APPLYING AN EQUITY LENS TO COLD CHAIN DEPLOYMENT

Applying an Equity Lens to Cold Chain Deployment in Pakistan

Background

Access to potent vaccines is a challenge for nearly 20 million under-immunized children around the world. Improving immunization coverage and equity requires a comprehensive approach addressing many supply- and demand-side challenges contributing to persisting inequities. A critical part is ensuring potent vaccines are available when and where individuals need them. To maintain their potency, vaccines need to be kept at specified cold temperatures from manufacture to point of administration, which requires establishing an end-to-end cold chain.

Functioning cold chain equipment (CCE) for vaccine storage is an essential component of an end-to-end cold chain. Health facilities can only receive as many vaccines as their cold chain storage capacity allows, even if this quantity is insufficient for their target populations, which may lead to inequities in immunization access and, thus, coverage. In 2014, Gavi, the Vaccine Alliance, estimated 90% of health facilities in Gavi-eligible countries were not equipped with adequate cold chain equipment. CCE shortages that persist today will only become more extreme as countries introduce new vaccines and non-vaccine products that require cold chain, like oxytocin, and as populations grow.

To improve vaccine availability and, ultimately, improve coverage, Gavi and other donors are investing significant resources in helping countries acquire necessary CCE. In 2015, Gavi created the Cold Chain Equipment Optimization Platform (CCEOP) to expand availability of cold chain to store vaccines, making an initial investment of $50 million, and in 2017 committing $250 million over a five-year period. During 2015-2019, countries applied for Gavi support for new CCE through an in-depth application process that looks at different aspects of the immunization supply chain, including the country’s cold chain inventory. To date, 49 of 57 eligible countries have been approved for support. Even with these investments, Gavi estimated that demand for CCE would be 20-40% higher than originally forecast, and set a calculated ceiling amount for each country. In this constrained resource environment, countries must make important decisions about where to deploy new equipment... with a goal of prioritizing investments that improve coverage and equity.

---

4 Gavi, the Vaccine Alliance. https://www.gavi.org/
For example, countries must decide where to replace or rehabilitate existing equipment, versus expanding or extending equipment to new geographies. Gavi, the World Health Organization (WHO) and the United Nations Children’s Fund (UNICEF) provide guidance and support governments to develop CCE deployment plans (see resources section below).

In 2017-18, VillageReach led a technical process of re-designing the immunization supply chain for Pakistan in partnership with UNICEF, Gavi and the government of Pakistan. At that time, Pakistan was also one of the initial countries receiving cold chain equipment through the CCEOP, and in the first year of deployment. Recognizing the opportunity to inform deployment, the government requested that partners leverage the re-design process to develop an equity approach that could provide an additional lens to prioritize cold chain deployment in subsequent years. This document describes the equity approach developed during the supply chain re-design process in Pakistan, whereby areas with both insufficient cold chain and low immunization coverage are identified as highest priority areas for additional CCE. As new threats like COVID-19 emerge and new vaccines are developed, reassessing CCE needs using an equity lens in Pakistan and elsewhere will be important to ensure all people can access life-saving health products. Detailed steps are included in the appendix so that other countries can easily follow the process used in Pakistan.

Approach

VillageReach, UNICEF and the government of Pakistan developed a three-part process to identify priority geographies for CCE deployment to reduce inequities in immunization coverage. This approach involves understanding how existing cold chain storage capacity in an area compared to the volume necessary to immunize people in that area.

The three-step approach we took was to:

1. **Determine the cold chain storage volume necessary to fully immunize an individual.** We used the country’s Expanded Program on Immunization (EPI) schedule, vaccine presentation, delivery frequency and wastage rates to determine the cold chain storage volume needed to fully immunize a hypothetical individual.

2. **Determine the existing cold chain storage volume per individual.** We calculated existing cold chain volume per target individual based on the actual population in each district.

3. **Compare necessary vs. existing cold chain storage and immunization coverage to guide decision-making and advocacy.** We then identified districts with (1) less actual cold chain coverage than what was needed and (2) low immunization coverage. We recommended prioritization of these districts for additional CCE deployment.

Pakistan used this approach to identify districts that do not have sufficient CCE, so they could be prioritized for deployment. Since there is often lack of visibility into data at subnational level, this approach was extremely helpful in assessing the 156 districts in Pakistan receiving $50 million worth of CCE over five years. However, this level of analysis may still hide inequities that exist within districts regarding distribution of CCE across health facilities. Others looking to use this approach could apply it to different administrative levels, ideally using the health facility as the unit.
of analysis. Other factors that were not assessed as part of this exercise are also important to consider when making deployment decisions, such as the distribution network, the frequency of vaccine distribution, the reach and state of CCE management/maintenance, and site readiness for new equipment.

For this approach we used the Effective Vaccine Management (EVM) Assistant Tool v2.0 released in Oct 2018. Please note that this is different from the EVM Assessment Tool. Other documents used and consulted include Pakistan’s:

- EPI schedule for routine immunizations and campaigns
- Buffer stock policy
- District’s resupply frequency
- Most recent cold chain inventory
- District’s immunization coverage data

Part 1: Determine the cold chain storage volume necessary to fully immunize an individual

In this first part, we determined the cold chain storage volume required to store the vaccines needed to fully immunize an individual for Pakistan. We used the Effective Vaccine Management (EVM) Assistant Tool v2.0 to generate the amount of cold chain storage needed to fully immunize an individual according to Pakistan’s immunization schedule.5

We considered vaccines over the life course, starting with those required to fully immunize a child by one year of age, and adding vaccines that individuals require beyond the first year of life, such as the second dose of measles and tetanus vaccines. We incorporated these vaccines to reflect the full storage volume necessary to fully immunize an individual according to Pakistan’s vaccination schedule, resupply frequency and buffer stock policy. Additionally, we also included vaccines that were not yet part of the EPI schedule but that Pakistan anticipated introducing in the next three years, such as human papillomavirus (HPV) and typhoid vaccines. Since countries do not frequently make significant CCE investments, Pakistan included, this approach anticipated growing needs in CCE capacity over the next few years to accommodate planned new vaccine introductions and growing populations to ensure vaccine availability.

Since Pakistan has regular campaigns for polio, we included additional polio vaccines that would be needed. However, we did not include one-off outbreak or response campaigns as long as there was some buffer cold chain capacity to accommodate them.

For Pakistan, the calculated target cold chain volume needed to fully immunize an individual was 0.06 liters. See the appendix for the detailed step-by-step description of how we used the EVM Assistant Tool to calculate the liters of cold chain needed for districts in Pakistan.

Since countries do not frequently make significant CCE investments, Pakistan included, we wanted to anticipate growing needs in CCE capacity over the next few years to accommodate for new vaccine introductions and growing populations to ensure vaccine availability.

5 The EVM Assistant Tool is a Microsoft Excel tool used to assist in EVM Assessments.
Part 2: Determine the existing cold chain storage volume per individual

Next, we determined the amount of cold chain storage volume currently available per individual based on the target population at the same level of analysis, or district level. Part 1 calculated cold chain capacity needed per a hypothetical fully immunized individual, whereas in this part we estimated existing cold chain volume per individual based on the actual population requiring immunization.

In our analysis, we calculated the cold chain storage volume per “surviving infant,” or number of children that reach their first birthday in a given year. Although “surviving infant” does not fully capture the target population for all vaccines (as that also includes children over the age of one, adolescents and pregnant women for some vaccines), surviving infants are the target for the majority of the vaccines and, thus, we used this readily available figure as a proxy. As new vaccines and health products requiring cold chain are introduced, the approach should be adapted to include different target populations.

Our analysis in Pakistan was at the district level, so the steps described below were calculated for districts.

**STEP 1:** Determined current cold chain storage. We reviewed the most recent cold chain inventory to determine the cold chain storage capacity for each district.

**STEP 2:** Determined the number of surviving infants in districts. In the Pakistan national planning documents, the country estimated the number of live births equal to 3.5% of the population in the district, and that 92.6% of live births would survive to the first year (surviving infants).

\[
\text{Number of surviving infants in a district in Pakistan} = 92.6\% \times (3.5\% \times \text{district population})
\]

**STEP 3:** Determined the volume of cold chain per surviving infant for each district. To determine the cold chain volume per surviving infant, we used the inputs from steps 1 and 2 above in the following formula:

\[
\text{Liters of cold chain per surviving infant} = \frac{\text{aggregate cold chain volume in district}}{(\text{number of surviving infants})}
\]

Part 3: Compare necessary and available cold chain storage with immunization coverage to guide decision making

We compared the target or necessary amount of cold chain storage for a fully immunized individual (part 1) with the existing amount of cold chain storage for each surviving infant (part 2). If the amount of cold chain storage available was less than the target, we inferred that the facility would be unable to keep enough quantities of vaccines potent and would experience stockouts.

The results from the analysis in Pakistan were presented to the national and provincial EPI representatives. A sub-set of the anonymized results are shown in Figure 1 below, showing the cold chain per surviving infant and immunization coverage.
coverage, as measured by third dose of diphtheria-tetanus-pertussis (DTP3). There are several districts with cold chain close to or below the target for Pakistan. Based on the analysis, it was recommended that subsequent cold chain deployment should be prioritized in districts with both low cold chain coverage and low immunization coverage. For Pakistan this meant that, from an equity lens, districts A, B, and D should be prioritized.

Figure 1: Results for cold chain and immunization coverage from select districts in Pakistan
Red - Indicator is below the target; Yellow - Indicator is at or near the target; Green - Indicator is above the target

<table>
<thead>
<tr>
<th>District</th>
<th>Cold chain / surviving infant (liters)</th>
<th>DTP3 coverage (%)</th>
<th>Urban-Rural gap in DTP3 coverage (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>0.04</td>
<td>24</td>
<td>-</td>
</tr>
<tr>
<td>B</td>
<td>0.06</td>
<td>30</td>
<td>25 - 30</td>
</tr>
<tr>
<td>C</td>
<td>0.07</td>
<td>100</td>
<td>100 - 100</td>
</tr>
<tr>
<td>D</td>
<td>0.07</td>
<td>49</td>
<td>65 - 49</td>
</tr>
<tr>
<td>E</td>
<td>0.08</td>
<td>92</td>
<td>87 - 93</td>
</tr>
<tr>
<td>F</td>
<td>0.12</td>
<td>96</td>
<td>93 - 96</td>
</tr>
<tr>
<td>G</td>
<td>0.12</td>
<td>95</td>
<td>100 - 94</td>
</tr>
<tr>
<td>H</td>
<td>0.47</td>
<td>100</td>
<td>100 - 100</td>
</tr>
<tr>
<td>I</td>
<td>0.58</td>
<td>98</td>
<td>95 - 99</td>
</tr>
</tbody>
</table>

Based on the overall analysis for Pakistan, the relationship between cold chain coverage and immunization coverage varied based on the province. There were several districts that had low immunization rates, despite adequate cold chain coverage. This was expected as there are several factors, like demand and service delivery, that impact immunization rates. However, there were no districts with inadequate cold chain and high immunization rates, as cold chain is necessary to ensure vaccines are available and potent for service delivery.

Increasing the volume of cold chain storage in areas with insufficient CCE capacity helps ensure that sufficient vaccines can be stored and kept potent to reach individuals, thereby contributing to equitably improving immunization coverage. Alternately, changing the resupply frequency could also contribute to improving vaccine availability, depending on road infrastructure, transport availability and impact on service delivery. When planning CCE deployment, decision-makers should consider these factors in conjunction with other factors like site readiness, appropriate type of CCE and overall CCE maintenance capacity, among others.
Stakeholders can use this approach to guide decision-making and advocacy in several ways:

1. Provinces or districts can use this information to advocate to higher levels of government or donors for additional CCE capacity at specific health facilities, especially those with low immunization coverage.
2. Governments can use this information to prioritize specific health facilities or districts to adjust CCE capacity in future deployments.
3. When new CCE deployment is not planned, governments can evaluate alternate measures that can be taken to optimize available CCE. For example, resupply frequency could be increased or decreased to ensure the vaccines received are not beyond the available storage volume and that there is adequate vaccine supply for each level of the health system.

**Increasing the volume of cold chain storage in areas with insufficient CCE capacity helps ensure that sufficient vaccines can be stored and kept potent to reach individuals, thereby contributing to equitably improving immunization coverage.**

**Resources**

Available resources referenced above include:

1. [WHO Vaccine Management Handbook: How to calculate vaccine volumes and cold chain capacity requirements. March 2017](#).
2. [Gavi Cold Chain Equipment Optimization Platform (CCEOP) guidelines and templates](#).
3. [Effective Vaccine Management (EVM) Assistant Tool](#).

**VillageReach Contact**

**For more information, please contact:**
Mariam Zameer, Manager, Health Systems mariam.zameer@villagereach.org

Additional information about this work is also documented in the paper “Promoting equity in immunization coverage through supply chain design in Pakistan” available at: [https://doi.org/10.12688/gatesopenres.13121.1](https://doi.org/10.12688/gatesopenres.13121.1)
Appendix

We detail the approach we used to employ the EVM Assistant Tool v2.0 in calculating liters of cold chain storage needed to fully immunize an individual according to Pakistan’s existing and proposed EPI schedule. Since the EVM Assistant Tool uses fully immunized child (FIC)\(^6\), we have used this terminology at times, but note that we included all vaccines over the life course according to the Pakistan EPI schedule.

**STEP 1: Opened and prepared the Effective Vaccine Management (EVM) Assistant Tool.**
We clicked on the “Cover” worksheet tab and entered Pakistan as the country. See Figure 2.

**Figure 2: We entered country name, language choice and date on cover tab**

![EVM Assistant Tool](image)

**STEP 2: Clicked on the “vaccine_select” worksheet tab** and cleared the default entries in the first row.

a. **Selected the vaccine database filter we wanted to use** *(average, min, or max)* [cell E4]. Given that vaccine presentations’ packed volumes can vary depending on the manufacturer, we used the dropdown in cell E4 to select that we wanted the average packed volumes from the Vaccine_database worksheet tab to be used as the default figures in column F (as opposed to minimum or maximum). See Figure 3 below. Later, we replaced these auto-populated values by entering actual country volume figures for Pakistan into columns D and E.

b. **Selected “FIC,” or “fully immunized child,”** as the type of recipient group to be used to estimate vaccine demand [cell E7]. See Figure 3 below.

---

\(^6\) A fully immunized child (FIC) is one that has survived to their first birthday and received all recommended doses of vaccines in that time.
Figure 3: In Vaccine_select worksheet, we chose vaccine filter and selected FIC as recipient group

**Table: Vaccine storage volumes**

- **STEP 3:** Entered all the vaccines in Pakistan’s current and anticipated immunization schedule [column B], and specified the vaccine presentations [column C]. Pakistan was using for each vaccine using the pre-filled drop-down lists. We manually entered vaccines not included in the drop-down list, such as “typhoid.” See Figure 4.

We also entered vaccines that were not yet part of Pakistan’s immunization schedule (typhoid and HPV vaccines), to understand the effect that adding them may have on required cold storage volume. Considering new vaccines helped us anticipate future CCE needs.

In this step, we included bivalent oral poliovirus vaccine type 1 and 3 (bOPV1+3) twice—one for routine immunization and a second time to account for regular polio campaigns.

Figure 4: We entered all vaccines in current immunization schedule and specified presentations

**STEP 4:** Entered Pakistan-specific volume and wastage rates. Once we completed columns B and C, columns F, G, J and K populated automatically. Where available, we used country-specific volume and wastage rates, and entered that information in columns D, E and I (as specified in points (a) and (b) below) to override the default figures. See Figure 5.

a. **Average, minimum, or maximum packed volume** for each vaccine and any diluent [columns F and G] automatically populate from the Vaccine_database tab in the EVM Assistant Tool, according to what we selected in step 2(a). We were able to override these auto-populated values by entering actual country volume figures into columns D and E.
b. **Standard wastage rates** and wastage factors from the database automatically populate [columns J and K]. We replaced these auto-populated values by entering available Pakistan-specific vaccine wastage rates into column I.

**Figure 5: We entered country-specific volume and wastage rates**

![Figure 5](image)

**STEP 5:** Entered the **total number of doses per individual** for each vaccine [column O] according to the national EPI schedule. See Figure 6. We considered the doses that would be administered through both routine immunization and through regular campaigns.

For example, in Figure 6 below, we included four routine doses of bOPV1+3 and 46.8 campaign doses of bOPV1+3 per child. Based on Pakistan’s shipment history of vaccines, the country shipped 11.7 doses of polio vaccines for regular campaigns for every dose of routine polio vaccine, as there are almost monthly polio campaigns. Hence, as there are four doses of bOPV in the routine schedule, we estimated that 11.7 x 4, or 46.8 doses of polio vaccine (bOPV1+3) would be needed per fully immunized child for campaigns.

**Figure 6: We entered total number of doses per individual for each vaccine**

![Figure 6](image)

**STEP 6:** Entered the **maximum supply interval and the safety stock amount for each vaccine** [columns R and S, respectively]. We entered the maximum resupply interval and safety (or buffer) stock in months for our level of analysis, which was districts. Since districts are supplied monthly and frequency does not vary by vaccine, we entered “1” for all vaccines. Safety stock refers to the level of buffer stock (in months) that needs to be stored at the level being analyzed. For Pakistan, we entered one month for each vaccine into column S. See Figure 7.
The maximum stock volume for each vaccine was then automatically generated [column U] after we entered maximum supply intervals and months of safety stock.

**Figure 7:** We entered the maximum supply interval and safety stock amount

**STEP 7:** Added the maximum volumes required to store vaccines and diluents per fully immunized individual [cells U37 + X45]. The volume in cell U37 is the aggregated maximum cold chain capacity that might be needed for vaccines at any given time at the district level of the supply chain (based on the maximum resupply and safety stock entered in columns R and S). Cell X45 is the maximum storage volume that might be needed at any given time for diluents. We added these two values to determine the maximum storage volume needed at any given time for both vaccines and diluents. See Figure 8.

**Figure 8:** We added the maximum volumes required to store vaccines and diluents per FIC in cells U37 and X45

**STEP 8:** Converted cm$^3$ to liters since cold chain volume is often assessed in liters to establish a target for cold chain per fully immunized child (FIC).

We divided the volume in cm$^3$ by 1,000 to determine the amount of cold storage volume in liters. The cold chain target will be different for every country depending on the immunization schedule, vaccine volumes, buffer and cycle stock policies, wastage rates, and level of analysis, all of which are used as inputs in this approach. In the case of Pakistan, the cold chain volume target needed per fully immunized child for districts was $56.5 + 1.7 = 58.2cm^3/1,000$, or 0.06 liters.