PSA TRANSFORMING THE SUPPLY CHAIN

Africa's Covid-19 Vaccine Supply Chain and Logistics Readiness

Dr Lakshmy Subramanian and Joanna Nayler

Pamela Steele Associates Ltd
Prama House, 267 Banbury Road, Oxford, OX2 7HT, United Kingdom
T +44 (0)1865 339 370 **E** info@pamsteele.co.uk **W** www.pamsteele.co.uk
company/psa-ltd PamelaSteeleLtd @PamelaSteeleLtd

Table of Contents

Acknowledgements

The authors wish to thank Dr Gamal Khalafalla Mohamed Ali and Mr Andrey Levitskiy who supported the production of this paper by providing information and feedback.

Suggested Citation

Subramanian, L. and Nayler, J. (2021). *Africa's Covid-19 Vaccine Supply Chain and Logistics Readiness.* Pamela Steele Associates Ltd.

Executive Summary

The Covid-19 pandemic has had a devastating human impact and exerted unrelenting pressure on pharma and healthcare supply chains. This study investigates the vaccine logistics and supply chain readiness of various countries, particularly in Africa, to support the immunisation program.

The study methodology includes a desk review of literature and an online questionnaire, which was circulated through multiple channels including the International Association of Public Health Logisticians (IAPHL) platform and the South-South Knowledge Network (SoSoKe). The survey received 41 responses, 88% of whom were from Africa, 10% from Asia and 2% from South America. 41% of respondents were from organisations at the national level, 15% from the state level, 5% from the local level and the remaining 39% were 'other.'

Covid-19 vaccines have started to become available in some countries. To vaccinate at least 60% of the population, Africa will need around 1.5 billion vaccine doses and, as urged by Gavi, the Vaccine Alliance, the time to put suitable structures in place for effective immunization is *now*. Key areas for vaccine supply chain readiness include plans for how vaccines will be imported, stored (including cold chain storage) and distributed. It is essential that appropriate infrastructure (e.g., power back-up) and vaccine management policies are in place. Other support areas for preparedness include standard maintenance systems, use of a Logistics Management Information System (LMIS), sufficient and well-trained staff, regulatory frameworks, contingency planning and secure funding.

Covid-19 Vaccine Preparedness Survey Results

Amongst survey respondents, 41% said their organisation had a plan for procuring Covid-19 vaccines. A slightly higher percentage—65%—also agreed or strongly agreed that their organisation was well-prepared for the Covid-19 vaccine. The areas that respondents said they were most strongly prepared for were vaccine management policy and vaccine transportation. Within support areas, those that respondents were best prepared for were forecasting, maintenance systems, monitoring and evaluation (M&E) and communication/reporting channels.

Respondents stated that the key areas they were least well prepared for were cold chain capacity, facility power back-up and creation of distribution plans. Concern over cold chain capacity was more prevalent for national and state-level stakeholders. The support areas they were least well prepared for were hiring new staff, having a sufficient budget and staff being well briefed and trained. Human Resources were identified as a critical bottleneck in the successful implementation of the inoculation programme. Respondents also highlighted that misinformation and fears around vaccinations is a key challenge.

Respondents did not have an extremely high average level of readiness for any of the factors surveyed. Not a single factor resulted in more than 70% of respondents agreeing or strongly agreeing that they were prepared. Of the total 21 factors studied, for 10 factors less than half of respondents agreed or strongly agreed that they were fully prepared.

Respondents listed recommendations for improving vaccine supply chain preparedness across a range of areas. This included a need for more training, training of staff, partner engagement, clear communication with the public to address vaccine hesitancy and the use of LMIS.

Based on the study, tentative recommendations for improvement include ensuring existing staff are well-briefed and trained, leveraging accurate funding (which could be financed through bonds backed by Organisation for Economic Cooperation and Development [OECD] countries), exploring new technologies such as direct-drive refrigerators, using robust digital tools to identify patients, establishing protocols for contingency plans and communicating with communities about Covid-19 vaccines.

1. Background

Covid-19 is an unprecedented crisis. As of 23rd February 2021, there have been 111 million confirmed cases of COVID-19 globally, including nearly 2.5 million deaths. This number continues to increase. Alongside its devastating human impact, the pandemic has exerted unrelenting pressure on pharma and healthcare supply chains.

Government interventions, such as social distancing and lockdowns, have led to disruptions in the health supply chain. A recent modelling study predicted that low and-middle-income countries (LMICs), especially in Africa, are particularly vulnerable to the indirect effects of Covid-19 on supply chains (Roberton et al., 2020). The increasingly interconnected and interdependent global economy has left countries vulnerable to external shocks, including in Africa. Modern management strategies and innovations aimed at streamlining systems and maximising profits such as lean manufacturing, just-in-time and strategic inventory tend to reduce flexibility and are more susceptible to external shocks. African countries' close economic and manufacturing ties with China have also been impactful.

Vaccines are widely viewed as one critical step to end the ongoing pandemic and they have started to become available in some countries. These include the Pfizer-BioNTech, Moderna and Oxford-AstraZeneca vaccines. Each has important differences with widespread implication for their distribution and use.

Vaccine production is very complex; albeit the extent of complexity varies depending on the platform used. Moreover, due to funding gaps, weak health systems, poor supply chain infrastructure and undefined eligibility, the delivery of Covid-19 vaccines to African countries requires thoughtful planning and unprecedented coordination across a wide-range of stakeholders. As urged by Gavi, the Vaccine Alliance, the time to put suitable structures in place for effective immunization is *now*. This review will examine how supply chain organisations, particularly in Africa, are prepared to support the vaccine logistics and supply chain requirements in their communities.

2. Literature review

This section discusses the various dimensions of vaccine logistics that act as critical pillars in national immunisation programmes. It also highlights the primary and secondary activities for vaccine logistics.

2.1 Covid-19 Vaccine Logistics and Health Supply Chain Readiness

African countries will require around 1.5 billion vaccine doses in order to vaccinate at least 60% of the population (the estimated percentage required to achieve herd immunity) (Nkengasong et al., 2020). It is estimated that this will cost US $8 billion - $16 billion, with additional mark-up costs for vaccination programme delivery (Gitahi, Myganda-Onyando and Macharia, 2020). The Africa Director of the WHO identified the goal of vaccinating 3% of Africans by the end of March 2021, and 20% by the end of 2021 (Africa Research Bulletin, 2020). However, WHO Africa also estimated that only around a quarter of countries in the region had adequate plans in place for resources and financing.

WHO, UNICEF and Gavi have worked together to help countries prepare to introduce a Covid-19 vaccine, including creating a Vaccine Readiness Assessment Tool intended to be used by Ministries of Health. There are other upcoming tools and resources in the pipeline, such as a tool for planning Covid-19 vaccine acceptance and demand, which has not yet been released, highlighting how this is an emerging area.

The following are key and support areas of vaccine supply chain readiness, drawing on WHO guidelines as well as broader literature.

2.1.1 Key areas of vaccine supply chain

Vaccine logistic planning. It is critical that plans are in place for where, how and by whom the vaccine will be administered. Good planning is important to ensure that infrastructure can deliver vaccines effectively, and demand planning is particularly important when millions of vaccine doses are required (KPMG, 2020). Prior to vaccine introduction, countries can prepare by assessing their existing supply chain capabilities and gaps. Equity in vaccine access should be a guiding principle throughout the planning process (WHO, 2020c). Countries should strive for a lean supply chain for quick distribution, possibly bypassing regional storage sites and holding stock for a limited time (WHO, 2020c)

Vaccine arrival. In the short-term, African countries will still need to rely on reserved doses from foreign producers, particularly as there is a lack of local pharmaceutical manufacturers in Africa. This means vaccines will need to be imported.

Airlines can play a key role in moving medical supplies, helping overcome infrequent shipping services or poor infrastructure for ground transportation (International Civil Aviation Organisation, n.d.). Ethiopian airlines has recently signed a partnership agreement with Cainiao Smart Logistics Network, the logistics arm of China's Alibaba Group, to launch a cold chain air freight for transporting temperature-controlled medicines, including the Covid-19 vaccine. However, the ongoing pandemic has caused issues with airline delivery, such as reduced passenger demand and quarantine measures impacting cargo capacity (World Trade Organisation, 2020). Planners should assess available transport options and check whether airports or ports can handle the increased traffic and map routes (KMPG, 2020).

Storage. Vaccines are perishable and highly sensitive to temperature fluctuations (Kartoglu and Milstien, 2014). Covid-19 vaccines that have been approved in several countries and have started to be distributed include the Pfizer-BioNTech vaccine (which requires storage at the ultra-cold temperature of -70°C), the Moderna vaccine (stored at -20°C) and the Oxford-AstraZeneca vaccine (which requires storage at normal refrigeration temperatures, 2-8°C). Countries receiving certain types of vaccines will have to plan for ultra-cold chain transport and storage at -70 °C. Most existing vaccines do not typically require an ultra-cold chain, so many countries will need to develop their ultra-cold-chain infrastructure to use such products.

Infrastructure. As well as having an appropriate layout and security, all facilities should also have power back-up and a 24-hour technical support service guaranteeing electricity. Further, temperature, shock, and moisture logging, with system alerts, are also beneficial, providing time to prevent damage and spoilage (KPMG, 2020). The WHO provides a Cold Chain Equipment Inventory and Gap Analysis Tool which can be helpful in this regard.

Stock management. Robust inventory management is critical to optimise product flows from suppliers and wholesalers (KMPG, 2020). This process includes standard operating procedures (SOPs) for stock management and handling, as well as disposal procedures for damaged or expired goods.

Distribution. The transport of vaccines between each level of the supply chain should be effective, with a distribution plan that is disseminated to relevant supply chain staff at all levels. The specific distribution plan will be dependent on the type of vaccine and its properties.

Vaccine management. Recommended policies for vaccine management, including the use of vaccine vial monitors (VVMs), should be adopted. According to the WHO, VVMs are a preferred characteristic for Covid-19 vaccines (WHO, 2020b). However, VVMs alone are not a substitute for a well-monitored cold chain, and the first vaccines supplied may not have VVMs (WHO,2020a; WHO, 2020b).

2.1.2 Support areas of vaccine logistics:

- **Maintenance**. Standard maintenance systems should be operational for all facilities and vehicles.
- **Information management**. The Logistics Management Information System (LMIS) should effectively support vaccine-needs forecasting. KPMG suggests that a rolling 13-26 week demand forecast should be created, so that locations can be reached before vaccines expire.
- **Human resources.** Governments should ensure that there are sufficient well-trained staff. Staff should be aware of relevant SOPs and plans. They should have adequate personal protective equipment to ensure their safety.
- **Leadership and governance.** Leaders should link the vaccine rollout to the broader immunisation strategic plans. For example, the Covid-19 vaccine could be incorporated into other preventative care services, such as basic health check-ups or influenza vaccine programmes (WHO, 2020c). The WHO also recommends that countries should use or adapt existing managerial/governance frameworks to oversee the planning and implementation of Covid-19 vaccinations.
- **Regulatory framework.** As highlighted by an Africa Dialogues Webinar on African country readiness for Covid-19 vaccines, barriers to regulation and approval of the Covid-19 vaccines across Africa should be removed. Harmonised regulatory processes and fast-tracking country authorisation of safe and effective vaccines could help achieve this goal. To facilitate regulatory alignment, the WHO has developed product-specific roadmaps to assess specific vaccine candidates (World Trade Organisation, 2020).
- **Monitoring and evaluation** should inform decision-making and include reviews. A traceability mechanism is also important. Countries should also have a robust vaccine safety monitoring and Adverse Event Following Immunisation (AEFI) system in place.
- **Communication.** Communication and reporting channels should be clearly defined. The Africa Dialogues Webinar on country readiness for Covid-19 vaccines urged that governments should engage communities to address mistrust and minimise vaccine hesitancy.
- **Funding.** Governments should act now to secure funding and a sufficient operational budget should be in place. The COVAX facility is an example of an initiative strengthening the bargaining power of existing countries and negotiating lower prices.
- **Contingency planning.** Contingency plans should be in place and clearly communicated.

3. Methodology

The study aims to understand preparedness for the Covid-19 vaccine across health supply chains in Africa. The methodology of the study includes the following components:

- A desk review of relevant literature was carried out on Covid-19's impact on health supply chains and challenges for the vaccine rollout. This review includes peer-reviewed articles, as well as global project reports and studies.
- An online questionnaire collected responses across a wide group of stakeholders, particularly logistics providers at the central, district, and state levels, as well as from implementing partners and private sector participants in the health supply chain. Invitations to complete the survey were circulated through multiple channels, such as the International Association of Public Health Logisticians (IAPHL) platform and the South–South Knowledge Exchange network (SoSoKE). The survey

included questions on the impact of Covid-19 on supply chain operations, resilience of operations, preparedness of health supply chain participants, and issues around vaccine logistics. The questionnaire follows a 5-point Likert scaling.

The study will follow non-probability sampling, using selective, or judgment sampling. This technique relies on the judgement of the researcher when choosing who to ask to participate. Thus, researchers may implicitly choose a "representative" sample to suit their needs, or specifically approach individuals with certain characteristics. Judgement sampling has the advantage of being time- and cost-effective to perform whilst resulting in a range of responses, which is particularly useful in qualitative research. The study follows a detailed research protocol including ethical consent.

4. Results

This section analyses the survey responses (41) and highlights the key trends that emerge across the various dimensions of vaccine readiness and supply chain logistics.

4.1 Respondent profiles

The survey details the responses in order of the geographical location and the type of organisation the respondents represent.

4.1.1 Geographical profiling

88% of responses were received from Africa, 10% from Asia, and 2% from South America. The geographic distribution of the survey responses can be seen in Figure 1.

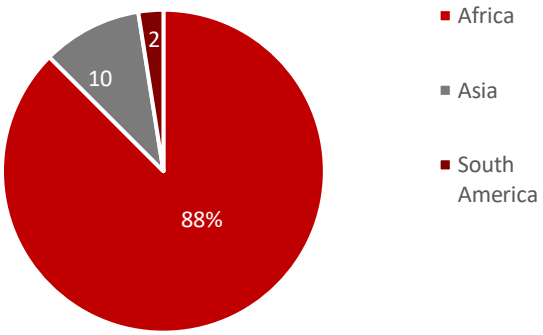

Figure 1: Geographic distribution of survey responses

Within Africa, the survey elicited 47% of responses from Nigeria, 29% of responses from Ethiopia, 6% of responses from Burundi, Liberia, and Kenya each, and 3% of responses each from other countries including Togo, Sierra Leone, Ghana, Chad, Mali, and Zimbabwe.

4.1.2 Type of organisation

The survey included 41% of responses from organisations at the national level, 15% from the state-level, 5% from the local level, and the remaining 39% from organisations not belonging to the national, state, or local level. The distribution can be seen in Figure 2.

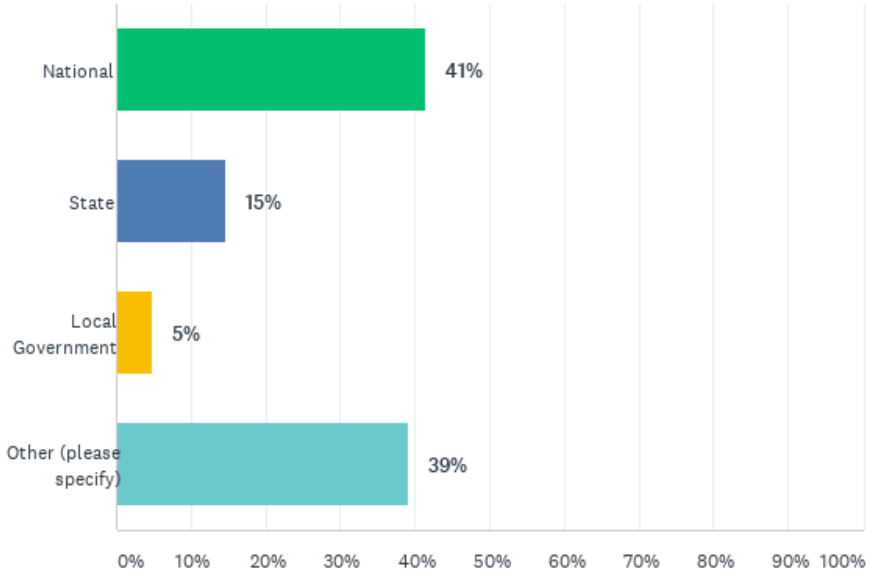

Figure 2: Survey respondents' type of organisation

The private sector, non-profit organisations, non-governmental organisations, quasi-government institutions, international agencies, etc. constituted the 39% of the 'other' organisations in the survey responses.

4.2 Covid-19 vaccine plan and associated logistic planning

41% of respondents stated that their organisation had a plan for procuring Covid-19 vaccines (59% said they did not). 37% of respondents also stated that a plan for vaccine logistics had been discussed.

4.2.1 Key areas of vaccine supply chains

Respondents chose the extent to which they agreed or disagreed that their organisation was prepared in a range of key vaccine supply chain areas. 65% of respondents either agreed or strongly agreed that their organisation is generally well-prepared to deal with Covid-19 vaccine logistics.

The other categories that respondents most strongly agreed they were prepared for were vaccine management policies and vaccine transportation: 64% agreed or strongly agreed that recommended policies for vaccine management have been adopted, and 61% agreed or strongly agreed that transport of vaccines between each level is effective.

The areas that respondents were least well prepared for were cold chain capacity, facility power back-up and creation of distribution plans. 27% disagreed or strongly disagreed that current cold chain capacity is

sufficient at all levels, and 27% also disagreed or strongly disagreed with the statement that all their facilities have power back-up and 24-hour technical support. A further 19% disagreed or strongly disagreed that a distribution plan had been created and disseminated.

A relatively high number of respondents (around one third) were also undecided for each category. For detailed information on survey responses, refer to the table below.

Table 1 Survey Respondents Preparedness for Key Areas of Covid-19 Vaccine Supply Chains

Category	Strongly Agree	Agree	Undecided	Disagree	Strongly disagree
General: Your organisation is well-prepared to deal with the vaccine logistics and supply chain requirements.	24%	41%	32%	0%	2%
Vaccine Arrival: The pre-shipment and arrival procedures (including documentation) ensure that every international shipment of vaccines will reach its first destination in the country.	22%	34%	32%	7%	5%
Storage: Current cold chain capacity at all levels is sufficient to accommodate expected vaccines quantities, surge capacity, etc.	7%	29%	37%	20%	7%
The **cold chain capacity** has been assessed according to the three ranges of temperature (i.e., +2 - +8°C; -20°C; and -70°C) for Covid-19 vaccine storage.	17%	32%	34%	12%	5%
Infrastructure: The layout of facilities and security arrangements enable supply chain effectiveness.	17%	41%	27%	12%	2%
All facilities have **power back-up** and a 24-hour technical support service guaranteeing electricity.	15%	24%	34%	17%	10%
Stock management: Adequate SOPs for stock management are in place vaccine handling and inventory.	20%	32%	37%	5%	7%
The **disposal procedures** for damaged and expired vaccines are governed by standard practices.	20%	39%	27%	10%	5%
Distribution: Transport of vaccines between each level of the supply chain is effective.	22%	39%	24%	15%	0%
The **distribution plan** has been created and disseminated to all concerned supply chain staff at all levels.	10%	34%	37%	17%	2%
Vaccine Management: Recommended policies for vaccine management, including the use of vaccine vial monitors (VVMs), are adopted.	32%	32%	24%	12%	0%

4.2.2 Support areas of vaccine supply chains

Similarly to the above question, respondents selected the extent to which they agreed or disagreed that they were prepared in a range of Covid-19 support areas. The categories in which respondents stated they were most prepared were forecasting, maintenance systems, M&E and communication/reporting channels. 59% agreed or strongly agreed that LMIS effectively support vaccine-needs forecasting, 54% agreed or strongly agreed that standard maintenance systems are operational. A further 51% agreed or strongly agreed that a robust M&E system supports decision-making and a traceability system has been developed, and 51% also stated that communication and reporting channels are clearly defined.

Table 2 Survey Respondents Preparedness for Support Areas of Covid-19 Vaccine Supply Chains

Category	Strongly Agree	Agree	Undecided	Disagree	Strongly disagree
Maintenance: Standard maintenance systems are operational for facilities and vehicles.	15%	39%	29%	17%	0%
Information management: The Logistics Management Information Systems (LMIS) effectively support vaccine-needs forecasting.	20%	39%	29%	10%	2%
Human Resources: Existing healthcare and SC staff are adequately briefed and trained.	10%	34%	29%	20%	7%
New staff are being hired and trained to support the immunisation programme.	15%	15%	37%	20%	15%
Leadership and governance: The Covid-19 vaccine rollout is linked to the health-sector's broader immunisation strategic plans.	7%	39%	37%	15%	2%
Regulatory framework: The National Medicine Regulatory Authority is ready to approve the Covid-19 vaccine without delay.	22%	27%	41%	7%	2%
Monitoring and evaluation: A robust system supporting informed decision-making and traceability mechanism has been developed.	12%	39%	41%	5%	2%
Communication: Communication and reporting channels are clearly defined.	10%	41%	37%	12%	0%
Funding: A sufficient operational budget is secured and made available.	2%	29%	41%	22%	5%
Contingency planning: Contingency and maintenance plans for all areas of the supply chain are clearly written and communicated.	5%	29%	41%	17%	7%

The categories respondents stated they were least prepared for were hiring new staff, having a sufficient budget and that staff are briefed and trained. 35% of respondents disagreed or strongly disagreed that new staff are being hired to support the immunisation programme, 27% disagreed or strongly disagreed that a sufficient operational budget is secured and available, and 27% disagreed or strongly disagreed that existing staff are adequately briefed and trained.

Again, around one third of respondents were undecided for each category. For detailed information on survey responses, refer to the table above.

4.3 Recommendations provided by survey respondents

The questionnaire provided space for respondents to list their recommendations for supply chain preparations for the Covid-19 vaccination, which are summarised below.

Need for training

Decision-makers, health workers and populations should be quickly trained and sensitised on the Covid-19 vaccination. They also called for training vaccine and supply chain personnel at all levels due to the vaccines' different storage temperature requirements and handling equipment.

Human Resources (HR) and Staffing

Additional HR for managing vaccine products should be hired and pharmacists should be in charge of procurement. They also stated that vaccines must only be administered by qualified and trained personnel, including community pharmacists.

Participants also identified the challenge of low turnout from health workers and caregivers who are scared to come to health facilities for fear of infection, and they recommended it be addressed.

Infrastructure

Covid-19 vaccine supply chains should be integrated with existing, modified cold chain management systems where possible. All organisations should also procure Covid-19 vaccine storage facilities as a priority due to the different temperatures required by the Covid-19 vaccine compared with vaccines stored for routine immunisations. They also recommended that sufficient freezer capacity should be available.

Partnerships and international coordination

WHO should use diplomacy to push governments to begin the vaccine rollout. They also stated that it is beneficial to engage more partners or hire companies with expertise in supply chain management and logistics and assist other countries that may have stockouts.

Governance

Honesty and a lack of corruption should drive the overall process. The government should ensure optimal distribution and storage of the vaccines and there should be transparency in planning and distribution.

Overall vaccine strategy

Initially, only the eligible must be given the vaccines. Additionally, the vaccines must not be hoarded and there must be proper supply chain planning.

Communications with public

Several respondents stressed the importance of sensitising the population to Covid-19 vaccinations. They noted ongoing conspiracy theories and rumours leading to vaccine hesitancy, and the importance of clear communication on when, where and how vaccines will be available. They also recommended the rollout of risk management strategies to address ongoing Covid-19 vaccine hesitancy.

One respondent from Nigeria noted that many perceive Covid-19 as a global conspiracy to under populate Africa and many citizens are not prepared to receive the vaccine. They recommended that the government

should spend more time on information dissemination via 'top-down' and 'bottom-up' approaches and use awareness campaigns, radio, television and other forms of distribution at all levels.

Regulation
The certification of vaccines must be carried out by a regulatory authority before it is accepted.

Data/M&E
Use LMIS to manage Covid-19 vaccine inventory for traceability, utilisation and accountability; they also recommended conducting a needs assessment.

5. Discussions

5.1 Key areas of Covid-19 vaccine supply chains: strengths and challenges

Regarding preparation for key areas of vaccine supply chains, 65% of respondents said that their organisation was generally well-prepared for the vaccine roll out. Other areas with the highest levels of preparation were adoption of policies for vaccine management and transport of vaccines between each level. Respondents said they were least well-prepared for cold chain capacity, power back-up and 24-hour technical support at facilities, and creation and dissemination of a distribution plan. 64% of the respondents were either unsure or did not agree that there was strong cold chain capacity at all levels in their organisation. Concerningly, this issue was more prevalent for the national and state-level stakeholders, which can have serious implications for national vaccination programs.

There were also concerns regarding the required temperature control for the vaccines (51% of the respondents), especially at the national level. 61% of respondents were unsure of or disagreed that power back-up and a 24-hour technical support service guaranteeing electricity were in place, suggesting this was a major issue. 57% of respondents also hinted that the distribution plan was not shared and disseminated to all concerned supply chain staff at all levels.

As seen in Figure 6, storage remains a critical challenge at the national (41%[1]) and state levels (36%). Maintaining cold chains at the specified temperature emerges as a common issue across the national (38%), state (19%), and local levels (5%). The survey highlighted respondents representing the private (38%) and charitable organisations (38%) (belonging to the category 'other') to be equally struggling in this area of vaccine supply chain (38%). Power back-up and continual IT support was realised to be low and difficult by the national stakeholders (41%), private sector (37%) and international agencies (13%). In addition, the poor dissemination of distribution plan was articulated as a limiting factor by the national (40%), state (13%), local (7%), and other stakeholders (40%).

Overall, there are many areas where respondents can improve their preparedness. Of the 11 key areas identified, there were four where less than half of respondents agreed or strongly agreed that they were fully prepared (cold chain storage, cold chain capacity, power back-up and distribution plan). There were no areas where at least 70% of respondents agreed or strongly agreed that they were prepared.

[1] Percentage in bracket indicates the proportion of respondents from each category who identified this area as a challenge.

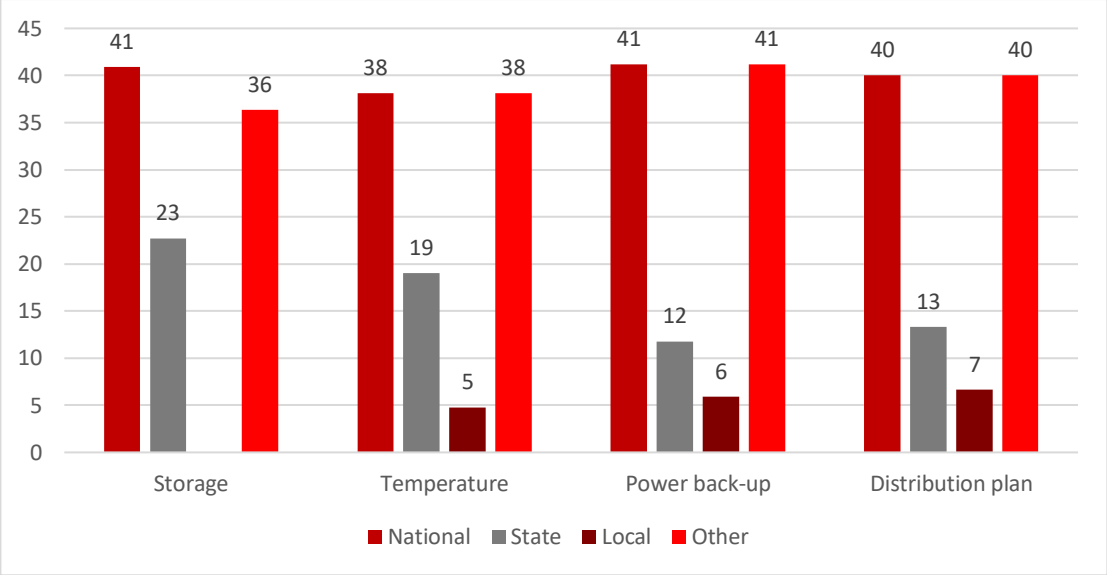

Figure 6: Distribution of key challenges across stakeholders

5.2 Support areas of Covid-19 vaccine supply chains: strengths and challenges

Regarding preparation for support areas of vaccine supply chains, respondents stated they were most prepared in the following areas: LMIS to effectively support vaccine-needs forecasting, operational standard maintenance systems, a robust M&E support system and communication/reporting channels. The areas respondents said they were the least well prepared for were the hiring of new staff to support the immunization programme, an available and sufficient budget, briefing and training, and staff. In this regard, maintenance systems, LMIS support, leadership, and governance, monitoring and evaluation, and communication have been recognised as enabling support areas of vaccine logistics.

In the support areas, human resources were identified as a critical bottleneck in the successful implementation of the inoculation programme. 56% of the survey responses agreed that the existing supply chain staff were not adequately briefed and trained; while 72% pointed out that new staff were not being hired and trained to support the immunization program. 50% of the survey respondents were apprehensive that the National Medicine Regulatory Authority is ready to approve the Covid-19 vaccine without delay and support the nation-wide operation. Other critical challenges included insufficient funding for the vaccination programme (66% of the respondents) and weak contingency planning (64% of the respondents). Whilst it was not included as a category in the quantitative part of the survey, within the recommendations section, several respondents also highlighted the need to communicate with the public concerning the safety and efficacy of the vaccine.

Figure 7 demonstrates the allocation of challenges in the support areas of vaccine logistics. Capacity development in the form of adequate briefing and training to health logisticians is challenging for national policymakers (43%), and stakeholders belonging to the category "other" (30%). Recruitment of new staff to support the immunization programme appears to be difficult for the private sector, non-governmental organisations (NGOs) and quasi-government agencies (41%), primarily followed by the national health system (35%). Weak regulatory support is viewed as a bottleneck across all stakeholders—national (38%), state (19%), local (5%), and other (38%). Funding inadequacies are highest at the national level (50%), and lack of

contingency planning along the vaccine supply chain stakeholders—national (46%), state (18%), local (4%), and other (32%) will lead to reduced health benefits.

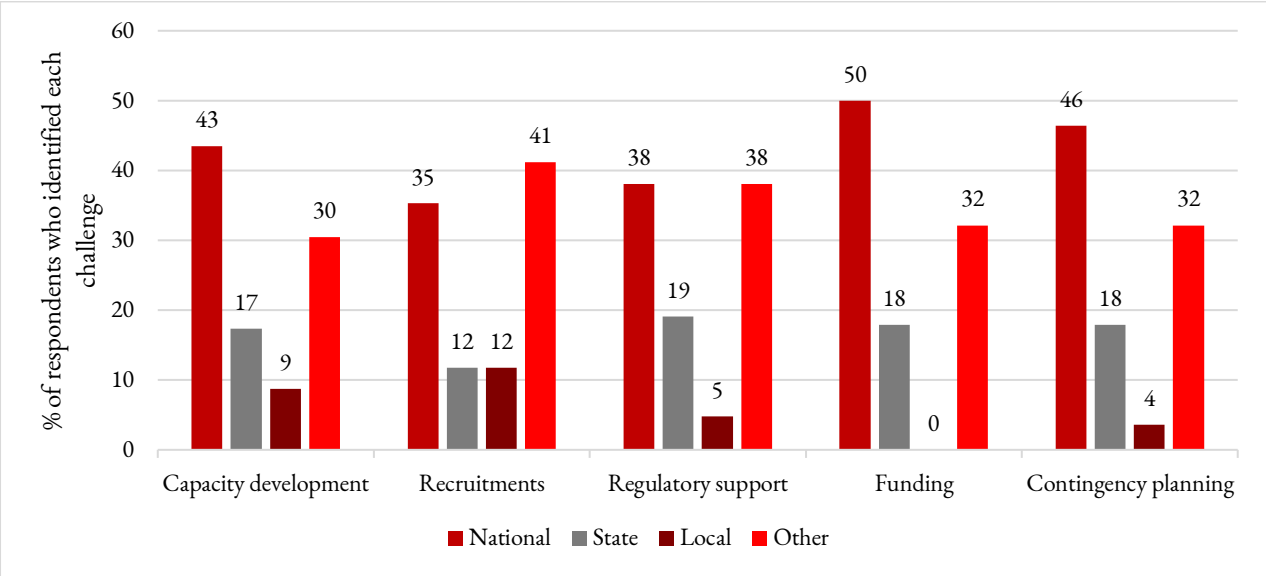

Figure 7: Distribution of challenges in support areas across stakeholders

Similar to the key areas, there are many areas where respondents expressed they did not have a high level of preparedness. Of the 10 support areas identified, there were six where less than half of respondents agreed or strongly agreed that they were fully prepared (briefing and training staff, hiring new staff, leadership and governance, regulatory framework, funding and contingency planning). There were no areas where at least 60% of respondents agreed or strongly agreed that they were prepared.

6. Recommendations

Human Resources emerged as a key area of concern. Where possible, organisations should ensure that existing staff are well-briefed and trained, and that sufficient new staff are recruited. However, having sufficient funding to hire new staff, as well as finding in-country staff with the relevant qualifications, can prove challenging. The pandemic has also had an overwhelming impact on the health system, putting workforces at risk. Not only will this impede the treatment of patients inflicted with Covid-19, but it will also affect the programme's ability to administer the eventual vaccine. Investment in personal protective equipment and testing capacity is needed to protect the global frontline workforce.

Adequate funding for supporting the Covid-19 inoculation programme will be a key priority for all countries, especially the LMICs. Low-income countries might not be able to bear the cost of deploying a new vaccine for Covid-19 and supporting its mass rollouts. Such countries should be supported by introducing smaller instalments over time and by having easy access to vaccine funding. A novel way to provide this financing is the issuance of a bond structure backed by OECD countries that would allow the money to be raised in capital markets. This would be similar to the IFFIm Vaccine Bonds introduced by Gavi. Similar bonds for Covid-19 vaccines would offer a unique opportunity for donors and investors to support the ongoing efforts to win the battle against Covid-19.

It is well documented that in many LMICs power and electricity sources are either absent or unreliable. This can cause serious damage to vaccines and result in wastages. **New technologies such as direct-drive solar**

refrigerators, ice-lined refrigerator technology, etc., should be explored. The use of these technologies has been successful in Vietnam and Senegal. Experience in both countries has shown that solar direct-drive refrigerators are a viable solution for areas lacking consistent power and/or electricity (Optimize: Vietnam Report; Senegal Report; 2013).

Another concern highlighted by the survey is the need to seamlessly track temperatures of vaccines and provide alerts for any wastage along the vaccine supply chains. The introduction of **vaccine transport modelling sensor and user interfaces** can protect vaccines. There has been preliminary success in this regard in Tanzania and Kenya (Nextleaf, 2019).

A critical pillar supporting the immunization programme will be identifying residents in different countries, which will be essential to verify that each dose reaches a patient. Corruption, leakage and duplication will prove precarious for vaccine supply chains, especially in LMICs. The **use of digital identity and biometrics** can be a solution to this challenge (Dahan and Sudan, 2015). Using robust digital tools to integrate the proof of vaccinations with the national identification systems can help governments overcome identification barriers to ensure that everyone receives a Covid-19 vaccine (Phelan, 2020).

Technology will play a vital role in ensuring smooth movement of the vaccines across the different levels of the supply chain. It will support increasing the overall visibility of relevant data for everyone involved. **Use of technology can identify potential bottlenecks in supply chains**, which can slow the transport and distribution of vaccines. Ecommerce-led platforms and data sharing platforms across other industries can provide shipment visibility, smart routing information, forecasts, identification of distressed suppliers and flag other disruptions. Adapting similar solutions to vaccine logistics could greatly ease some of the challenges.

Contingency plans preparing for diversions and thefts should also be in place. Throughout these supply chains, distributors and transport firms should think about how to maintain a double watch on the product at all times. It is essential to establish protocols for reacting quickly when an unplanned incident occurs or if vehicles are forced to make unplanned stops.

Communicating with the community. Several respondents highlighted the need to sensitise the population to Covid-19 vaccinations and counter misinformation. The WHO is using a tool to scan radio broadcast news in Uganda and identify any misinformation, and the WHO is looking to scale this up. Tools like this could be a useful area to explore further. Other mass communication campaigns and working through community healthcare activities will also be useful.

7. Conclusion

This survey, of which 88% of respondents were from African countries, revealed some areas for optimism regarding vaccine preparedness. 65% agreed or strongly agreed that their organisation was well prepared for the Covid-19 vaccination, and 59% agreed or strongly agreed that that LMIS effectively supports vaccine-needs forecasting. However, there are several areas where preparation is lacking. Of the 11 key areas identified, there were four where fewer than 50% of respondents agreed or strongly agreed that they were fully prepared (cold chain storage, cold chain capacity, power back-up and distribution plan). Of the 10 support areas identified, there were six where fewer than 50% of respondents agreed or strongly agreed that they were fully prepared (briefing and training staff, hiring new staff, leadership and governance, regulatory framework, funding, and contingency planning). Particular areas that need improvement are HR, cold chain capacity (where national and state level organisations were less well prepared) and communication with the public. Reaching full preparedness at all levels will be critical for the smooth rollout of the Covid-19 vaccine.

8. References

1. Africa Research Bulletin, 'WHO: Covid-19 Vaccine Plans' *Africa Research Bulletin: Economic, Financial and Technical Series* 57(11)
2. Dahan, M., and Sudan, R. (2015). Digital IDs for Development: Access to Identity and Services for All. Connections, World Bank Group.
3. G. Gitahi, R. Myganda-Onyando and E. Macharia, 'Are African Countries Ready for the COVID-19 Vaccine? (2020) Available at https://www.gavi.org/vaccineswork/are-african-countries-ready-covid-19-vaccine Accessed 14th Jan 2021.
4. International Civil Aviation Infrastructure (n.d.) Moving Air Cargo Globally: Air Cargo and Mail Secure Supply Chain and Facilitation Guidelines.
5. Kartoglu, U. and Milstien, J. (2014). 'Tools and approaches to ensure quality of vaccines throughout the cold chain' *Expert Review of Vaccines* 13(7).
6. KPMG (2020). Five ways to optimize the Covid-19 Vaccine supply chain.
7. Nextleaf Analytics (2019). Annual Report 2019.
8. Nkengasong, J. N., Ndembi, N., Tshangela, A. and Raji, T. 'Covid-19 Vaccines: How to Ensure Africa Has Access' *Nature* 586, 197-199 (2020)
9. Phelan, A.L. (2020). COVID-19 immunity passports and vaccination certificates: scientific, equitable, and legal challenges. The Lancet. Volume 395, Issue 10237, P1595-1598, May 23, 2020.
10. Optimize: Vietnam Report. PATH and WHO; 2013. Available online at www.path.org/publications/detail.php?i=2269
11. Optimize: Senegal Report. PATH and WHO; 2013. Available online at http://www.path.org/publications/detail.php?i=2272
12. Roberton, T., Carter, E.D., Chou, V.C., Stegmuller, A.R., Jackson, B.D., Tam, Y., et al., (2020). Early estimates of the indirect effects of the COVID-19 pandemic on maternal and child mortality in low-income and middle-income countries: a modelling study. The Lancet. Volume 8, Issue 7, E901-E908, JULY 01, 2020.
13. World Health Organisation (2020a). Bar-codes, QR codes and vaccine vial monitors in the context of COVID-19 vaccines.
14. World Health Organisation (2020b). WHO Target Product Profiles for Covid-19 Vaccines.
15. World Health Organisation (2020c). Guidance on Developing a National Deployment and Vaccination Plan for Covid-19 Vaccines.
16. World Health Organisation. WHO Coronavirus Disease (COVID-19) Dashboard. https://covid19.who.int/ Accessed 23rd February 2021.
17. World Trade Organization (2020). 'Developing and Delivering Covid-19 Vaccines Around the World'.