

LANDSCAPE ANALYSIS

Review of Existing Research on Cold and Ultra-Cold Chain Storage and Distribution Capacity for Countries Receiving COVID-19 Vaccines

To support USAID and GAVI to deliver COVID vaccines worldwide, GHSC-PSM conducted a desk review of available data and materials about the cold chain (CC) and ultra-cold chain (UCC) capacity of countries. This review found that publicly available data is limited, particularly regarding the availability of the ultra-cold chain equipment required for mRNA vaccines. However, the table below provides a list of several tools and resources that aim to help prepare countries for vaccine distribution.

The World Food Programme’s (WFP) Rapid Logistics Capacity Assessment is the only identified tool listed below that provides detailed information about countries. It also provides information about private-sector CC capacity. Few tools exist to assess UCC capacity; the World Health Organization (WHO) Immunization Supply Chain Sizing tool seems to be the most comprehensive tool in assessing CC and UCC capacity at multiple supply chain levels and service points for specific vaccines, including COVID-19 vaccines. The National Deployment and Vaccination Plan for COVID-19 Vaccines recommends collecting information from the private sector.

Table 1: Key Cold Chain and Ultra-Cold Chain Assessment Tools

| Tool (To view, click on titles) | Date | UCC | CC | Routine vaccines | COVID vaccines | Appropriateness for planning purposes |
|--|------|-----|----|------------------|----------------|--|
| Cold Chain Equipment Inventory and Gap Analysis Tool | 2021 | | ✓ | ✓ | ✓ | Contains information on cold chain equipment and capacity but nothing on ultra-cold chain. |
| COVID-19 Vaccine Introduction Readiness Assessment Tool (VIRAT/VRAF 2.0) | 2020 | | | | | Records whether or not a country has conducted a cold chain assessment but lacks relevant details about the status of a country’s capacity or readiness to manage vaccines requiring cold chain. |
| Immunization Supply Chain Sizing Tool | 2021 | ✓ | ✓ | ✓ | ✓ | Provides comprehensive data on CC and UCC capacity at multiple levels and service points within countries. |
| Effective Vaccine Management (EVM) Assessment Tool | 2020 | | ✓ | ✓ | | Does not gather data on the private sector capacity, nor does it collect information on ultra-cold chain equipment or capacity. |
| National Deployment and Vaccination Plan for COVID-19 vaccines (NDVP) | 2020 | ✓ | ✓ | | ✓ | Provides guidance to countries, leveraging information from the tools above, but is not a tool for collecting information on cold chain capacity. |
| World Food Programme: Rapid Logistics Capacity Assessments | 2021 | | ✓ | | | The depth of information depends on the country, but often includes contact details to support the assessment. |

Although many useful tools exist to assess countries' cold chain capacity at various levels of the supply chain, many require extensive time to gather and enter the required information. Additionally, most of the resulting data is not publicly available, and it is unclear which countries have completed which tools. Information regarding private-sector CC and UCC capacity would be a helpful supplement to the information that may have already been collected by country governments using existing tools.

WHO and UNICEF: Country Readiness Tools

WHO and UNICEF provide tools that countries can use in assessing readiness and preparing for vaccine introduction. WHO's [COVID-19 vaccination: Supply and logistics guidance](#) provides an overview of the recommended tools in assessing country readiness and cold chain capacity. In addition to recommending the below cold chain-related tools, the guidance identifies four decision criteria to consider when recommending available tools for country use. These criteria are: 1) exists or leverages existing data, processes, and tools; 2) has clear and non-duplicative use cases(s) to countries; 3) uses readily available data; and 4) is simple, easy to use and deploy by country stakeholders. As a result, countries may elect which tools to use in assessing their cold chain and ultra-cold chain capacity. On the pages below, more information is provided about the first four tools.

Table 2: WHO and UNICEF cold chain-related tools

| Tool | Description |
|--|--|
| Cold Chain Equipment Inventory and Gap Analysis Tool | Cold chain equipment (CCE) assets management spreadsheet with details, including number per site, functionality and age. |
| COVID-19 Vaccine Introduction Readiness Assessment Tool (VIRAT/VRAF 2.0) | High-level readiness checklist for vaccine introduction across various thematic areas. Per CC related information, states if a country has conducted a vaccine-readiness assessment but not results from the assessment. |
| Immunization Supply Chain Sizing Tool | CC capacity, gap and basic cost assessment tool for COVID-19 vaccination deployment. |
| Effective Vaccine Management (EVM) Assessment Tool | Supply chain assessments tool, where performance, gaps and action plans are identified. |
| Vaccine Volume, Forecasting and Cold Chain Gap Analysis Tool | Tool for assessing vaccine volumes and corresponding CCE requirements per catchment area. <i>(Note link to tool not found.)</i> |
| Cold Chain Deployment Plan | Tool for identifying planned and future cold chain investments for each supply chain levels. <i>(Note link to tool not found.)</i> |

Reference: [COVID-19 vaccination: Supply and logistics guidance](#)

Cold Chain Equipment Inventory and Gap Analysis Tool

Summary: The WHO CCE tool is an asset management spreadsheet for national program managers to estimate the size and capacity of the required supply chain infrastructure for routine and COVID-19 vaccines, including storage and transportation at each level and facility. The tool is intended to assess CC and logistics needs in support of new vaccine introduction by collecting data on passive cold chain—including cold boxes and vaccine carriers; refrigerators & freezers; cold/freezer rooms; and cold storage (+5 C and -20 C)—and collating a list of cold chain equipment and related specifications such as functionality, age and storage capacity. The tool collects data on inventory location by supply chain level—including service points, lowest distribution, sub-national and national—and generates facility segmentation for cold chain capacity at service points. After data entry, the tool produces several graphs for gap analysis. Note, however, that this tool only assesses CC capacity and does not gather information on UCC equipment.

Finding: Data are not publicly available, and it is unclear which countries have utilized this tool, per WHO's selection criteria.

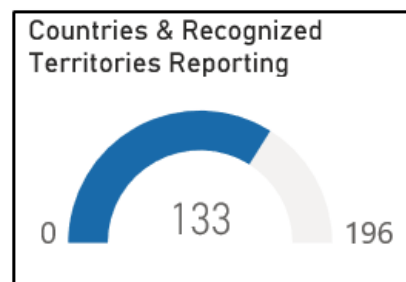
Utility and limitations: In addition to collecting information on routine immunization, the tool includes the option to select specific COVID-19 vaccines, including AstraZeneca, Johnson & Johnson, Moderna and Pfizer vaccines. However, it is unclear how many countries have used this tool or when they may have conducted gap analyses. The tool does not include specific information on UCC equipment, which will be essential for mRNA vaccines.

Reference: [Cold Chain Equipment Inventory and Gap Analysis Tool \(2021\)](#)

COVID-19 Vaccine Introduction Readiness Assessment Tool (VIRAT/VRAF 2.0)

Summary: The WHO VIRAT/VRAF 2.0 provides an Excel-based National Readiness Tool for the assessment of 10 key priority areas for COVID-19 vaccine introduction, including cold chain. The tool is designed for governments as a high-level readiness checklist for vaccine introduction, including mapping a timeline for administrative and financial steps. The tool contains one readiness assessment question specific to CC capacity assessment: “Assess dry storage and cold chain capacity at all levels with regards to the COVID-19 vaccines characteristics and fill the identified supply and logistics gaps”. The World Bank released a report, “[Assessing Country Readiness for COVID-19 Vaccines: First Insights from the Assessment Rollout](#)”—which includes key insights from completed country VIRAT-VRAF tool—and a [Country Readiness Core Indicators Dashboard](#), in partnership with WHO and UNICEF. The findings reported below are summarized from these key resources.

Findings: The VIRAT tool requires countries to “assess dry storage and cold chain capacity and infrastructure needs at all levels with regards to the COVID-19 vaccines characteristics and fill the identified supply and logistics gaps”. Based on the [Country Readiness Core Indicators Dashboard](#), 148 countries reported completing the VIRAT-VRAF tool. Of these, 28 countries reported conducting a CC assessment, but findings on UCC and CC capacity are not captured. Conducting the assessment alone does not necessarily indicate readiness. Forty-three (43) more countries reported being in the process of conducting a CC assessment, 34 had not yet conducted an assessment, and 23 were “not applicable.” The status of the remaining 5 was unknown.



One of the many data points in the VIRAT/VRAF tool dashboard.

The VIRAT-VRAF tool provides a list of key considerations and required activities to prepare for COVID-19 vaccine introduction. It does not provide a structured means for countries or other stakeholders to gather and analyze detailed information on the available cold chain and other infrastructure that would be required. The lack of details regarding CC capacity and readiness within the VIRAT/VRAF assessment tool leads to a large degree of variability in countries’ assessments and the captured level of detail. If country VIRAT/VRAF data were accessible, it would likely lack sufficiently detailed information on countries’ dry storage and CC capacity.

Utility and limitations: This tool provides countries a process for vaccine introduction preparedness. Alone, it does not provide tools for collecting detailed CC capacity information or guidance to determine how to scale up capacity if the assessment revealed that a country cannot ensure sufficient CC for COVID-19 vaccines. Conducting an assessment alone does not equal readiness.

According to the [World Bank Assessing Country Readiness for COVID-19 Vaccines report](#), Gavi suggests that in most low-income countries, the cold chain will be able to hold COVID-19 vaccines requiring temperatures as low as -20 degrees Celsius in quantities not exceeding what would be needed for up to 5 percent of the country’s population at any given time. This aligns with the expected phasing of vaccine deliveries to most low-income countries, therefore minimizing potential blockages in the cold chain. Note, however, that 59 countries eligible for financing from the World Bank’s International Bank for Reconstruction and Development/

International Development Association to purchase vaccines and strengthen systems for vaccine delivery have expressed interest in procuring the Pfizer vaccine from COVAX and have begun readiness assessments. As the Pfizer vaccine will have temperature requirements lower than -20 degrees Celsius, COVAX is developing UCC guidelines to help countries assess their CC needs and prepare for receipt of Pfizer vaccines.

References:

[COVID-19 Vaccine Introduction Readiness Assessment Tool \(VIRAT/VRAF 2.0\)](#)

[Country Readiness Core Indicators Dashboard](#)

[World Bank Assessing Country Readiness for COVID-19 Vaccines \(March 2021\)](#)

WHO Immunization Supply Chain Sizing Tool

Summary: This tool assesses ultra-cold chain and cold chain capacity, gaps and basic costs for COVID-19 vaccination deployment. The tool is designed for country governments and programs to estimate the required UCC and CC capacity for vaccine storage and transportation at each level and facility. The tool helps plan for significant changes in the national immunization program, such as undertaking multi-year planning exercises, introducing new vaccines and undertaking a large-scale comprehensive accelerated control program. To estimate the required CC capacity, the tool begins with estimating the maximum net storage volume of vaccines, diluents and injections equipment required per recipient using [WHO's Vaccine Volume Calculator](#). The tool has essential updated information on the vaccines available from all WHO pre-qualified manufacturers, including type, presentation and packed volume per dose. This tool includes information regarding routine vaccines and many COVID-19 vaccines, including AstraZeneca, Moderna and Pfizer.

Findings: Data are not publicly available, and it is unclear which countries have utilized this tool, per WHO's selection criteria.

Utility and limitations: This tool collects data on vaccine storage points at each level of the supply chain and available CC net capacity by temperature (including UCC and dry storage) at each storage point. By considering net vaccine storage for vaccines, diluents and injection supplies, the tool produces estimates of required CC capacity and equipment needed for storing routine and COVID-19 vaccines at national and district levels. This includes information on the required CC capacity at each facility, the most appropriate equipment to meet CC needs, and the estimation of facilities to be equipped with refrigerators and freezers.

Reference: [WHO Immunization Supply Chain Sizing Tool](#)

Effective Vaccine Management (EVM) Assessment Tool

Summary: This tool uses a series of Excel workbooks designed for national immunization programs to plan and allocate resources for routine immunizations. It assesses key vaccine supply chain criteria at each level of the supply chain, including the primary level, sub-national level, lowest delivery point and service point. The nine assessment criteria are: 1) Pre-shipment and arrival procedures, 2) Storage within recommended temperature ranges, 3) Cold storage, dry storage and transport capacity, 4) Buildings, cold chain equipment and transport systems, 5) Maintenance, 6) Stock management, 7) Distribution, 8) Appropriate vaccine management policies and 9) Information systems & supportive management functions. The EVM captures data on CC only (not UCC) equipment and does not capture data on COVID-19 vaccines. It is meant as a resource for information on a country's CC equipment and capacity gaps to inform planning for COVID-19 vaccine distribution.

Findings: Data are not publicly available; however, WHO published an analysis of results from the EVM assessments in 89 countries between 2009 and 2018. According to the report, only 11 countries completed an

EVM assessment in 2018, with most countries submitting their most recent EVM before 2016. Key observations from the report include:

- The maintenance of CC infrastructure grows progressively weaker as vaccines flow through the supply chain from the national medical store to health facilities.
- During the 2018 EVM assessment, a higher percentage of national store cold rooms were mapped by countries, compared to the first round of EVM assessments in 2009.
- The maintenance of CC equipment remains over 80 percent. According to the WHO, “an area of vaccine management is considered ‘effective’ if its criterion score is greater than or equal to 80 percent - the EVM standard”. It is unclear, however, if this means 80 percent of machines are functional or if all documented machines are 80 percent functional.



COVID-19 vaccine cold chain management in Malawi. Photo: GHSC-PSM/Urban Dynamix

Utility and limitations: The tool collects information on vaccine storage equipment at the supply chain facility level, including temperature ranges, storage capacity and utilization rate, as well as CC-related resources such as dry ice and generators. The tool uses a sampling technique to provide nationally representative information, so does not collect information from each facility. Implementing the EVM Assessment Tool requires a significant investment of time and resources. If the data has not been collected recently, it will unlikely be useful for COVID-19 vaccine planning. There are no data gathered on private-sector capacity nor information on UCC equipment or capacity.

References:

[Effective Vaccine Management \(EVM\) Assessment Tool](#)
[Effective Vaccine Management: Global Data Analysis 2009-2018](#)

National Deployment and Vaccination Plan for COVID-19 Vaccines (NDVP)

Summary: This is a framework for countries to develop a plan to deploy COVID-19 vaccines to identified populations and to assess readiness to receive vaccines. It includes information on regulatory preparedness, planning and coordination, identification of target populations, preparation of supply chains, waste management, human resource management and training, vaccine delivery strategies, demand planning, safety monitoring and management of adverse events, and monitoring and evaluation. All countries participating in COVAX were required to submit an NDVP. While the VIRAT gives a snapshot of country readiness, the NDVP provides a more detailed outline of each country’s plan to distribute vaccines. The NDVP covers information related to CC and UCC specific to COVID-19 vaccines.

Findings: Data are not publicly available, but all countries participating in COVAX were required to complete and submit an NDVP. [This article links](#) to a list of the 92 Gavi COVAX Advanced Market Commitment-eligible countries and economies that may have completed an NDVP.

Utility and limitations: The supply chain management section of the NDVP covers information related to both CC and UCC capacity for +2 to +8 °C; -20 °C; and -70 °C. However, the type of data that countries are required to provide is unclear. A WHO and UNICEF guidance document published in June 2021 highlights

limitations of the NDVPs submitted to date, noting that “many NDVPs described cold chain capacity in general but not in the context of preferred product, e.g., how many doses they could manage in a single shipment.”

References:

[COVID-19 national deployment and vaccination plan: Submission and review process](#)

[Guidance on developing a national deployment and vaccination plan for COVID-19 vaccines](#)

World Food Programme: Rapid Logistics Capacity Assessments

Summary: The World Food Programme (WFP) facilitates logistics capacity assessment and rapid logistics capacity assessment in the context of humanitarian emergency preparedness and response. Assessments may be conducted by WFP staff or other humanitarian organizations in any country every two years, with WFP providing the assessments to humanitarian response organizations and other private or public sector partners. These rapid capacity assessments exist for over 100 countries, and many include a component on public and private-sector CC (but not UCC) capacity.

Findings: While not intended for vaccines or the health sector, the logistics capacity assessments document CC type and capacity in the public sector and—in many cases—some commercial entities. The latest assessment results are available, by country, at the link below.

Utility and limitations: The assessments describe storage facilities and access, and include basic information on CC (but not UCC) storage types, capacity and operating conditions. The quantity of information varies by country. Some include key storage bottlenecks or constraints and contact details to update information.

Many countries have not updated their assessments recently, although the following countries have conducted storage assessments in the past 18 months: Algeria, Bangladesh, Burundi, Ethiopia, Kyrgyzstan, Nepal, Panama, South Africa, Tanzania and Tunisia.

Reference: [Logistics Capacity Assessments \(LCA\) Homepage](#)

Additional Resources

Project Last Mile: CO₂ Supply Feasibility Assessment

Summary: This is a feasibility assessment of liquid CO₂ (LCO₂) supply within the Coca-Cola supply chain to support storage and distribution of COVID-19 vaccines that require UCC in 47 countries in Africa and 23 countries in Latin America and the Pacific to assist in meeting dry ice needs. Project Last Mile (PLM) also completed a rapid assessment of the supply of LCO₂ in 70 countries from Coca-Cola partners and suppliers. Data include three options: a) LCO₂ production capacity and dry ice production capability, b) the cost of dry ice air transport and c) the cost to install new dry ice supply capacity. The assessment assumes that 1 percent of the population will be vaccinated over a 30-day period.

Findings: PLM concluded that there is abundant LCO₂ capacity to support the UCC requirements for COVID-19 vaccination programs for up to one percent of the population in each of the 70 countries evaluated. Of



Preparing for COVID-19 vaccine distribution in Malawi. Photo: GHSC-PSM/Urban Dynamix

those, 23 countries have sufficient dry ice production capability to service one percent of the population with COVID-19 vaccines (two doses 21 days apart). Countries in Africa include Angola, Cote D'Ivoire, Egypt, Ghana, Kenya, Madagascar, Morocco, Mozambique, Nigeria, Senegal, South Africa, Sudan, Tanzania, Tunisia and Uganda. Countries in Latin America and the Pacific include Bolivia, Costa Rica, El Salvador, Guatemala, Honduras, Papua New Guinea, Trinidad and Tobago and Vanuatu. Dry ice capability is measured at the central level of distribution and does not include last mile. If air transport is feasible, there is enough production capacity across the regions to meet demand. Alternatively, new supply capacity would need to be installed in 27 countries, with other countries being supplied by refrigerated trucks.

Utility and limitations: The analysis would need to be redone based on updated assumptions about the population to be reached. The analysis also focuses on the availability of dry ice at a central point of distribution in each country. It does not assess capacity for transportation or storage at lower levels of the health system.

Reference: [Project Last Mile: CO2 Supply Feasibility Assessment: Final Report](#)

Pamela Steele Associates: Africa's Covid-19 Vaccine Supply Chain and Logistics Readiness

Summary: Pamela Steele Associates conducted a two-part study to determine country preparedness for distributing COVID-19 vaccines that included a desk review of literature and an online questionnaire. Forty-one (41) stakeholders at the central, state and local levels responded to the questionnaire, with 88 percent from Africa, including half from Nigeria.

Findings: The study report notes that respondents consider cold chain capacity as being among the areas where countries are least well prepared, with 51 percent of respondents expressing concern about the temperature requirements for the vaccines.

Utility and limitations: For vaccine distribution planning, the findings are of limited use based on the limited number of responses and countries represented, the qualitative nature of the study, and the lack of detail about CC and UCC capacity across the supply chain.

Reference: [Africa's Covid-19 Vaccine Supply Chain and Logistics Readiness](#)

This document was last updated July 7, 2021