD is involved focus on local priorities of research, public health training and manufacturing.
- 2) **Workforce development:** IPD has been working on training and human development for the last ten years in 40 out of 55 African countries, one example being the Knowledge and Workforce for Africa Manufacturing's Equity (KWAME)⁴.
- 3) **Equity-focused:** IPD actively strives towards building resilience as a culture through their community-centered approach and developing workforce, and building business models that prioritize manufacturing for equity over profit.

- 4) **Partnership:** IPD builds open partnerships with diverse stakeholders in the R&D field including Gavi, UN-entities, CEPI, key players such as the Africa CDC and African health organizations, and hires community-members including anthropologists.
- In 2021, IPD made an agreement with Belgian Biotech Univercells Inc. to transfer their production line to Senegal and train local staff to eventually run the operation⁵⁴.
 - IPD is currently increasing partnerships with Southeast Asia as key emerging players in vaccine manufacturing, such as Indonesia, India and Singapore.

IPD's role during the COVID-19 pandemic

IPD has been active from the beginning of the outbreak, to ensure rapid responses and ensure that people have necessary products. The United States and European Union funded the expansion of IPD to incorporate COVID-19 vaccines which was expected to cost around USD200 million, with the aim to produce 300 million COVID-19 doses by the end of 2022. Activities included research on testing and genomic surveillance, manufacturing rapid diagnostic COVID-19 tests which were sold in 15 West-African countries, and working towards making them accessible and affordable.

One major initiative was the Manufacturing in Africa for Disease Immunization and Building Autonomy (MADIBA)⁵⁹ project. With a focus on building self-reliance of Africa, the project worked on rapid development of COVID vaccines, resource mobilization and developing infrastructures required for COVID-19 as well as other vaccines for future pandemics. Japan is one of the major supporters of MADIBA, through financial contributions and collaborations with Japanese institutions such as GHIT and the University of Tokyo.

The following were key approaches to MADIBA:

- 1) Developing flexible infrastructures that are capable of producing a variety of routine vaccines.
- 2) Ensuring end-to-end vaccine development processes including R&D and manufacturing.
- 3) Building the workforce by establishing training sites for vaccine production, including training for African youth and women.
- 4) Strengthening regulatory supply-chains to be able to manufacture and qualify vaccines to be in line in 2025.

CONCERNS AROUND REGIONAL EFFORTS IN AFRICA

While regional efforts are imperative for Africa to ensure diversification and sovereignty of vaccine R&D and production, there are issues in the current global health landscape that must be addressed in order to achieve Africa's goals. For instance, there are concerns around the market for African made vaccines. While it has been expected to impose 'resilience premiums' on buyers of African-made vaccines, it is uncertain who will be willing to pay extra to support the development of the African industry⁵⁶. Suggestions have been made to have international and philanthropic organizations such as GAVI, to purchase vaccines from LMICs.

CHALLENGES AND SUGGESTIONS

The flurry of global initiatives to strengthen R&D and manufacturing capacities of LMICs may sound appealing, but the lack of coordination among global entities including governments, private sector, international organizations and communities make it challenging to effectively decipher what efforts and investments are most effective in preparing the world for future health emergencies and ensuring equitable access to health products. This section highlights some concerns raised by civil society and individuals working in this field.

PERSISTING DEPENDENCE OF LMICs

While many LMICs have been dependent on foreign aid in the effort to procure medical technologies and respond to health emergencies, the many initiatives aimed at strengthening regional capacities maintain this system of dependence.

For instance, many projects are heavily funded by bilateral loans and philanthropic funding. Large loans will continue to burden LMICs, impairing their ability to fund their own regional initiatives, and manufacturers' ability to pay back the loans will depend on the products and access to markets. With decreased demands in COVID-19 responses, it is uncertain whether the regional initiatives will be a way out of depending on rich countries and financing institutions.⁴⁶

"The Covid guilt will be over by this afternoon. I just don't see South Africa agreeing to buy vaccines from Nigeria at a higher price than vaccines from India or Europe — that's a tough ask."

Martin Friede, vaccine research unit at WHO⁴⁶

"East African preparedness and response relies heavily on loan finance. Large loans are required to match the burden of infectious disease, resulting in further burden of loan repayments, impairing the region's ability to self-fund regional R&D and manufacturing infrastructure."

Heulwen Philpot, IPPS

SUSTAINABILITY

Building on the previous point, there are concerns around whether the regional initiatives include sufficient mechanisms that promote the sustainability of regional capacities. According to IPD's Dr. Amadou A Sall, the following are some points that are required to build sustainability:

- 1) Improve the procurement model of medical technologies, to ensure a healthy market with fair pricing. This includes strengthened coordination and focus on delivering what is needed in LMICs.
- 2) R&D with capacities that are based on local needs, rather than the interests of foreign entities.
- 3) End-to-end manufacturing capacities with reduced dependence on foreign entities that are economically viable, rather than 'filler and finish' of products.
- 4) Bring communities to a level where they can influence the agenda, and accelerate innovation.
- 5) Enhance equitable financing incentives, for instance by funding research that has policies of global access.

"End-to-end product development ecosystems must operate within a wider health system. This model must have equity and accessibility embedded into the design, but with clear definitions of equity."

Participant from the East Africa regional listening exercise by IPPS³⁶

Furthermore, Intellectual Property Rights still remain a key issue for manufacturing medical technologies. The end of COVID-19 as a Public Health Emergency of International Concern (PHEIC) could allow vaccine producers to assert their patents again, which holds significant implications on many initiatives including the WHO's mRNA technology transfer hub. Intellectual Property issues must be addressed to ensure sustainable and equitable ecosystems.

COORDINATION AT LOCAL AND GLOBAL LEVELS

As shown by the many initiatives, there are diverse efforts from the local level to global arenas which highlight the need for improved coordination and collaboration, for instance to avoid overlaps, but also for understanding local needs and effectively mobilizing manufacturers. This includes collaborations between pharmaceutical initiatives, governments, regional bodies such as the Africa CDC and researchers, monitoring actions and having governance bodies that can hold institutions accountable. While the pandemic outbreak spurred private and public interests in strengthening regional capacities, GAVI critiqued the disorderly expansion into Africa as a risk of unhealthy market competition, particularly if initiatives fail to realize Africa and AU's aspirations towards sustainable regional manufacturing²³.

As it would be a challenge for each country to develop end-to-end vaccine manufacturing capacities, regional collaborations, including South-to-South collaborations can help reduce the gaps in technology capacities and knowledge, such as pooling of resources, technology-transfer and regional distribution networks⁷⁰. However, such coordination requires strong, long-term governance and policies.

NATIONAL LEVEL EFFORTS

While regional and global entities can work to build local capacities, they cannot substitute policies and mechanisms that countries must develop and implement at the national level. Political will is key to strengthen local health systems including investments in developing skilled workforce, incentivize equity among industries, reduce barriers that restrict access, and collaborate with stakeholders including civil society and communities to develop effective interventions that meet local needs.

CIVIL SOCIETY ENGAGEMENT

Civil society and community engagement play key roles in ensuring equitable access to medical technologies. Various nonprofit organizations have been contributing to the advancements of R&D for COVID-19 vaccines. For instance, in 2021, the Médecins Sans Frontières identified over 100 manufacturers in Africa, Asia and Latin America with potential to produce mRNA vaccines⁴³. Additionally, the International AIDS Vaccine Initiative (IAVI)²⁹, an organization that conducts clinical trials for vaccines of diseases for which there is no market for development, has been working on developing vaccine candidates. Furthermore, others have engaged in research to investigate the issues around regional R&D and manufacturing capacities, including Action Global Health Advocacy Partnership¹ on Africa and the South Asia Alliance for Poverty Eradication (SAAPE)¹¹ with a focus on South Asia. Advocacy has been crucial in raising awareness of inequities not only seen during the COVID-19 pandemic, but in linkage with other epidemics, such as the Action Global Health Advocacy Partnership on tuberculosis², and the Treatment Action Group on HIV/AIDS⁷⁵.

Furthermore in 2023, the Health Justice Initiative demanded open access towards the South African courts to information regarding COVID-19 vaccine contracts²⁶, which revealed inequities in vaccine procurement, such as the fact that J&J charged South Africa 15% more per COVID-19 vaccine, than it charged the European Union. Such actions show that governments can be held accountable for their spending of public funds and that it is in the public interest to have transparency in all actions.

REFERENCE

Interviews were conducted with the following organizations: CEPI, People's Vaccine Alliance Asia and Africa, IPD and IPPS.

1. Action Global Advocacy Partnership, "Discussion Paper on Advancing African Regional Manufacturing of Vaccines and Other Medical Countermeasures," 23 October, 2023, <https://action.org/2023/10/23/discussion-paper-on-advancing-african-regional-manufacturing/>
2. Action Global Advocacy Partnership, "The impact of COVID-19 on the TB epidemic: A community perspective," 1 June, 2021, <https://action.org/2021/06/01/the-impact-of-covid-19-on-the-tb-epidemic-a-community-perspective/>
3. Africa Centres for Disease Control and Prevention (Africa CDC), "A Breakthrough for the African Vaccine Manufacturing," 8 December 2023, <https://africacdc.org/news-item/a-breakthrough-for-the-african-vaccine-manufacturing/>
4. Africa CDC, "Africa CDC, Institut Pasteur de Dakar and the South African Medical Research Council take concrete action to ramp up Africa's biomanufacturing workforce," 2 July 2022, <https://africacdc.org/news-item/africa-cdc-institut-pasteur-de-dakar-and-the-south-african-medical-research-council-take-concrete-action-to-ramp-up-africas-biomanufacturing-workforce/>
5. Africa CDC, "African Vaccine Acquisition Trust (AVAT) announces 108,000 doses of vaccines arriving in Mauritius as part of the first monthly shipment of Johnson & Johnson vaccines," 7 August, 2021, <https://africacdc.org/news-item/african-vaccine-acquisition-trust-avat-announces-108000-doses-of-vaccines-arriving-in-mauritius-as-part-of-the-first-monthly-shipment-of-johnson-johnson-vaccines/>
6. Africa CDC, "African vaccine manufacturing capacity," 3 October 2023, <https://africacdc.org/news-item/african-vaccine-manufacturing-capacity/>
7. Asahi Shimbun, "South Korea pledges nearly \$2 billion to become major COVID-19 vaccine producer," <https://www.asahi.com/ajw/articles/14411849>
8. Association of Southeast Asian Nations, "ASEAN Leaders' Declaration on ASEAN Vaccine Security and Self-Reliance (AVSSR)," 2 November 2019, <https://asean.org/asean-leaders-declaration-on-asean-vaccine-security-and-self-reliance-avssr/>
9. Becker, Zoey, "BioNTech gets ready to ship first modular factory to Rwanda," 22 December 2022, <https://www.fiercepharma.com/manufacturing/biontech-ships-first-biontainer-modular-facility-rwanda-site>

10. Byrne, T., Callahan, C. Kyoung, I. & Lepez, S., "South Korea as a Global Vaccine Hub," 26 October 2022, <https://keia.org/publication/south-korea-as-a-global-vaccine-hub/>
11. Chaudhuri, Sudip, South Asia Alliance for Poverty Eradication (SAAPE), "COVID -19 Vaccines, Patent Barriers and Local Production in Developing Countries," 2022, https://saape.org/files/Patent%20barriers%20and%20local%20production_11112022-1_compressed_1.pdf
12. Coalition for Epidemic Preparedness Innovations (CEPI), "SCARDA and CEPI collaborate to strengthen global pandemic preparedness and response," 26 June 2023, https://cepi.net/news_cepi/scarda-and-cepi-collaborate-to-strengthen-global-pandemic-preparedness-and-response/
13. CEPI, "Equitable Access Framework," May 2023, https://cepi.net/wp-content/uploads/2023/05/CEPI_Equitable-Access-Framework_May-2023_2.pdf?swfpc=1
14. CEPI, "CEPI expands partnership with Clover Biopharmaceuticals to rapidly advance development and manufacture of COVID-19 vaccine candidate," 7 July 2020, https://cepi.net/news_cepi/cepi-expands-partnership-with-clover-biopharmaceuticals-to-rapidly-advance-development-and-manufacture-of-covid-19-vaccine-candidate/
15. CEPI, "100 Days Mission," <https://100days.cepi.net/>
16. Chanda, Rupa; Gupta, Pralok & Helble, Matthias, Asia Development Bank Institute, "From Lab to Job: Improving Asia and the Pacific's Readiness to Produce and Deliver Vaccines," 2023, <https://www.econstor.eu/bitstream/10419/276209/1/Postigo-Chapter-3-ADB-2023.pdf>
17. Coalition for People's Right to Health, <https://www.facebook.com/cprPH/>
18. Dynavax Technologies Corporation, "Dynavax and Clover Biopharmaceuticals Announce Research Collaboration to Evaluate Coronavirus (COVID-19) Vaccine Candidate with CpG 1018 Adjuvant," 24 March 2020, <https://investors.dynavax.com/news-releases/news-release-details/dynavax-and-clover-biopharmaceuticals-announce-research>
19. Embassy of the People's Democratic Republic of Algeria to Japan, "Sputnik, Sinovac vaccines: Saidal to produce 2.5 million/month as from September," 13 July 2021, <https://algerianembassy-japan.jp/en/2021/07/15/sputnik-sinovac-vaccines-saidal-to-produce-2-5-million-month-as-from-september/>
20. Foreign Policy, "Why Attempts to Build a New Anti-China Alliance Will Fail," 27 January 2021, <https://foreignpolicy.com/2021/01/27/anti-china-alliance-quad-australia-india-japan-u-s/>
21. Global Health Innovative Technology (GHIT) Fund, <https://www.ghitfund.org/>
22. Global Trade Alert, "Republic of Korea: Introduction of K-Bio Vaccine Fund," 27 July 2022, <https://www.globaltradealert.org/intervention/113807/capital-injection-and-equity-stakes-including-bailouts/republic-of-korea-introduction-of-k-bio-vaccine-fund>
23. Global Vaccine Alliance (GAVI), "Expanding sustainable vaccine manufacturing in Africa: Priorities for Support," November 2022, <https://www.gavi.org/news-resources/knowledge-products/expanding-sustainable-vaccine-manufacturing-africa-priorities-support>
24. Grover, Natalie & Peyton, Nellie, "Senegal institute wins \$50 mln in boost to Africa's vaccine capacity, 20 January, 2023 <https://www.reuters.com/business/healthcare-pharmaceuticals/senegal-institute-get-50-mln-make-vaccines-global-south-2023-01-19/>
25. Headquarters for Healthcare Policy of Japan, "Global Health Strategy of Japan," 24 May, 2022, https://www.kantei.go.jp/jp/singi/kenkouiryuu/en/pdf/final_GHS.pdf; (Japanese) 健康・医療戦略推進本部決定、「グローバルヘルス戦略」2022年5月24日, https://www.kantei.go.jp/jp/singi/kenkouiryuu/senryaku/r040524global_health.pdf
26. Health Justice Initiative, "Open the Contracts: Court rules in favour of vaccine transparency," <https://healthjusticeinitiative.org.za/pandemic-transparency/#contracts>
27. Institut Pasteur de Dakar, <https://pasteur-network.org/en/members/african-region/institut-pasteur-de-dakar/>
28. Institute for Security and Development Policy, "Tokyo's Long View on the Coalition for Epidemic: The "100 Days Mission" and More," 21 February 2023, <https://www.isdp.eu/tokyos-long-view-on-the-coalition-for-epidemic-the-100-days-mission-and-more/>
29. International AIDS Vaccine Initiative, <https://www.iavi.org/>
30. International Pandemic Preparedness Secretariat (IPPS), "100 Days Mission Implementation Report," 31 January 2023, <https://d7npznm5zywd.cloudfront.net/prod/uploads/2023/01/100-Days-Mission-2nd-Implementation-Report-1.pdf>
31. IPPS, "A Participatory Discussion and Listening Exercise – Summary of Proceedings," July-August 2023, conducted with partners in four regions: 1. South and Southeast Asia,

- <https://d7npznm5zvwd.cloudfront.net/prod/uploads/2023/10/100DM-Regional-Listening-Exercises-Report-South-and-South-East-Asia.pdf>; East Africa
<https://d7npznm5zvwd.cloudfront.net/prod/uploads/2023/10/100DM-Regional-Listening-Exercises-Report-East-Africa.pdf>; West Africa
<https://d7npznm5zvwd.cloudfront.net/prod/uploads/2023/10/100DM-Regional-Listening-Exercises-Report-West-Africa.pdf>;
32. IPPS & FIND, "2023 Diagnostics Report," 28 November 2023, https://d7npznm5zvwd.cloudfront.net/prod/uploads/2023/11/IPPS_Diagnostics-Report_2023.pdf
 33. International Vaccine Institute, "SK bioscience's COVID-19 vaccine makes WHO's Emergency Use Listing," <https://www.ivi.int/sk-biosciences-covid-19-vaccine-makes-whos-emergency-use-listing/>
 34. Japan Bank for International Cooperation (JBIC), "Supporting COVID-19 measures in India, experiencing firsthand the unique excitement of policy-based finance," February 2023, https://www.ibic.go.jp/en/information/today/today_202301/jtd_202301_pi1.html
 35. Japan Bank for International Cooperation (JBIC), "Africa," as of 31 October, 2023, <https://www.ibic.go.jp/en/support-menu/bank-export/africa.html>
 36. Japan International Cooperation Agency (JICA), "Signing of a loan agreement to support COVID-19 responses in Africa (Private Sector Investment and Finance)," 7 April, 2022 https://www.ica.go.jp/english/information/press/2022/20220407_10e.html
 37. JETRO, "中長期的発展を描けるか", 4 July 2022, <https://www.ietro.go.jp/biz/areareports/2022/36ae90f1e5e9514b.html>
 38. Konsumen Cerdas, "Bio Farma aims to make IndoVac as COVID-19 multi-strain vaccine," 27 January 2023, <https://konsumencerdas.id/en/berita/bio-farma-aims-to-make-indo-vac-as-covid-19-multi-strain-vaccine>
 39. Korean Economic Institute (KEI), "South Korea as a Global Vaccine Hub," 26 October 2022, <https://keia.org/publication/south-korea-as-a-global-vaccine-hub/>
 40. Li, M., Ren, J., Si, X. et al., "The global mRNA vaccine patent landscape." 7 July 2022, Human Vaccines & Immunotherapeutics, <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC9746484/>
 41. Mazzouzi, Riad, "Algeria Begins Producing a Coronavirus Vaccine," 22 October 2021, <https://www.al-fanarmedia.org/2021/10/algeria-begins-production-of-coronavac/>
 42. Médecins Sans Frontières (MSF), "Removing intellectual-property barriers from COVID-19 vaccines and treatments for people in South Africa," 28 January 2023, <https://msfaccess.org/removing-intellectual-property-barriers-covid-19-vaccines-and-treatments-people-south-africa>
 43. MSF, "Pharmaceutical firms across Asia, Africa and Latin America with potential to manufacture mRNA vaccines," 16 December 2021, <https://msfaccess.org/pharmaceutical-firms-across-asia-africa-and-latin-america-potential-manufacture-mrna-vaccines>
 44. Ministry of Foreign Affairs (MoFA) Japan, Global Health Strategies <https://globalhealthstrategies.com/>
 45. MoFA Japan, "Quad Summit Fact Sheet," 12 March 2021, <https://www.mofa.go.jp/files/100159237.pdf>
 46. MoFA Japan, "G7 Hiroshima Leaders' Communique," 20 May 2023, https://www.g7hiroshima.go.jp/documents/pdf/Leaders_Communique_01_en.pdf?v20231006
 47. MoFA Japan, "G7 Hiroshima Vision for Equitable Access to Medical Countermeasures," 20 May 2023, <https://www.mofa.go.jp/files/100506811.pdf>
 48. MoFA Japan, "Quad Summit Fact Sheet," 12 March, 2021, <https://www.mofa.go.jp/files/100159237.pdf>
 49. MoFA Japan, "Tokyo International Conference on African Development 7 (TICAD7) was held on August 28," 28 August 2019, https://www.mofa.go.jp/af/af1/page4e_001088.html
 50. Ministry of Foreign Affairs of the People's Republic of China, "Xi Jinping Attends and Delivers an Important Speech at the Global Health Summit," 21 May 2021, https://www.fmprc.gov.cn/eng/zxxx_662805/202105/t20210522_9133147.html
 51. Ministry of Science and Technology of the People's Republic of China, "Online Launching Ceremony of BRICS Vaccine R&D Center and Workshop on Vaccine Cooperation successfully held," https://en.most.gov.cn/pressroom/202206/t20220622_181229.htm
 52. Moting, Jiang & Xintong, Wang, Caixin, "How a Chinese mRNA COVID vaccine was approved in Indonesia," 12 October 2022, <https://asia.nikkei.com/Spotlight/Caixin/How-a-Chinese-mRNA-COVID-vaccine-was-approved-in-Indonesia>
 53. NIKKEI Asia, "Pharmacy of the world: China's quest to be the No.1 drugmaker," 23 December 2021, <https://asia.nikkei.com/static/vdata/infographics/chinavaccine-2/>

54. NIKKEI Asia, "Production, politics and propaganda," 12 October 2021, <https://asia.nikkei.com/static/vdata/infographics/chinavaccine-1/> McAllister, Edward, "In boost for Africa, Senegal aims to make COVID shots next year, 6 June 2021, <https://jp.reuters.com/article/uk-health-coronavirus-africa-vaccines-ex-idUKKCN2DI043>
55. Nippon Export and Investment Insurance (NEXI), "NEXI Provides Loan Insurance for Afreximbank (COVID-19 Vaccine and Healthcare Finance Facility)/ LEAD Initiative Project," 17 March 2022, <https://www.nexi.go.jp/en/topics/newsrelease/2022031401.html>
56. Nolen, Stephanie, "Can Africa Get Close to Vaccine Independence? Here's What It Will Take," 25 April 2023 <https://www.nytimes.com/2023/04/25/health/africa-vaccine-independence.html>
57. Observer Research Foundation, "Quad and ASEAN," 15 June 2023, <http://20.244.136.131/expert-speak/quad-and-asean>
58. Otake, Tomoko, Japan Times, "Japan has a new vaccine research funding unit for future pandemics — is it up to the task?" 18 May 2023, <https://www.japantimes.co.jp/news/2023/05/18/national/science-health/japan-funding-unit-future-pandemics/>
59. Pasteur Network, 2 February 2023, <https://pasteur-network.org/news/en/the-institut-pasteur-de-dakar-and-cepi-partners-for-access-to-vaccination-in-africa/>
60. People's Vaccine Alliance, <https://peoplesvaccine.org/>
61. Prime Minister of Australia, "Quad Joint Leaders' Statement," 20 May 2023, <https://www.pm.gov.au/media/quad-leaders-joint-statement>
62. Prime Minister of Australia, "Quad Joint Leaders' Statement," 24 May 2022, <https://www.pm.gov.au/media/quad-joint-leaders-statement>
63. Republic of Rwanda, "Rwanda receives first BioNTainer for African-based mRNA manufacturing facility," 13 March 2023, <https://www.gov.rw/blog-detail/rwanda-receives-the-first-biontainer-for-african-based-mrna-manufacturing-facility>
64. Reuters, "Moderna to build mRNA vaccine manufacturing facility in Kenya," 8 March, 2022, <https://www.reuters.com/business/healthcare-pharmaceuticals/moderna-build-mrna-vaccine-manufacturing-facility-kenya-2022-03-07/>
65. Reuters, "S.Korea pays price for reliance on COVAX, scrambles for vaccines," 2 April 2021, <https://www.reuters.com/article/us-health-coronavirus-southkorea-vaccine/s-korea-pays-price-for-reliance-on-covax-scrambles-for-vaccines-idUSKBN2B05BZ/>
66. RIGHT Foundation. <https://rightfoundation.kr/en/>
67. Samsung Biologics, "Moderna COVID-19 Vaccine Manufactured in Korea by Samsung Biologics Receives Marketing Authorization from Ministry of Food and Drug Safety of Korea," 14 December 2021, <https://samsungbiologics.com/media/company-news-view?boardSeq=1480>
68. SK Bioscience, "Africa CDC Director General Visits SK bioscience to Discuss Vaccine Localization in Africa," 5 Nov 2023, <https://www.prnewswire.com/news-releases/africa-cdc-director-general-visits-sk-bioscience-to-discuss-vaccine-localization-in-africa-301977822.html>
69. SK Bioscience, "SK bioscience-Government Pharmaceutical Organization Sign Memorandum of Understanding to Strengthen Vaccine Infrastructure in Thailand," 5 July 2023, https://www.skbioscience.com/en/news/news_01_01?mode=view&id=218&
70. South Asia Alliance for Poverty Eradication (SAAPE), "COVID -19 Vaccines, Patent Barriers and Local Production in Developing Countries," October 2022, https://saape.org/files/Patent%20barriers%20and%20local%20production_11112022-1_compressed_1.pdf
71. The Diplomat, "The Disappointment of the Quad Vaccine Partnership," 1 July, 2022 <https://thediplomat.com/2022/07/the-disappointment-of-the-quad-vaccine-partnership/>
72. The Telegraph, "South Korea accelerates vaccine production to shore up defences against future pandemics," 2 October 2023, <https://www.telegraph.co.uk/global-health/science-and-disease/south-korea-vaccines-pandemic-preparedness-outbreaks/>
73. The World Health Organisation (WHO), "The mRNA vaccine technology transfer hub," <https://www.who.int/initiatives/the-mrna-vaccine-technology-transfer-hub>
74. Think Global Health, "The Past and Future of Health Cooperation in the Quad," 19 May 2023, <https://www.thinkglobalhealth.org/article/past-and-future-health-cooperation-quad?fbclid=IwAR1CftNtQy2f8lZdJSpxmnSaq5BAiTIpiAXzY-uRI56D-Z8uPqu4fpbfaCk>
75. Treatment Action Group, "Investment in HIV Research Profoundly Benefits the COVID-19 Response," 2 December 2020, <https://www.treatmentactiongroup.org/publication/investment-in-hiv-research-profoundly-benefits-the-covid-19-response/>

76. United Nations Development Programme (UNDP), "Access and Delivery Partnership: TB, Malaria and NTD Health Technologies for Those in Need," 1 December 2022, <https://www.undp.org/publications/access-and-delivery-partnership-tb-malaria-and-ntd-health-technologies-those-need>,
77. UNDP, "Workshop Advances Vaccine Access and Production Capacity in Viet Nam's COVID-19 Response," 22 May 2023, <https://www.undp.org/vietnam/press-releases/workshop-advances-vaccine-access-and-production-capacity-viet-nams-covid-19-response>
78. Uniting Efforts for Innovation, Access and Delivery <https://www.unitingeffortsforhealth.org/>
79. World Health Organisation (WHO), "FAQ - The mRNA vaccine technology transfer hub," <https://www.who.int/initiatives/the-mrna-vaccine-technology-transfer-hub/faq>
80. WHO, "mRNA Technology Transfer Programme moves to the next phase of its development," 20 April 2023, <https://www.who.int/news/item/20-04-2023-mrna-technology-transfer-programme-moves-to-the-next-phase-of-its-development>
81. Wipatayotin, Apinya, "GPO signs vaccine pact with Korean biotech giant," 5 July 2023, <https://www.bangkokpost.com/thailand/general/2606091/gpo-signs-vaccine-pact-with-korean-biotech-giant>
82. Bridge Beijing, "China COVID-19 Vaccine Tracker," <https://bridgebeijing.com/our-publications/our-publications-1/china-covid-19-vaccines-tracker/>