The
FINAL 2◖
Project

Lessons Learned in Reaching the Final 20: Building a
Next-Generation Immunization Supply Chain in Mozambique

VILLAGEREACH®
Starting at the Last Mile

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Executive Summary

The government of Mozambique is committed to increasing the availability of immunization services to help ensure the health of its citizens. Like most low- and middle-income countries (LMICs), the system of people, infrastructure, and equipment required to deliver vaccines was developed for a time when immunization programs were much smaller and vaccines much less costly. More than a decade ago, VillageReach began working with Mozambique's Ministry of Health to improve the immunization supply chain (iSC) and help reach the remaining one in five children who lack access to life-saving vaccines. The country's health leaders recognized that poor supply chain performance hinders their ability to improve immunization coverage and equity of immunizations for all children.

VillageReach, the Foundation for Community Development (FDC) and the Provincial Directorates of Health first developed and piloted a new iSC in Mozambique's northern provinces of Cabo Delgado and Nampula. Today, government leaders run and manage a vastly improved immunization supply chain across half the country, serving more than 550 health centers and more than 8 million people (Figure 1). This has helped develop regular and reliable vaccine distribution to immunization sites, provided greater data and visibility into immunization system performance, and greatly increased the availability of vaccines.

Figure 1: VillageReach supported activities, 2016

Why was the approach used in Mozambique so effective? Most iSC improvements tend to focus only on incremental changes in individual components of supply chain performance, such as better cold chain equipment, additional training, improved data for management, or transport. Since its inception, VillageReach's mission and programmatic focus have been heavily influenced by its founding work in Mozambique, driven by an approach firmly rooted in 'the last mile' and lessons learned in scaling and sustaining health innovation in low- and middle-income countries. VillageReach discovered that in order to achieve lasting change it was essential to move beyond incremental improvements to reconsider the entire supply chain system. As part of the Final 20 project over the last three years, we focused on supporting the Mozambican government to implement improved vaccine delivery systems; increasing data visibility and utilization; exploring options for new transport services; and documenting and disseminating evidence from Mozambique to key audiences.

This report highlights elements of the work in Mozambique that we believe provide helpful insights for other countries looking to move to an updated, or "next-generation," immunization supply chain. The following pages first share the backdrop for VillageReach's project in Mozambique. Then it focuses in detail on the specific approaches and tools VillageReach has used, along with lessons learned, in the following areas:

- A streamlined and efficient supply chain that decreases wastage and logistics costs. In Mozambique, this approach was developed through a holistic system design process including the use of computer simulation modeling. A new cadre of provincial logistics officers manages distributions to the service delivery point and has the authority to make supply chain decisions based on data and actual, on-the-ground circumstances.

- Data visibility and access to actionable data. In Mozambique, an open-source, web-based logistics management system called "SELV" provides details of vaccine availability and quality all the way to the point of delivery and facilitates the use of data for decision-making and continuous improvement. Robust KPIs are used to monitor progress.

- Maintenance of the right cold chain equipment. High-performing cold chains are essential to delivering quality vaccines the full length of the supply chain, and VillageReach helped demonstrate that remote temperature monitoring is one viable solution.

- A well-managed transportation system, including testing the use of private sector companies to augment government transport resources.

- An evidence base to help determine the root causes of poor immunization system performance. This includes studies VillageReach conducted on such issues as performance management and accountability, understanding the true vaccine coverage rate, and reliable funding to the service delivery level.

- Leadership and political will. Leaders must be supported through an enabling environment, and leadership skills must be developed in order for effective leaders to apply creativity and innovation to next-generation iSC.

Finally, this document concludes with a look ahead at how VillageReach is using its experience from Mozambique to help ensure all children have access to life-saving vaccines. The evidence from VillageReach's work, along with strong partnerships with Gavi, the Vaccine Alliance, UNICEF, WHO and other partners working to improve the immunization supply chain, have been instrumental in helping influence other countries and broader immunization supply chain strategies critical for reaching global vaccine goals. The first Ministerial Conference on Immunization in Africa, held in Addis Ababa, Ethiopia in February 2016, was a positive first step toward increasing demand for supply chain changes across Gavi-eligible countries. Now a systemic shift is on the horizon – a shift away from incremental improvements narrowly focused on individual aspects of iSC toward fundamental, comprehensive change to address all aspects of the iSC for sustained, system-wide improvement. Moving from acknowledgement into action will require a dedicated and long-term commitment and resources.

The promise of next-generation immunization supply chains relies on our ability as implementers, donors, and government stakeholders to continue to work together: to be transparent with our data and share successful approaches, to encourage and support leaders who are willing to question and change the status quo, and to invest adequate resources from the global level down to the point of immunization. Only then will we truly reach the final 20% of children who, today, are still waiting for life-saving immunizations to reach them.

Setting the Stage

Since vaccines were first introduced through the Expanded Program on Immunization (EPI) in the 1970s, great strides have been made to provide life-saving vaccines to children around the world, currently reaching 86% of infants globally with the third dose of diphtheria-tetanus-pertussis (DTP3).[1] Despite these tremendous efforts, vaccine coverage rates have stagnated in the past decade with one in five children worldwide without access to basic vaccines— the final 20% of unvaccinated children.[2] Persisting vaccine coverage gaps drove global health leaders to establish the "Decade of Vaccines" in 2010 and subsequently develop the Global Vaccine Action Plan (GVAP) to focus commitment on improving the quality and availability of vaccines by 2020.

Ongoing challenge: Reaching effective vaccine management standards
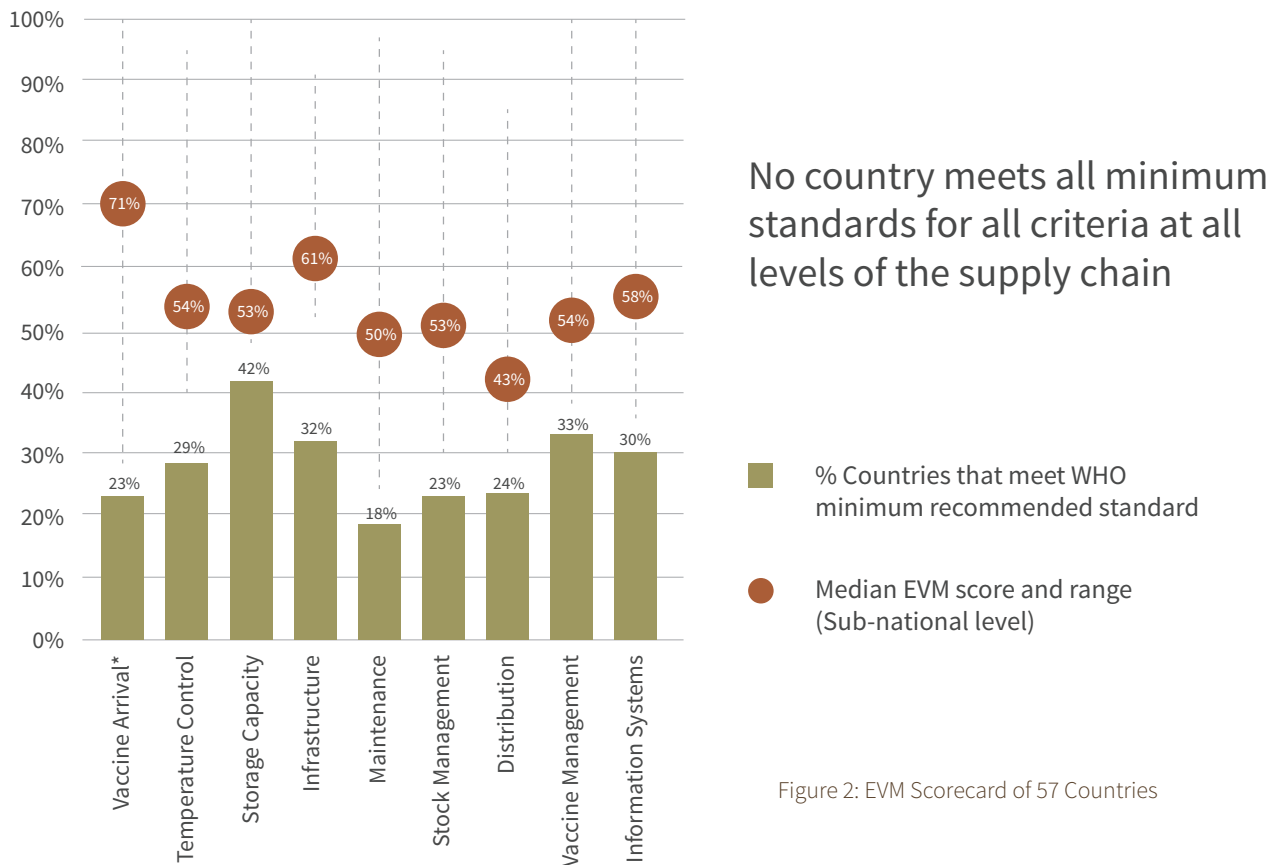
No country meets all minimum standards for all criteria at all levels of the supply chain

■ % Countries that meet WHO minimum recommended standard

● Median EVM score and range (Sub-national level)

Figure 2: EVM Scorecard of 57 Countries

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1 World Health Organization. Immunization Coverage Fact Sheet, March 2016. http://www.who.int/mediacentre/factsheets/fs378/en/
2 World Health Organization. Fulfilling a promise: Ensuring immunization for all in Africa. Ministerial Conference on Immunization in Africa. 2016.

The GVAP has brought needed attention and additional financial support to vaccines for low- and middle-income countries, yet significant unmet need remains. Coverage gaps of the basic vaccines exist not only among countries, but also within countries. Factors such as urban versus rural environments and socioeconomic determinants influence the disproportionate access to vaccines. Additionally, the introduction of newly developed vaccines risks adding financial and logistical challenges to already overburdened health systems, particularly those with immunization supply chains which are outdated and ill-designed for such large-scaled, time-sensitive changes.

Implementing a well-performing supply chain that can ensure vaccines are available at health facilities will help overcome the persisting barrier to reaching that final 20% of unvaccinated children worldwide. Due to growing demands caused by increasing populations and birth rates, new and more expensive vaccines, ever-challenging logistics, and fluctuating politics, significant operational and structural changes in iSC are urgently required to remain relevant and able to effectively improve health outcomes. According to a Gavi analysis of results from Effective Vaccine Management (EVM) assessments in 57 countries, no country met the WHO recommended 80% score across all of the nine categories of supply chain management (Figure 2), with results particularly low for the categories of stock management, maintenance, and distribution.[3]

Read more about system design in the Final 20 policy paper:

System Design: Repair or Replace

The drive for improved iSC is gaining traction globally as thought leaders have called for vaccine supply systems to be strengthened and optimized for available resources and ground realities.[4] Recognizing that poor infrastructure and inefficient iSC are constraining growth in vaccine coverage, Gavi, the Vaccine Alliance developed its first Immunization Supply Chain Strategy for 2015-2020 based on five fundamentals: supply chain leadership, data for management, better cold chain equipment, continuous improvement plans, and system design. This strategy encourages countries to design next-generation iSC that are flexible, adaptable to changing circumstances, and driven by evidence-based decision-making.

Mozambique is leading the way for iSC system design. Initial support from the Bill & Melinda Gates Foundation for the Final 20 Program addressed the inefficiencies of the iSC in Mozambique, using evidence from provincial level experience with the DLS to advocate for national level adoption of the Dedicated Logistics System as a key strategy for reaching the final 20% of children without access to vaccines. This initial support has laid the groundwork for ongoing and future efforts to drive the global conversation forward for next-generation iSC in all Gavi countries.

This report documents the history of this system design process in Mozambique as the inflection point in the drive towards a next-generation iSC. If system design is the inflection point, then tools to support continuous improvement of the next-generation iSC include better data visualization and processes for data utilization, computer simulation modeling, and better understanding of the evidence for change. This report documents those tools and the lessons learned related to national scaling strategies. We hope that thought leaders and decision makers around the world can leverage the experience of this process in Mozambique to navigate potential system design changes towards improved efficiencies and better performance of in-country iSC around the world.

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3 World Health Organization. EVM (Effective Vaccine Management) Assessments: Average score of principle, sub-national, local district, and service point level. EVM assessment for 57 Gavi countries. 2014.
4 Zaffran M, Vandalaer J, Kristensen D, et al. The imperative for stronger vaccine supply and logistics systems. Vaccine. 2013: 31S. dx.doi. org/10.1016/j.vaccine.2012.11.036

Supply Chain Design: Changes for Efficiency

Mozambique's supply chain for EPI, established in the 1970's, follows a traditional multi-tier distribution system, wherein stock first moves from a national warehouse to several provincial warehouses. Each provincial warehouse then moves stock to its respective district depots responsible for stocking health facilities in their jurisdiction (Figure 3).

This multi-tiered system is now outdated, constrained by decades of population growth and the introduction of additional vaccines to the supply chain, both of which can negatively impact vaccine availability at the health facility level if left unaddressed. In 2001, for example, the iSC in the northern province of Cabo Delgado experienced many of the constraints often faced in LMICs. At that time, the provincial capital received vaccines from the national level and delivered the vaccines to the district level. The district was then responsible for vaccine delivery to health facilities. However, inconsistently available funds and lack of reliable transportation at the districts made this last segment of the iSC process ad hoc, relying on facility-based frontline health workers to arrange their own money for transport and travel away from their posts for a day or more to retrieve the needed vaccines from the districts. As a result, health facilities closed for the time needed to retrieve vaccines, which worsened service delivery and vaccine reliability and added burden on already stretched health workers.

Constraints also included inadequate or absent health staff supervision and training, insufficient health budgets, and shortages of funds for essential supplies. Accurate and timely data were unavailable as data collection and reporting relied on a large number of health workers whose training focused on clinical care, thus pushing data collection to the bottom of health workers' already overwhelming list of monthly tasks.

In response to these needs in 2001, VillageReach, with support from the Bill & Melinda Gates Foundation, and in partnership with the Provincial Directorate of Health in Cabo Delgado province and a local community-based organization, Foundation for Community Development (FDC), developed the Dedicated Logistics System as a new system for the distribution of vaccines and related supplies. The DLS is an informed push replenishment system that uses transport loops, level jumping, direct data collection and utilization, and dedicated logisticians to create a more efficient and effective iSC. The components of the supply chain are the same, but were rearranged and strategically configured to fit the new circumstances of the province.

In the multi-tiered system, a typical province in Mozambique would need a vehicle, driver, and vaccine program specialist at the provincial level to distribute vaccines to approximately ten districts. Each of the ten districts would then need the same human resource and equipment components to reach about ten to twelve health centers in each district. This would also require about 100 health workers at the health center level who would perform supply
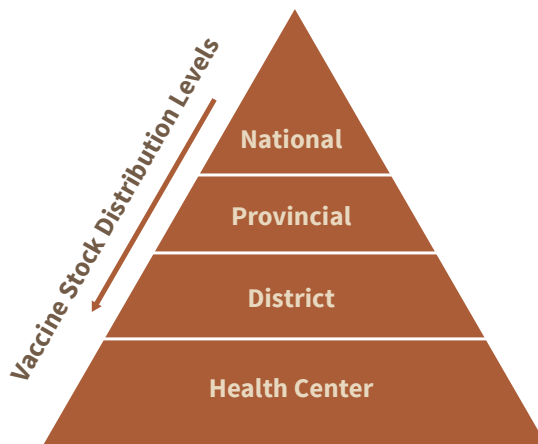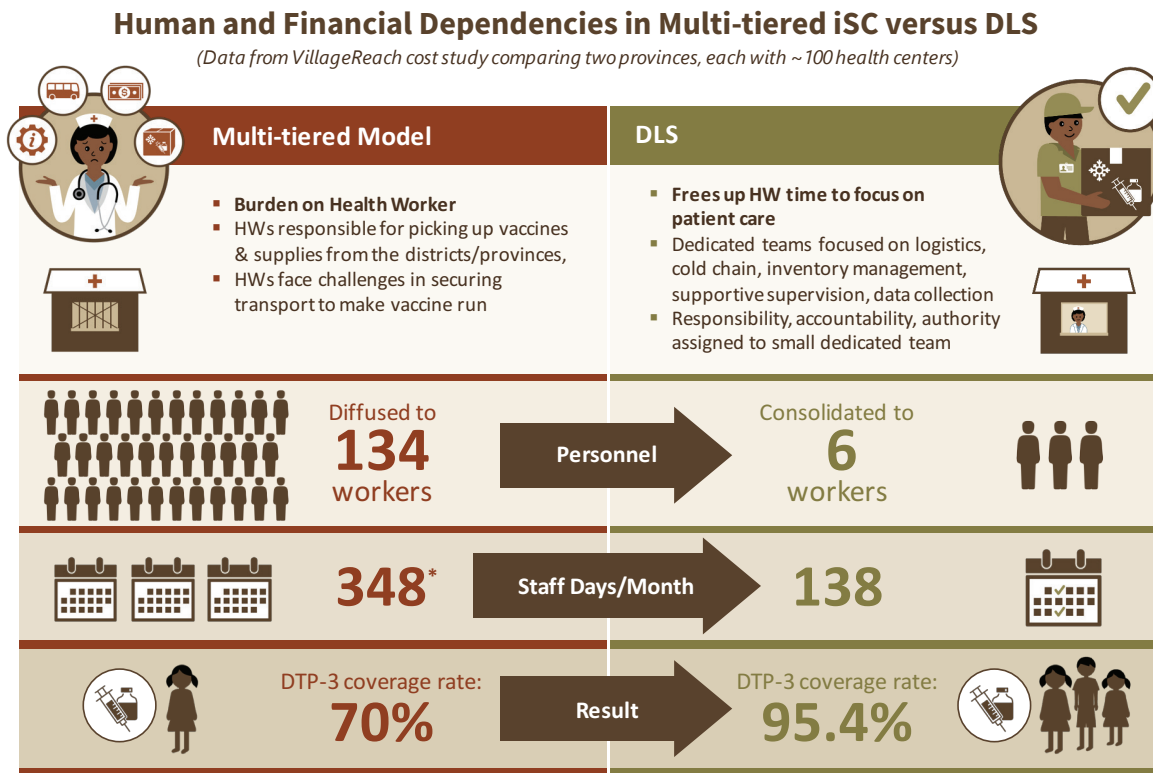

Figure 3: Levels in a Multi-Tier Distribution System

chain tasks as a minimum part of their overall responsibilities. Total equipment and human resource requirement would include 11 vehicles, the accompanying fuel, and more than 130 personnel adequately trained and skilled in iSC management. The same logic follows for cold chain equipment in a multi-tiered system, which requires sufficient storage space at each level to fully stock the next level in the distribution chain.

Human and Financial Dependencies in Multi-tiered iSC versus DLS
(Data from VillageReach cost study comparing two provinces, each with ~100 health centers)

Multi-tiered Model		DLS	
■ **Burden on Health Worker** ■ HWs responsible for picking up vaccines & supplies from the districts/provinces, ■ HWs face challenges in securing transport to make vaccine run		■ **Frees up HW time to focus on patient care** ■ Dedicated teams focused on logistics, cold chain, inventory management, supportive supervision, data collection ■ Responsibility, accountability, authority assigned to small dedicated team	
Diffused to **134** workers	Personnel	Consolidated to **6** workers	
348*	Staff Days/Month	**138**	
DTP-3 coverage rate: **70%**	Result	DTP-3 coverage rate: **95.4%**	

* The additional 210 staff days required to run the Ad-hoc Model falls <u>entirely</u> on the HWs; the Informed Push Model reallocates this time to HWs providing healthcare rather than collecting supplies and filing stock inventory reports.

Figure 4: Multi- Tier System versus DLS
Source: VillageReach. Comparison of costs incurred in Dedicated and Diffused Vaccine Logistics Systems: Cost-effectiveness of vaccine logistics in Cabo Delgado and Niassa provinces, Mozambique. October 2009.

Figure 4: Human and Financial Dependencies in Multi-tiered iSC versus Dedicated Logistics System

Conversely, the DLS approach requires only two to three full-time dedicated logisticians with drivers, each with a vehicle, (one for each delivery zone following optimized transport loops) working in each province. The dedicated logisticians determine the quantities of vaccines to distribute based on actual consumption at the health center. As such, training and provision of technology tools can be focused on these key supply chain personnel. The placement of these personnel at the provincial level also matches the financial reality of the system as cash resources required for distribution are more likely

Read more about human resources for health in the Final 20 policy paper:

Other Duties as Required: Efficient Use of Human Resources

to be available at the provincial level than the district level. Placing dedicated personnel at higher levels of the system instead of every health center is a more efficient use of human resources. The DLS approach reduces vaccine wastage, requires less forecasting skills and data analysis from a health worker, and allows health workers more time for patient care. Using the district level only for buffer stock also reduces the need for large capacity cold chain equipment at this level. This optimized system leads to financial savings and logistical efficiencies throughout the iSC.

As seen in Figure 4, the results of a 2008 independent evaluation of the five-year pilot project in Cabo Delgado showed that the DLS and its management approaches played a critical role in the marked improvement seen in immunization coverage in the province. The DLS directly improved the refrigerator uptime at facilities, reduced

facility vaccine stockouts from 80% to about 1% per month, and greatly improved the supervision and training of health facility staff. It streamlined the number of health workers involved in logistics tasks from 134 to 6, reducing the training requirements and allowing health workers to provide the clinical care they were trained to do. These system-wide improvements impacted the individual level with more reliable vaccine availability and increased vaccine coverage rate, with DTP3 coverage increasing in the pilot province from 70% to 95%.[5] Comparable improvements were not seen in other provinces over the same time period.

This optimized iSC was also found to be more cost-effective. Micro costing evaluation results which compared the actual capital and operational costs of the DLS versus the traditional multi-tier system showed the DLS had significant improvements in cost-effectiveness because of greatly higher vaccine coverage rates. The cost in the DLS province was $5.03 per child vaccinated with DTP-3 compared to $6.07 per child vaccinated in the comparison province. The DLS was also found to be 21% less expensive per vaccine dose delivered ($1.18 per dose compared to $1.50).[6]

Starting in 2010, at the request of other DPS, the DLS expanded to an additional four provinces in Mozambique. Management responsibility for the DLS has transitioned over the last four years; government staff are now responsible for distribution and applying a cost-share approach for operational expenses. As of late 2015, the DLS is operational in five provinces. An additional province has adopted the electronic logistics information management system supporting the DLS, which is used in approximately 830 health facilities, serving a total population of 13 million people. Ongoing monitoring of logistics data continues to indicate a high performing iSC with stockouts regularly less than five percent.[7] Updated studies of the government-led system showed similar efficiencies and availability increases as what was seen during the pilot project. Success of the DLS is also marked by keen interest nationally from the MoH to explore system design for other provinces in Mozambique.

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5 Kane, M. Evaluation of the project to support PAV (Expanded Program on Immunization) in Northern Mozambique; 2001-2008: An independent review for VillageReach with program and policy recommendations. Nov 2008.

6 VillageReach. Comparison of costs incurred in dedicated and diffused vaccine logistics systems: Cost-effectiveness of vaccine logistics in Cabo Delgado and Niassa provinces, Mozambique. June 2009.

7 Mozambique Dedicated Logistics System 2015 Performance Report. Accessed online at http://www.villagereach.org/wp-content/uploads/2015/12/All-Provinces-DLS-Performance-Report-Jan-Jun-2015-ENGLISH.pdf

Key Lessons Learned

Supply Chain Design: Changes for Efficiency

- **The system design of a supply chain must complement the context and policy implications**. In Mozambique, significant changes to the supply chain design were introduced to bring about efficiencies, (e.g. the district level was no longer used as a storage facility). The design was then fine-tuned to match policy requirements, for example, the inclusion of district level personnel during distributions to provide additional supervision and to match a decentralized government system.

- **Evidence for change must address the concerns of the decision makers**. Changing the supply chain in Mozambique resulted in more efficiencies through a reduced cost per dose of vaccines delivered and higher vaccine coverage rates. However, EPI managers at the provincial level need to know the absolute budget necessary to support reliable distribution in order to reach the largest number of children. The impact may be the same, but the decision-making process used to make the change may differ and may need different evidence.

SELV: The Technology Behind the Progress

The last mile of delivery is the first mile of information. The DLS is based on this principle and is designed strategically to facilitate the use of data for decision-making and continuous improvement. In the DLS, data collection responsibilities for tracking vaccines and related supplies at the district and health center levels are shifted to the dedicated logisticians using Sistema Electrónica de Logísticas de Vacinas (SELV), an implementation of OpenLMIS configured for Mozambique. OpenLMIS is an open source, web-based logistics management system with a simple user interface that can be customized to the medical commodities tracking needs of any country. Data entry on any device (desktop, laptop, tablet) can be done offline (without internet connectivity), which is essential for the Mozambican context. Further, being a web-based system, SELV allows access from any location or device, which is an improvement from previous electronic logistics management systems that relied on a locally-installed software (such as Microsoft ® Excel) on each user's computer.

SELV was introduced in the DLS provinces in 2014, replacing the previous electronic data collection tool while adding enhanced reporting capabilities and a direct-to-digital data collection option through tablets. Before the SELV roll-out, VillageReach worked closely with the dedicated logisticians, MoH partners, and key stakeholders to identify user requirements criteria for both data collection and final aggregated reporting. Stakeholders provided feedback for indicator measurements and confirmed assumptions made during system development. MoH partners identified three key benefits to SELV: (1) it was the only online-based system available in the country; (2) it locks data formulas that were previously erroneously changed in Excel-based systems; and (3) it includes an off-line reporting platform that provides drill-down features, giving insight into a facility-by-facility basis on both stock and coverage information. MoH partners also provided critical insight into future enhancements to the SELV software.

Using SELV on laptops or tablets, the dedicated logisticians enter data from different paper records available at the health facility level to confirm data validity, compare actual stock on hand with stock records, and provide immediate feedback to health workers on data quality which helps improve data management capacity. This direct-to-digital data collection component reduces the opportunity for human error caused when data from paper-based records are manually aggregated along administrative tiers. Additionally, the automatic data validation and calculations of stock requirements and wastage rates eliminate possible errors during manual calculation using paper forms and can be addressed immediately while at the health facility. Further, direct-to-digital functionality makes the data readily available since the logisticians sync the collected data at the end of a distribution allowing for more immediate data report availability. This provides decision makers at the provincial and national levels with relatively real-time data.

For data visualization, SELV provides an off-line dashboard highlighting the key performance indicators (KPI) tracked, using both graphical visuals and data tables that can be tailored to user interaction: the data can be filtered down to a specific health facility or rolled up for a province-wide view, depending on the needs of the user. KPIs tracked include:

- Delivery Intervals: The number of days between delivery of vaccines to each health facility

- Stockouts: Facilities stocked out at time of next delivery

- Cold Chain Equipment Uptime: Percent of refrigerators functioning with proper temperature throughout the month

- Number of Health Facilities Visited that Month

- Number of Health Facilities Reporting Data that Month

The introduction of the off-line dashboard (Figure 5) helped turn static data tables into information that is interactive, as well as easier and quicker to use, understand, and discuss.

Vaccine Distribution Report

Month	Province	Delivery Area	District	Health Center
October 2014 to October…		All	All	All

Health Centers Visited and Data Reported

Target >90%

% Reporting
% of Health Center Visits

If there is only one line, % reporting and % visited are equal.

Delivery Intervals

≥48 days 34-40 days
41-47 days 0-33 days

Stockout by Vaccine
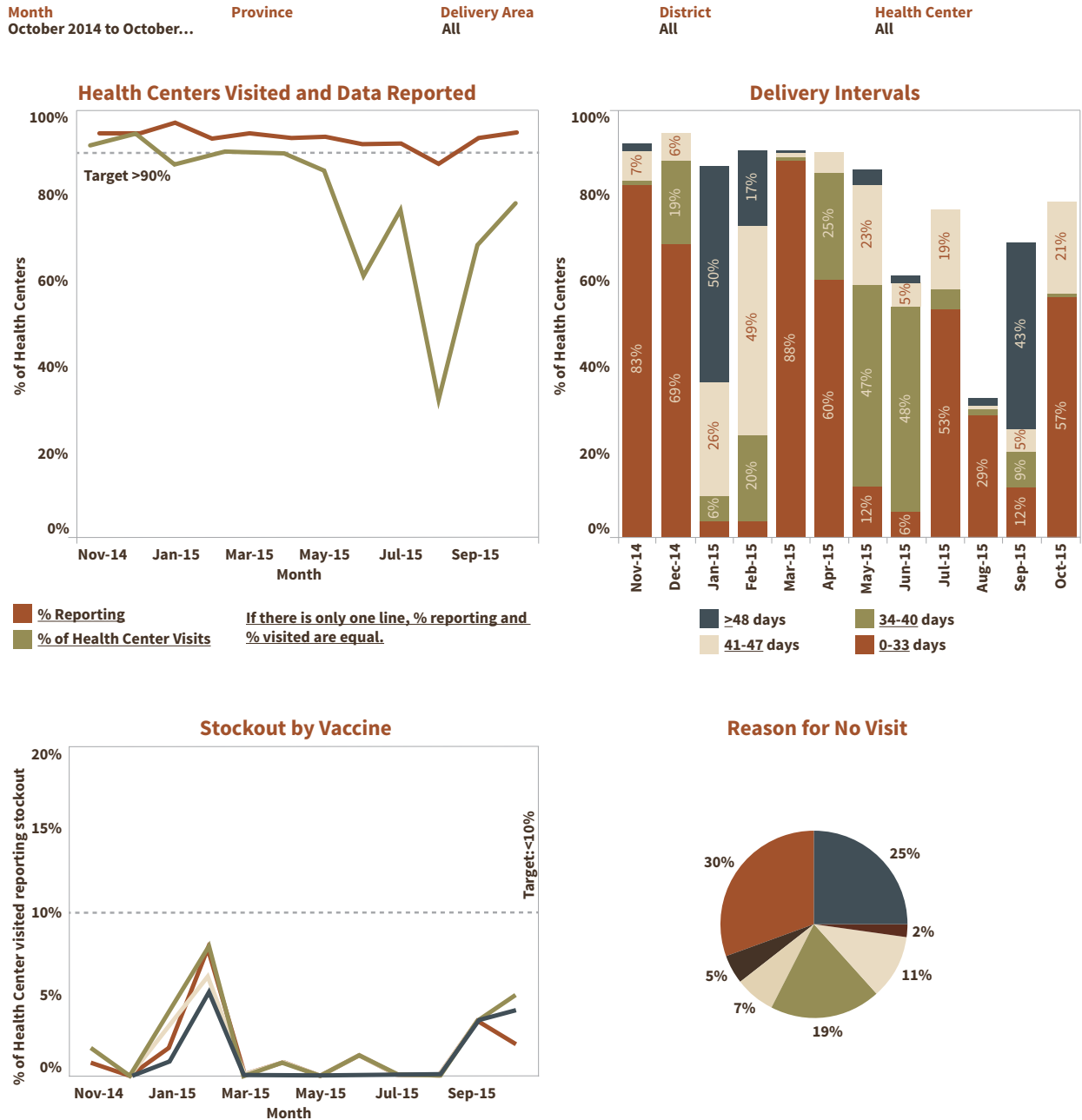
Target:<10%

Reason for No Visit

Figure 5: Sample Off-Line Dashboard from SELV

Dedicated logisticians were given tablets to take advantage of SELV's direct-to-digital data collection functionality. Gaza province served as a six-month pilot site to determine impacts on time required for data management before scaling to other provinces. Initially with the tablets, the logisticians took 30 minutes for data entry per health center, but after consistent use over six months, the average time for data entry dropped to 17 minutes per facility. In comparison, the paper-based process took about 25-30 minutes per facility (15 minutes to fill out the form while at the health facility and then an additional 10-15 minutes to enter data into SELV on a computer at the provincial capital). This adds up to an average time-savings of nearly one work day per month for each logistician. Before tablets could be rolled out to all provinces, dedicated logisticians in another province started using their own laptops for data entry during distribution as they saw their colleagues experience the benefits of reduced paperwork and time savings by avoiding double data entry on paper and then to a computer. Tablets are now used in all DLS provinces.

Key Lessons Learned

SELV: The Technology Behind the Progress

- **Time to thoroughly gather user requirements from all levels must be prioritized.** For a technology solution to be truly useful, it is essential that end-users' needs are gathered through direct conversations and enough time is allocated for these iterative conversations to take place. Because SELV was adapted from an earlier tool already in use at the provincial-level, less time was spent gathering all requirements at the national level during the initial planning. Requirements at the national level are now being refined and included in future releases of the information system.

- **The technology tool must be integrated throughout the iSC.** SELV is a technology tool— specifically optimized for the DLS — that is designed to support the supply chain process. SELV is not a stand-alone entity but instead as an intrinsic part of the entire iSC that can be used from planning a distribution before it starts, through the data collection during a distribution, to the data analysis at the end of a distribution. Technology tools should not be developed in absence of the system for which it is a support, nor should a supply chain workflow be developed without data needs in mind.

- **Capacity for technical troubleshooting must be built locally.** Especially when learning a new technology tool, end users may be turned off by issues that—given simple training— could be easily resolved by themselves or by someone else in-person. Identifying and training in-country technical capacity for troubleshooting simple issues with the technology helps reduce user attrition rates, especially during the critical, initial stages of the project roll-out.

Data Utilization: A Catalyst for Improved Performance Management

During project implementation, VillageReach was part of a consortium of public and private sector partners brought together by the Bill & Melinda Gates Foundation to participate in the Visibility & Analytics Networks (VAN) Project Blueprint Reference Model. The VAN group worked to apply private sector supply chain management practices to public health supply chains with the objective of improving medical commodity availability. The model is built on three key activities: (1) providing end-to-end visibility in data across the entire supply chain, (2) analyzing the data to gauge performance, and (3) improving performance through an improvement plan.

Read more about data utilization in the Final 20 policy paper:

Data for Management: It's Not Just Another Report

Developing this VAN approach validated much of the ongoing Final 20 activities and generated other ideas to further develop. A VAN is built on the people, processes and technology that can drive improvements to the performance of the iSC. Using dedicated logisticians to collect and drive data analysis and improvement consolidates responsibilities for managing supply chain operations across a province in a small group of highly trained personnel.

SELV provides a visually dynamic, analytical function in the monthly reports. The visualizations provide root cause analysis for determining follow-on actions to improve supply chain management. The process function is put in place after each monthly distribution with participatory follow-up sessions where the dedicated logisticians review the SELV dashboard with the DPS EPI manager, medical officer, and logistics supervisor. With this monthly review of the dashboard and alerts, the team can identify bottlenecks and ways to improve subsequent distribution activities. Additionally, this review process and analytical capacity of the team enables the dedicated logisticians to check data against previous deliveries and consumption data to find gaps that may not have been recorded by the health workers during the month. The final step in the cycle is for the dedicated logisticians to implement their improvement plan during the next month's distribution. In the VAN context, SELV is the 'technology' that provides the data in an easy-to-use format; the EPI team makes up the 'people' component; and the systematic data review and improvement plan feeds into the 'process' part of a VAN.

Niassa province provides an example of how data utilization with the roll-out of SELV led to achieving improvements in performance of the supply chain (Box 1). Graphs showing the performance of certain key performance indicators between 2013-2015 by province are included in Appendix A of this report.

Box 1:

How Data Transformed Niassa Province

Maintaining monthly vaccine deliveries to a health center is a global standard for immunization supply chains. Erratic delivery schedules lead to poor vaccine availability, higher stockout rates, and wastage because health centers are either under-supplied or over-supplied if the next visit date is unknown. Routinized, 33-day interval schedules deliver sufficient stock for the period, knowing that the next visit will be within a set time period.

SELV analysis looking at the length of time between vaccine deliveries during 2014 in Niassa province clearly shows an improvement starting in August, soon after the launch of SELV. Many factors influenced this improvement, but the Niassa EPI manager identified one of these factors to be the monthly review process with the new SELV reports. This review of data and discussions of issues or bottlenecks identified in the data provided the dedicated logisticians with a better understanding of the benefits of data to support their activities.

Delivery Intervals, Niassa Province (2014)

≤ 33 days %   34-40 days %   41-47 Days %   ≥48 Days %

After the introduction of SELV in June 2014, routine delivery (within one month) increased from an average of 15% to 70%, due in part to the monthly review of SELV data.
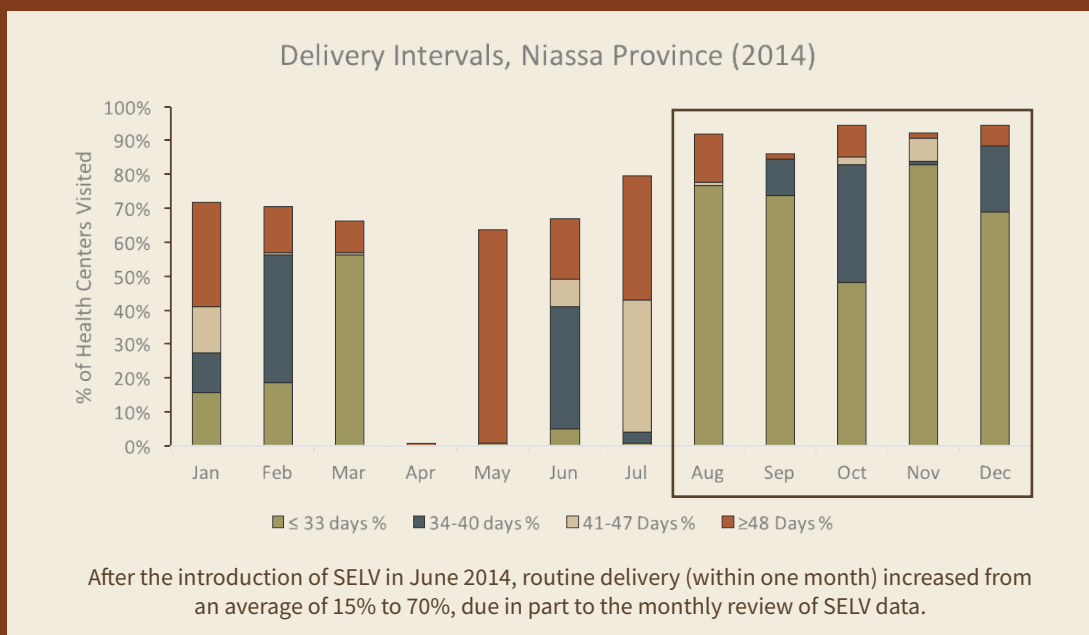
Figure 7: Delivery Intervals, Niassa Province

One change resulted in better vehicle management. Through review of the monthly reports, the DPS noted common delays on distribution departure days, thus contributing to longer delivery intervals. Through deeper analysis, they discovered these delays were due to vehicles not being sent for maintenance in a timely fashion. The reports provided clear analytics of the domino effect of one or two days' delay for vehicle maintenance accumulating up to two weeks' delay in the delivery cycle and thus higher stockout rates. Switching the vehicle service period to immediately upon returning from the distribution cycle has eliminated delays in distributions.

The cold chain provides another example of the use of data to improve supply chain management practices in Niassa. Reports showed consistent problems with low refrigerator uptime, usually less than 80%. The monthly review process acted as a constant reminder of this problem for DPS leadership. To that end, the DPS created a budget for refrigerator spare parts and began to include technicians on distribution activities to provide ongoing and regular preventive and corrective maintenance. By the end of 2014, the rate of functioning refrigerators increased to over 90%.

Key Lessons Learned

Data for Utilization: A Catalyst for Improved Performance Management

- **Data use can drive continuous improvement of a next-generation iSC.** With the introduction of SELV and the monthly review process, notable improvements have been seen in the performance indicators of the iSC.

- **Technology alone cannot drive decision-making.** As seen in the DLS provinces, the people and processes surrounding the technology have been instrumental in driving improvements. This was a significant shift from the previous system where data was not available and therefore not used except for reporting up the hierarchy. Introducing the monthly systematic review process required building trust over time, both in partners and a reliable information management system, support to analyze and apply data, and commitment from the DPS to use data to support decisions. These changes have begun to introduce a culture of data use.

- **Data visibility to the health facility level has increased interest from national level EPI in an improved information management system.** Because of the system design and SELV combined, decision makers at all levels of the health system have near real-time visibility into health center vaccine stock and consumption, which is not available in other information management systems in the country. Having this data availability in six provinces has driven the demand for the same level of visibility in all provinces, demonstrating the MoH interest and commitment to improving the performance of the iSC across the country.

Computer Simulation Modeling: One Tool for System Design

One approach that the Final 20 program used over the last three years to encourage data-driven decision-making in Mozambique and to encourage evidence-based system design is supply chain modeling. Computer simulated modeling is one tool available for supply chain system design that can be used as a "virtual laboratory" to test the effects of different equipment, strategies, and policies as they relate to the structure of the supply chain. Modeling can help explain how the different components and processes—cold chain equipment, network of transport routes, human resources, number of distribution levels, policies related to stock management, among many others—interact in a complex system design. Each interaction depends on all components as a single change in one component of the system can affect many other components in different ways. Modeling is the "what if" of supply chain management that can help predict those effects and to identify the best mix of components and processes in order to use time, effort and resources most effectively and efficiently. Modeling allows decision makers to see how one or multiple changes can impact various elements in the iSC, thereby determining best approaches to use without sacrificing time, funds, and other resources to testing each idea in practice.

When VillageReach approached the Mozambique MoH in 2014 with the idea of using a computer modeling simulation to examine ways to find efficiencies in the iSC beyond the existing provinces with the DLS, the MoH was at first reluctant to look critically at the current status quo. This reluctance was understandable, as a system design approach may require significant changes to policies and procedures, funding mechanisms, human resource requirements, and equipment needs. System design can be a significant undertaking, daunting for any policy maker.

As the first step in this process of change, the MoH decided to conduct a modeling exercise in two provinces where the DLS was already operating, Gaza and Cabo Delgado, in order to build the evidence for modeling. This decision also provided the ability to compare the results from computer simulation to the reality of the iSC systems operating in these two provinces and to explore options for fine-tuning the system to bring about even more efficiencies. The HERMES Logistics Modeling Team, a collaboration between the Pittsburgh Supercomputing Center at Carnegie Mellon University and Johns Hopkins Bloomberg School of Public Health, led this work with their software platform HERMES (Highly Extensible Resource for Modeling Supply Chains), which allows users to generate a detailed discrete event simulation model of any iSC. The process included data collection in each province, running preliminary models, and organizing a capacity building workshop for a local team of experts in Mozambique on the concept of modeling, system design, and use of the user-friendly interface of HERMES.

Participants at the workshop identified different scenarios to model, including the common multi-tiered government system and an informed push system, with variations of delivery intervals and the EPI schedule with planned introduction of new vaccines (Rotavirus, HPV, IPV and measles second dose). Modeling results provide two supply chain performance measures: vaccine availability at session and logistics cost per dose administered (Figure 7). The feasibility of each scenario is then considered based on these performance measures and other criteria, such as physical and political feasibility, current structures, available resources, and established goals. Full results of this initial modeling activity are available in the HERMES workshop report.

Gaza Province, Modeling Results Across Supply Chain Structures

Initial results for Gaza Province, comparing the government distribution system with the DLS, with alternative delivery intervals of every two months in the northern area of the province.
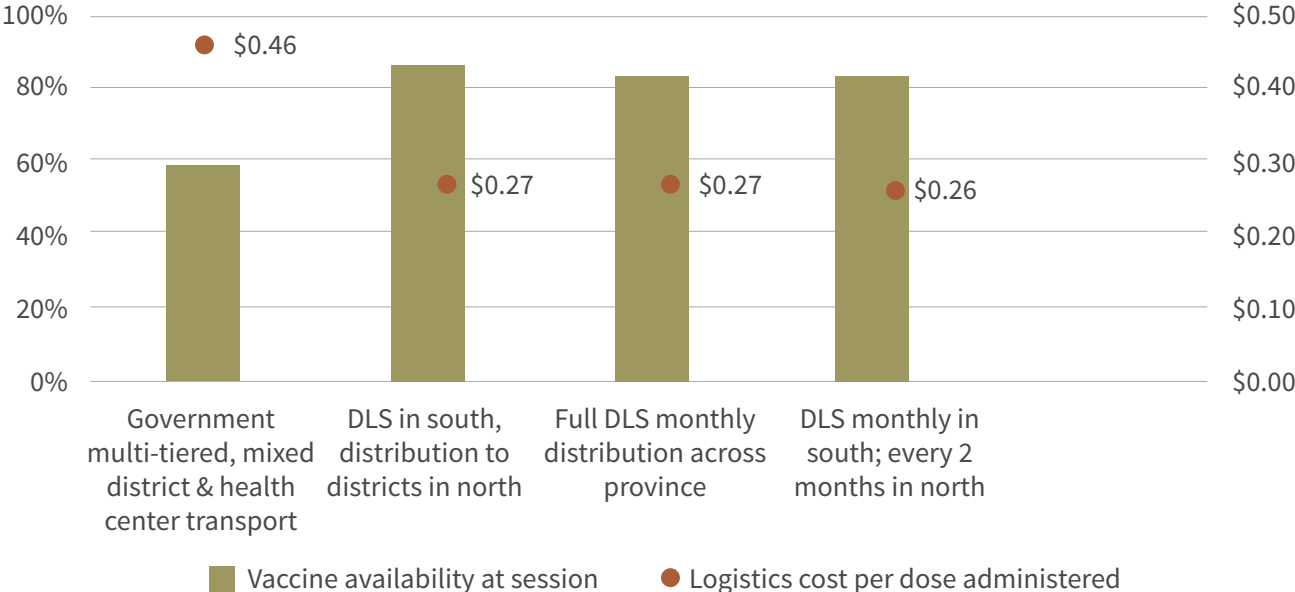

Figure 7: Initial Modeling Results, Gaza Province

Two key decisions came out of this initial modeling pilot. First, the modeling results showed that in Gaza province, vaccines could be efficiently and feasibly distributed every two months to the northern, hard-to-reach area using current transport and cold chain capacity. This decision took a few months to confirm as a two-month delivery interval goes against the global standard of monthly delivery intervals, and advocacy using this evidence was necessary to convince decision makers. This decision demonstrated the willingness of the provincial level decision makers to challenge the status quo while also reaffirming their commitment to improving the availability to deliver vaccines for all children.

The second significant decision was the MoH approval to build out a national level model to explore a system redesign from the top of the supply chain to all provinces and down to the health facility level across the country. This speaks to the power of evidence for change and the MoH recognition that the current iSC has areas that can and should operate more reliably and more efficiently.

Box 2:
Key Themes from Modeling Capacity Building Workshop:

- **Modeling allows for the exploration of "crazy ideas."** Using the HERMES tool makes it relatively easy to explore different scenarios for the iSC, include the "crazy ideas" that would not be possible to test in real life, and identify the strengths of these ideas that are actually feasible.

- **Improving the performance of the iSC is a priority**. Participants recognized that the current iSC design could be improved and modeling helps weigh the benefits of change in logistics cost per dose and vaccine availability.

- **Tools are available to improve the iSC**. The HERMES modeling tool is very useful to simulate changes in the iSC yet cannot be used in isolation. Results of modeling must be considered within the reality and context of the different scenarios.

- **Technology and knowledge transfer is the first part of the process**. Local ownership is a key part of the success factor for system design; the modeling workshop built the capacity of the local team of experts to use the HERMES tool and analyze the results in order to drive data-based decisions for improvements to the iSC. During this training, participants began to understand different aspects of modeling and how it can apply to the supply chain design.

National level modeling focused on building three scenarios to address key questions from the MoH regarding future iSC improvements.

Scenario A: National level delivery using cold trucks.

The current system for national level delivery of vaccines to provinces relies on air cargo to ship to the northern provinces with the three southern provinces going to Maputo to procure the vaccines. Due to capacity constraints, this entails more than the standard quarterly delivery as per policy, requiring between 5 and 14 shipments per year, depending on the province. The MoH had two cold trucks, purchased in 2015, but had questions about how to best deploy those trucks.

Results: Modeling showed that two new cold trucks had sufficient capacity to deliver all vaccines, including Rotavirus, in a delivery loop to all provinces and do it with a lower level of effort to match the expected quarterly delivery. The MoH was able to use the cold trucks for the initial distribution of the Rotavirus vaccine; however, the lengthy process to request funds for fuel purchase has constrained their use for regular delivery.

Scenario B: Introducing transport loops within provinces.

The MoH wanted to understand the optimal transport models for reaching health facilities from the province and wanted a comparison of different options for distribution from the subnational level down. They also wanted to use the results of this model to look at where cold chain investments would be needed.

Results: One scenario included in the modeling considers a DLS-type system in all provinces using transport loops to deliver from the provincial level directly to health facilities, using the district storage for emergency stock only. Compared with the multi-tiered system which follows administrative boundaries from national to province to district and then to health facilities, this scenario increases vaccine availability and decreases the logistics cost per dose (Figure 8), although constraints exist in the capacity of some cold chain equipment at health facility levels. Specific constraints are detailed in the modeling results, which can guide decision makers for improved procurement plans for cold chain equipment. These results were also used to address constraints brought on by the introduction of Rotavirus vaccine (Box 3).

Scenario C: Using three national warehouses to receive vaccines directly from manufacturers.

The Ministry of Health approved a supply chain strategy for the Central Medical Store (CMAM) in 2014. Included in this new strategic plan, called the Plano Estratégico de Logístico de Farmaceuticos (PELF), is moving from one central warehouse to serve the whole country to three regional warehouses (Maputo, Beira, and Nampula). The MoH was interested in seeing the costs and availability changes associated with aligning the vaccine national warehouse strategy with these three new national warehouses and then deliver from these three warehouses to the provinces with provinces running transport loops for direct delivery to health facilities.

Results: The results of modeling identified cold chain capacity constraints at the new regional warehouses that would need to be addressed before this model could be adopted. The model helped to provide the specific cold chain requirements for each facility which is being used by warehouse planners making decisions about future cold chain needs at the new warehouses.
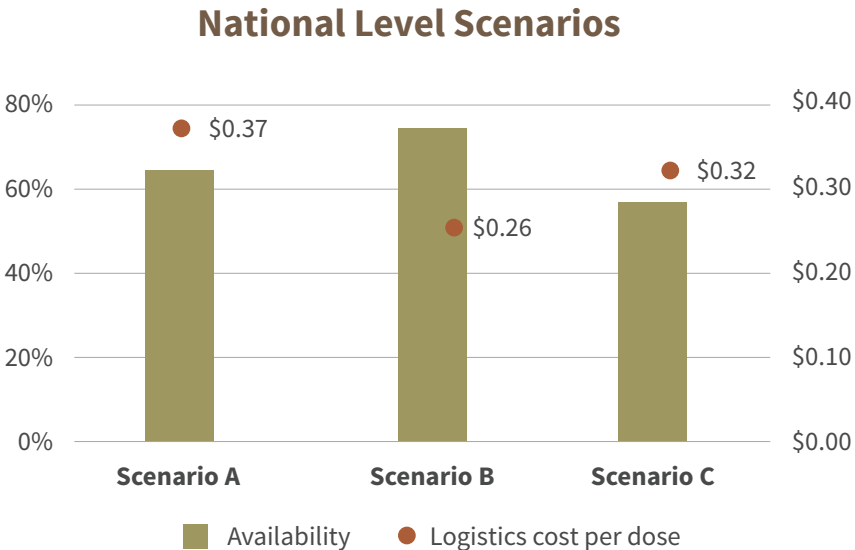
National Level Scenarios

Figure 8: National level modeling result. Scenario B introduces transport loops from the provincial level directly to health facilities, increasing availability and reducing cost per dose.

Based on the results of the modeling, Scenario B with transport loops from the province level directly to health facilities would provide the highest availability (74% compared to 66% in Scenario A and 57% in Scenario C) at the lowest cost per dose ($0.26 USD, compared to $0.37 and $0.32 for A and C). This would be akin to introducing a DLS type system in all provinces. In each of the scenarios that were modeled, the availability will be constrained by limited cold chain capacity, particularly for using three regional warehouses. The information from the model will feed into the long-term cold chain procurement plan for the country.

The next step for national-level system design is to develop a change management strategy together with the MoH and DPS to apply the modeling results, building on the DLS experience and in coordination with CMAM. The results of the EPI modeling are complementary to the CMAM long-term PELF. Beyond the addition of the three intermediary warehouses, the PELF also includes developing 30 intermediary warehouses which would replace all provincial and district-level storage sites. These intermediary warehouses would then be responsible for delivery to health facilities. For EPI, the next step includes building out the iSC model to explore the impact of the move to 30 intermediary warehouses for the iSC, in order to develop a plan for future potential integration of these two, currently vertical, supply chains.

Box 3:

Modeling to improve the introduction of the Rotavirus vaccine

The results of this national model came at a very opportune moment as Mozambique was introducing the Rotavirus vaccine in the middle of 2015. The results of the modeling identified specific health facilities and transport routes across the country that were going to experience constraints with the introduction of the new vaccine. To address this concern, the MoH organized support teams from the national level to spend time in each province with the modeling results and the goal of addressing constraints and supporting the micro-planning process together with each DPS.

One example of modeling results put to direct use comes from Niassa province where modeling showed that four health facilities along with the provincial warehouse would not have sufficient capacity for the new vaccine. Additionally, both transport routes in the DLS would be constrained. With this information, the DPS redesigned the transport routes to follow four loops (instead of two) of direct delivery from the province level, skipping the district level, to the health facilities, and adjusted the cold chain equipment at health facilities to meet the capacity needs required with the new vaccines. To address the storage constraint at the provincial level, the team used this micro-planning process and identified district level warehouses that were along the distribution route from the national level. Instead of having the national level cold truck deliver all vaccines to the provincial warehouse, as is typically the process and would have constrained storage capacity, the DPS team decided to have the cold truck deliver to the district level warehouses along the route before arriving at the provincial warehouse.

These changes could not have been made without the results of the model. With these changes, Niassa province successfully created sufficient capacity for transport and reduced the distribution time. Similar results were detailed for all provinces, leading to immediate actions that were taken to accommodate the new vaccine.

Key Lessons Learned

Computer Simulation Modeling: One Tool for System Design

- **Modeling can provide evidence to which people can respond.** Results of modeling can provide practical actions to improve the performance of the supply chain. For example, results show specific health facilities that have constraints in cold chain equipment. This information is known already by frontline health workers; however, having this data shown through modeling validates the reality and puts it in front of decision makers who can drive change.

- **Modeling results provide a significant amount of information that needs to be teased out to present the most important information to decision makers.** Building out a model provides insight into many components of the supply chain, such as logistics cost per dose and the availability of vaccines based on different supply chain models. Our experience shows, though, that the most appropriate results need to be presented to the appropriate decision makers. One concrete example is the logistics cost per dose, which provides great insight into the cost-efficiency of a supply chain design including amortization of equipment, salaries, energy costs, and even the portion of building costs used for the vaccine program. However, the EPI manager at the DPS needs to know, practically and simply, how they should be included in the budget for fuel and per diem. This information can also be gleaned from the modeling results but needs to be teased out and presented in an understandable way for the audience.

- **Modeling empowers decision makers to safely investigate the status quo.** One of the biggest challenges identified through this activity is a person's willingness to question the status quo and go beyond "this is how we have always done it." Modeling facilitates that shift by providing a safe mechanism through a computer simulation instead of having to test supply chain design options on the ground which would require financial support and a significant level of effort. With modeling, one can consider the 'crazy ideas' and let modeling find the good in the crazy.

- **Modeling provides a view to the whole system and how components fit together.** With this broader view, stakeholders can better understand how changing one component of the supply chain can impact another component. For example, introducing dedicated logisticians for distribution reduces the level of effort for logistics tasks required by health workers in health facilities, which is reflected in the modeling results. This helps move decision makers towards a holistic view of the supply chain instead of looking at siloed areas.

Reliable Distribution: More than Buying Vehicles

Any successful distribution operation depends greatly on a well-managed transport system which goes beyond purchasing vehicles and must include maintenance, transport planning, asset management, human resource capacity for fleet management, documentation, and responding to risks and threats, among many other aspects. Considering the complexity of what is involved, transport is consistently one of the biggest constraints identified by ministries of health globally to achieving a reliable distribution system.

To better understand the transport situation in Mozambique, VillageReach conducted an assessment in 2014 to examine current conditions of transport fleets and logistics practices managed by the MoH, evaluate the health system's transport ability to fulfill its goals, and consider the unique business environment and practices of private transport operators in order to suggest conditions under which private sector transporters could support MoH's freight transport and distribution requirements.

Key findings from this assessment include:

- There is growth in the private transportation sector due to increasing demand from the emerging extractive industries that are expanding operations in northern Mozambique.

- There are chronic shortages of MoH transport vehicles in the districts, with indications of severe over-reporting by provincial administrations of the share of functional vehicles at the district level.

- Current levels of MoH funding are insufficient to replenish fleets with new vehicles in order to maintain an average vehicle age of three to four years.

- Delays in payments for approved, budgeted expenditures has significant impact on the ability of transport managers to maintain and operate vehicle fleets.

- The established practice of district health system vehicle fleets owned and managed by the provinces limits the ability of the districts to allocate transport assets according to their priorities.

- In rural areas, poor road quality and limited transport service infrastructure (fuel depots and commercial mechanic/repair facilities) raise the cost for and limit the participation of commercial transport companies in many of the communities in which health centers are located.

- The severe shortage of logistics personnel and the limited number of vehicles at the district level makes comprehensive logistics planning for DPS all but impossible, with districts defaulting to ad hoc distributions.

These results led to the design and launch of a private sector engagement initiative to pilot outsourced transportation and distribution in 50% of Tete province's districts. Key goals of this initiative are to leverage the resources of the private sector to design and execute a more efficient logistics plan for vaccine distribution; to seek additional partners with a

vested interest in realizing a higher capacity and more efficient logistics health distribution program, which will reduce the unit cost for delivery through integration and cost sharing between programs; to develop additional management capacity within the DPS; and to document the results to support advocacy efforts.

Development of this pilot required close coordination with the DPS to understand its requirements and current capacity for transport management. A Request for Proposals (RFP) was developed in coordination with the DPS and the financial management department of the national government using the government's existing, stringent criteria for the RFP process.

Districts	Health Centers
1. Angonia	10
2. Cahora-Bassa	6
3. Changara	13
4. Moatize	13
5. Mutarra	11
6. Tsangano	7
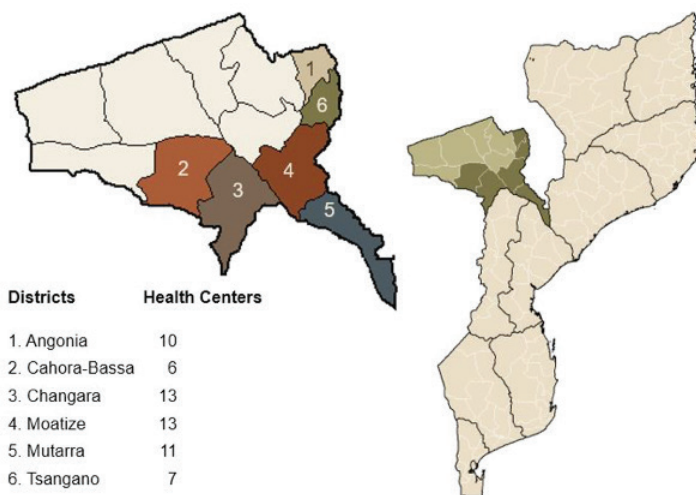
Figure 9: Six eastern districts of Tete province utilizing outsourcing as of 2016

Through early advocacy efforts highlighting the results of the 2014 assessment, Medicins Sans Frontieres (MSF) was identified as a partner for the development and financial support for the program in Tete province due to their commitment to HIV programs and supply chains in the province. By starting with a system which delivered both vaccines and antiretrovirals (ARVs), the province could test outsourced distribution with external support in the initial phases while also decreasing the unit cost of delivery for the two sets of commodities.

Starting operation in October 2015, transport vehicles from a commercial third-party logistics provider (3PL), based in Tete and chosen through the government-led RFP process, have been collecting vaccines, ARVs, and other incidental health commodity items from the provincial store and delivering them to rural health centers across eastern Tete. Development of the route was determined by the 3PL, and initial results showed the vehicles crossing district boundaries as necessary to deliver commodities to the health centers in the most efficient manner. The program launched initially in three districts to test the logistics plan and evaluate the 3PL for quality execution. Based on the success to date, and with the approval of the DPS - the program has now expanded to all six eastern districts covering a population of approximately 1.5 million. From the initial six months of implementation, the following results have been realized.[8]

- **Decreased stockouts:** The incidence of stockouts of vaccines recorded at the time of delivery has been reduced from 40% at the start of the project in November 2015 to 5% in April 2016.

- **Decreased distribution times/less time in supply chain:** The amount of time it takes for vaccines to move from the provincial store to the health facility has reduced over 55% from 18 days to 8 days.

- **Increased efficiency, as measured by kilometers traveled:** Travel distances have been reduced by as much as 40% as a result of level jumping (direct distribution from the DPM to health facilities) and new route paths designed to cut across districts.

- **Integrated delivery reduced unit cost of delivery for vaccines:** MSF compensates the 3PL for the distribution of HIV commodities. This cost-share is based on the volume of the commodities meaning that the EPI program is only responsible for 15% of the costs of distribution.

- **Increased capacity among DPS staff:** VillageReach conducted extensive training for DPS staff at the provincial, district and health center levels on managing a 3PL, quantification of commodities, and proper distribution planning coordinated with the 3PL. The training allowed the DPS to anticipate the distributions and ensure the 3PL performed to required standards.

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8 Data and findings are preliminary data from a 6-month assessment of Transport Services Solution (TSS) in Tete Province to be published by VillageReach in 2016.

- **Established private sector incentives:** The 3PL's compensation is based on completing the distributions as scheduled and documenting the deliveries. As it is motivated to complete the distributions as efficiently as possible in order to limit its costs, the 3PL has introduced new route plans to serve the health centers that cut across district boundaries. Payments are made monthly only after VillageReach, MSF and the DPS have reviewed the results of each distribution. To date, the 3PL has completed all distributions as required and has received full compensation.

- **Gained DPS support for the initiative:** After three months, the DPS expressed strong satisfaction with the program and requested it be expanded from three to six districts with additional commodities added to the distributions; 100% of health center personnel polled requested that the project continue.

Several steps were key in setting up this private sector engagement initiative, including initial engagement with the DPS to advocate for outsourcing, understanding the DPS requirements for contracts and the RFP process, and building the DPS capacity to manage an outsourced process from commodity packing for distribution to monitoring the 3PL performance. Outsourcing, as it is mentioned in the National Pharmaceutical Strategic Plan, was not a new concept to the DPS in Tete, so advocacy efforts were minimal to convince decision makers of the value of this pilot. The DPS also recognized the constraints in the current distribution system and were interested in finding improved models. Establishing a RFP created a process to vet private sector companies in a transparent way and establish high standards for performance.

Key Lessons Learned

More than Buying Vehicles

- **RFP processes have pros and cons to them.** Companies qualifying for the RFP needed to meet certain criteria that had little to do with their technical and operational capacity to satisfy the program requirements. This had the effect of limiting the number of candidate 3PLs that could submit proposals. While it greatly reduced the applicant pool and caused delays in starting operations, the government's potential anxiety regarding using the private sector to transport medicines and vaccines was allayed by willingness of all parties to participate in the process and provide feedback on ways to improve it.

- **Meeting 3PL timelines and requirements increased DPS capacity to manage distributions.** Initial distributions exposed many holes in the capacity of the DPS in terms of preparing supplies for distribution. Commitments of provincial storage staff for on-time loading were not met initially and resulted in protests from the 3PL out of concern that they would incur higher costs due to the delays. The DPS was able to rectify these issues by building capacity with their warehouse staff and improving their planning process for distribution to meet 3PL timelines.

- **Introducing a new approach is an ongoing process.** Despite extensive training conducted for the 3PL on documenting the transport logs and ensuring a particular signature approval process for delivery and receipt of commodities, initial distributions still showed some drivers required ongoing support and re-training to complete this process properly. Quality data collection during distributions has taken a number of months to get right.

- **Transparent financial management is essential in a project with multiple partners.** To ensure complete accountability of all parties, VillageReach drafted several agreements to ensure the DPS, VillageReach and MSF acted according to agreement and in concert with one another. As a result of this initial work, all partners receive and review the distribution reports from the 3PL, and payments are on-time and transparent.

Beyond the Fridge:
Keeping the Cold Chain Cold

Introducing new vaccines into the supply chain can be a complex undertaking, especially considering the investment needed to improve cold chain infrastructure. According to Gavi, the Vaccine Alliance, up to 90 percent of health facilities in Gavi-supported countries lack the right equipment to keep vaccines safe and efficient. This has become a key barrier to reaching the hard-to-reach communities and is particularly an issue when vaccines are more expensive and take up more physical space (such as Rotavirus

> *Read more about cold chain equipment in the Final 20 policy paper:*
>
> *Keeping the Cold Chain Cold*

vaccine). As part of its work in Mozambique, VillageReach and partner Nexleaf led the introduction of a remote temperature monitoring device called ColdTrace to monitor vaccine refrigerator temperatures on a continuous basis, drive action through SMS alerts, and transmit the data to an online dashboard. This data is used to improve cold chain uptime and guide maintenance plans for the country.

Nexleaf, VillageReach, and other partners conducted a study of sites using the ColdTrace technology to test the effectiveness of the implementation in comparison to other temperature monitoring approaches and build the case for potential future expansion of the devices. The qualitative part of the study found that health center staff wanted to expand the use of the devices and appreciated how the ColdTrace system provided 24/7 supervision of the refrigerators even when the nurses and health center staff were not physically present. For the quantitative study, the partners divided refrigerators into three groups. The first group used ColdTrace with SMS alerts sent to health facility staff when refrigerator temperature was less than 2°C for 30 minutes or more than 8°C for five hours. Escalated SMS alerts are sent to supervisors when refrigerator temperature is less than 2°C for 60 minutes or more than 8°C for 10 hours. The second group used 30-day temperature recorders (30DTRs) with visual alerts, and the third group used only stem thermometers as has been the standard practice. Key findings from this study include:

- Sites in Group 1 on average spent 73-74% less time per month below 2˚C (in cold excursion status) than sites in either Groups 2 or 3;

- Sites in Group 1 spent 56% less time per month over 8˚C (in hot excursion status) than sites in Group 3;

- The average yearly cost of the ColdTrace system was found to be $208 per health center.

This study generated broad interest in adopting the system; it also raised awareness of a number of issues, including an insufficient number of cold chain technicians available to respond to alerts for refrigerator maintenance, as well as the shortage of refrigerator spare parts required by technicians. The study also noted that some additional electrical expertise would be needed for installing ColdTrace on solar refrigerators and for health centers that experience frequent power surges. The Ministry of Health continues to evaluate remote temperature monitoring with devices like ColdTrace in order to develop a cold chain monitoring and maintenance strategy and implementation plan.

Key Lessons Learned

Keeping the Cold Chain Cold

- **Standard operating procedures (SOPs) need to be documented.** Interviews conducted at the health centers, districts, and province demonstrated the need for clear, easy to find documentation of SOPs. Currently, SOPs are in place for the SMS alerts escalation system and the necessary actions to be taken at each level, but additional SOPs regarding system administration, equipment installation, and refresher training processes for new and existing staff are needed.

- **Remote temperature monitoring can help to highlight the gaps in operational funding for cold chain maintenance and to address training and communication needs.** Many provinces and districts lack sufficient resources to reach health facilities regularly to address cold chain maintenance or outages. Although remote temperature monitoring does not solve this capacity issue, it does help to quantify the resources needed for future maintenance support, spare parts, and training.

- **Government policies are important to future expansion and adoption.** Though the Ministry of Health showed interest in expansion of remote temperature monitoring, the current strategy only budgets for remote temperature monitoring (RTM) at the national and provincial levels. This raised questions of sustainability, evidence and human capacity before a transfer of ownership could be discussed.

Building More of the Evidence Base

In addition to supporting the MoH in vaccine distribution, data management, and utilization, and providing technical assistance to the MoH and DPS for improving management capabilities of iSC, the Final 20 program has also conducted a number of sub-studies throughout the last three years to explore other approaches to addressing the root causes of low iSC performance. These studies were useful to the MoH and other partners in Mozambique to help improve performance and refine future plans and approaches to iSC improvement, but also can provide useful information to the global immunization and supply chain communities as other countries look to improve their supply chain performance.

Getting to the Root Cause: Performance Management as a Driver of Success

One research study used a root-cause analysis of poor performance of the iSC to drive improved performance. Between March 2014 and 2015, VillageReach worked with the William Davidson Institute (WDI) at the University of Michigan to explore the introduction of a data driven performance management and accountability system for

the iSC in two provinces (Gaza and Maputo), using a third province (Niassa) as a control. The study tracked three indicators: (1) percent of health facilities that received a delivery within 33 days, (2) percent of health facilities that report a stockout at time of delivery, (3) percent of health facilities submitting a report. The DPS EPI team used a decision tree tool each month after distribution to document these three performance indicators and identify the root cause of the supply chain issues in order to think through possible solutions. During the monthly meeting, the EPI team, which included field coordinators, EPI managers, and medical officers, would discuss causes for delays in distribution, in stockouts, or reasons for not submitting reports.

Results of the study showed that the intervention only had marginal impact on reducing stockouts and improving distribution discipline, although some of the effects may take longer to show performance gains. Based on the written monthly resolution reports, creative problem solving took place to resolve issues within the control of the distribution team. Monthly resolution reports provided a continual resource for root cause identification, making it feasible to consider key impact areas for engagement among government and outside actors. For instance, through these reports the research team discovered that of the deliveries made over the course of the study, 20 percent more would have been possible had refrigerators been functional.

The study included a performance based reward as well, comparing an average of three months of performance at the beginning of the study and at the end. The province that achieved the largest improvement over the course of the study would receive a laptop for the EPI provincial department. Gaza showed the greatest improvement during the course of the study and was rewarded with the laptop. Interestingly, the EPI manager did not suggest that this was a motivator for their performance.

Interestingly, in the control province of Niassa, the EPI team took it upon themselves to implement deeper analysis of the monthly data when SELV was deployed and provided an easy analytic tool. They introduced several changes to their management system that brought about significant improvements in the performance of the iSC. This was done without the study's decision tree tool and, presumably, was initiated based on the intrinsic motivation of the EPI team, interested in reducing stockouts and making vaccines available at all health facilities.

The main lesson learned from this study is that regular and systematic review of data can lead to improvements in the iSC. This was seen in the study provinces as well as the control province, which took its own initiative to use data for decision-making and resulted in improved delivery intervals and reduced stockouts. Application of this principle of data use is included in a VAN approach and a priority of VillageReach's technical assistance to the MoH in Mozambique and other countries.

The Denominator Conundrum

Knowing the true vaccine coverage rate is important for assessing the EPI program and making programmatic decisions. Using administrative data to calculate coverage, though, has some obvious limitations which are common in many low-income countries,[9] and Mozambique is not excluded. Inaccurate population estimates – which are used as the denominator in calculations of administrative coverage rates - can sometimes lead to nonsensical results such as coverage rates exceeding 100% of the target group,[10] which is often seen in annual reports from the provinces in Mozambique. Additionally, these target populations are used to plan distributions, often resulting in over- or under-stock.

9 Cicciò L. Certainties and Uncertainties of the Expanded Programme of Immunisation in Uganda: Are the Achievements Sustainable? Health Policy and Development, 2008; 6:1.
10 Borgdorff M, Walker G. Estimating Vaccination Coverage: Routine Information or Sample Survey? J Trop Med Hygiene. 1988; 91:35-42.

With that challenge in mind, the Final 20 program implemented a study to examine the possibility of using a locally adjusted population for better distribution planning and coverage rate calculation based on a more valid denominator. Several options were explored: number of first ante-natal care visits, number of births reported, and number of infants receiving the BCG vaccine, typically given at birth. Coverage rates using these denominators as proxies were compared to the recent national household surveys (from 2008 and 2011). Ultimately the best candidate for a proxy denominator was the three options pooled together and adjusted.

The results of the study identified a moderately correlated coverage rate indicator based on this pooled proxy denominator, but still landed far from a gold standard as another option to reliably measure coverage rate. What this study did produce, however, is a tool in Excel that could be used as an easy, ongoing monitoring tool for vaccine coverage using the proxy denominator identified in this study. This tool would not replace the household surveys that occur every few years but could be more reliable than administrative data.

The results also make the case for triangulation of data for distribution planning—using target populations as currently used, combined with the locally adjusted population calculation, and influenced by historical data to ensure the most reliable quantification of vaccine need at each health facility. The main lesson learned from this study is that distribution planning and ongoing coverage rate monitoring could be enhanced by looking at other data sources and not relying solely on administrative data.

Delivering the Money:
The Importance of Efficient Financial Flows for Vaccine Distribution

A critical input to any supply chain is financing and the ability of the government to manage financial mechanisms to ensure that vaccines and supplies are available at the places where they are needed. Unfortunately, routine expenses for the final steps are often overlooked in government budgets. Even if resources are available at the national level, this does not necessarily translate to lower levels of the system. In Mozambique, funds are not always available in the right places or for the right amounts to cover expenses for fuel, staff per diems or vehicles. When they are not, it is impossible to ensure on-time deliveries. During the course of this project, a study looked into the reasons behind the financial flow bottlenecks in order to identify strategies for more efficient financial management and improved supply chain performance.

Read more about financial flows in the Final 20 policy paper:

Delivering the Money: The Importance of Efficient Financial Flows for Vaccine Distribution

As identified by this study, many barriers to managing vaccine programs from the financial management perspective exist: delays in disbursement of funds, lengthy administrative procedures of requesting and justifying funds, and reduction to the overall budget with little information as to the required line item changes. Some of these risks can be mitigated through better planning and communication; however, the fact remains that even the most effective leader may be restricted through factors that lie mainly in others' hands.

A few recommendations have come out of this study:

- **Each DPS needs a stronger system to monitor core immunization service activities and expenses.** Participants in the study were unaware of how much money was spent annually on EPI activities and had no established reporting system to track expenses, making it nearly impossible to create an accurate annual budget.

- **Adapt planned activities to fit within the known budget delays.** It is an accepted occurrence that government funds will not arrive in January as planned and will be fully spent by the fourth quarter of the year. As such, the DPS can plan ahead for the known gaps, by delivering a two-month vaccine supply to accommodate the gap in funds in some months, for example.

- **Advocate for prioritization of vaccine distribution costs.** With better understanding of the true costs of distribution, the EPI manager can be better equipped to advocate and appeal to policy makers for sufficient funding to ensure vaccine distribution.

The issues of financing supply chains are not unique to Mozambique. Many country policies and corresponding financial flows still follow a traditional supply chain model that adheres to rigid government administrative structures, which are not always the most effective or efficient way to deliver health commodities. Eventually, countries will need to allocate more government resources at the right levels for next-generation iSC to deliver the immunizations that are needed when and where they are needed.

Photo Credit: Bill & Melinda Gates Foundation

The True Driver of Change: Leadership & Political Will

Any changes to the supply chain require an effective leader to define the new vision for the system and the processes that lead to the transformation. Often system design requires changes that may go against established policies and procedures that have become ineffective and out of date due to growing population and new vaccines. The champion for system design must be willing to question the status quo and use evidence to show how improvements can be made.

In Mozambique, political will and change leadership have been cultured over the years of implementation and can be seen in examples with both small and large influences. First started as a pilot project in one province, the DLS has transformed into a government-run system with a cost-share approach. In 2016, the provinces are taking over the full costs of distribution with catalytic support from outside donors decreasing. In one province, the medical officer has verbally committed to the DLS and has presented its effectiveness to decision makers at the national level. His confidence is backed by reliable data collected for use in the DLS, showing evidence for system changes that can bring about efficiencies. This same medical officer was willing to apply a two-month distribution cycle in one area of the province because of the increased efficiency and vaccine availability, going against the norm of monthly deliveries. Another example of effective leadership is the commitment of the EPI manager in another province to ensure that a vehicle is available and on-time each month for distribution, with guaranteed fuel.

Even great leaders can encounter road blocks with policies and procedures, and Mozambique is no exception to this. For example, in one province, the DPS committed to paying all distribution costs as they were expecting financial support from a new partner. When the availability of these funds failed, the DPS was left scrambling to find additional support for monthly distribution expenses, and distributions were delayed.

Champions of system design have been instrumental in moving the DLS forward, creating an enabling environment for it to expand to other provinces, and overcoming some potential barriers. Armed with data and evidence of the success of this system in increasing the availability of vaccines at the last mile, these champions have become advocates for the DLS both within their provinces and at the national level. This advocacy has not only helped open the eyes of decision makers to allow for system design modeling but has also driven forward the changes supported by modeling results.

The evidence generated in Mozambique for an efficient supply chain has been bolstered by the global conversation around system design and the importance of finding efficiencies to the iSC. Other countries, such as Benin and Niger, have used modeling to start the system design process, and the Gavi Supply Chain Strategy provides additional motive for champions to move this agenda forward.

Mozambique and the Final 20 project have seen many examples where decision makers have become great leaders through their willingness to drive context-appropriate changes, despite deviation from the norm, and their ability to generate support for that change from a wide audience. One key factor to the continuation of an effective next-generation iSC, reliable availability of vaccines at health facilities, and a high vaccine coverage rate is having strong leaders in place that are committed to achieving these goals.

> *Read more about change leadership in the Final 20 Policy Paper:*
>
> *Change Leadership: The Making or Breaking of an Immunization Supply Chain*

Key Lessons Learned

The True Driver of Change is Leadership and Political Will

- **Continuous improvement of the iSC is a management approach and not a pilot project.** All governments are equipped to manage their iSC; some may need more capacity to manage it in an efficient way. Through the efforts of each component of this Final 20 program, we hope we have built some of that capacity to manage an efficient iSC in Mozambique.

- **Government ownership and commitment is a requirement for system design.** One of the success factors of the DLS expanding to additional provinces was the initiative of the DPS leaders to seek improvements for the iSC. VillageReach played a technical role and, to some extent, provided financial support; however, the initiative, follow-through, and management were all DPS-driven. The provincial-level leadership is now trickling up to influence national level decision makers and generate additional interest in system design.

- **Leaders can drive the change towards next-generation iSC.** Leaders must be supported through an enabling environment, and leadership skills must be developed in order for effective leaders to apply creativity and innovation for system changes. This work in Mozambique has demonstrated that decision makers can become great leaders through their willingness to drive context-appropriate changes, despite deviation from the norm, and has shown their ability to generate support for such a change from a wide audience.

Looking Forward

VillageReach's mission and programmatic focus have been heavily influenced by our founding work in Mozambique. Our approach is firmly rooted in 'the last mile' and lessons learned in scaling and sustaining health innovation in low- and middle-income countries. One of the most important lessons that has come out of our immunization supply chain work in Mozambique is that system design cannot be seen as a pilot or a one-off project, but instead needs to be seen as a first step in a continuous process of improvement. The Final 20 program has focused on instilling a sense of urgency to drive improvements and efficiencies to the iSC through government engagement and capacity building while creating tools to support that effort. Any government can manage an iSC; the hope with the Final 20 program is that through these efforts the Mozambique government has developed the skills and the commitment to manage its iSC in a more effective and efficient way. We have seen this shift during our fifteen years working in Mozambique. What started as a pilot in one province, being designed and managed by VillageReach and partners, has phased into a government-managed, government-funded approach to improving the iSC.

The evidence generated by evaluation of the initial pilot, ongoing monitoring of distribution activities, and the results of modeling has empowered decision makers to question the status quo of the standard iSC and consider changes that will bring efficiencies. It is this management approach that we hope will continue in Mozambique and in other countries in the years to come.

The evidence from Mozambique and other countries like Senegal, Benin, and Nigeria that have taken bold steps to improve their iSC has helped to shape the current global immunization strategies designed to meet new and ambitious immunization goals set forth by Gavi, UNICEF and other global development leaders. The prioritization of supply chain has created momentum around and demand for next-generation supply chain innovation, and provided a common framework for donors, implementers and government stakeholders to work from when evaluating iSC systems.

Through this work, we have learned that next-generation iSC are not a one-size fits all supply chain that can be replicated as an exact model across multiple countries. Instead next-generation iSC share a set of characteristics that represent a fundamental change in how EPI supply chains have historically operated in Gavi-eligible countries and lead to a significant increase in performance:

1. **A streamlined and efficient supply chain** that decreases wastage and logistics costs.

2. **Clear data visibility** of vaccine availability and quality all the way to the point of delivery, through appropriate information technology solutions.

3. **State-of-the-art cold chain equipment** with ongoing monitoring and maintenance.

4. **A professionalized logistics workforce** with authority to make supply chain decisions based on data and actual, on-the-ground circumstances.

5. **Key performance indicators** (KPIs) to promote evidence based decision-making, evaluate system performance and guide continuous improvement.

6. **Reliable funding and financial flows** throughout the supply chain to enable routine, reliable access to vaccines.

7. **Leadership and political will** prepared to initiate and support change.

In the coming years, VillageReach will continue to support the Government of Mozambique to build sustainable immunization supply chain improvements across the whole country, expanding iSC improvements nationally with government resources. In addition, we will work with global, regional, and country-level partners to continue to build the overall evidence base for how improvements to immunization supply chains can contribute to overall immunization coverage and equity goals.

This transition to next-generation immunization supply chains will catalyze changes in immunization programs across Gavi countries to ensure that all children—including the final 20 percent—have access to life-saving vaccines.

Appendix A:
Evidence from the Final 20 Program, Key Performance Indicators (2013-2015)

The following data, collected as part of monthly immunization supply chain activities in Mozambique from 2013 to 2015, covers each province's changes in performance over time across key performance metrics that impact health centers and their beneficiaries including on-time vaccine deliveries and vaccine availability. Data are included from four provinces with the longest VillageReach engagement (Gaza, Niassa, Maputo, Cabo Delgado). The newest DLS province, Tete, is still in the initial stages of its DLS implementation, with five distributions since starting operations in November 2015. Zambezia only started tracking key performance metrics in the information system in April 2016 and therefore is not included here.

Regular Vaccine Deliveries

The graphs here show two measurements - tracking health centers visited and visited on-time

Health Centers Visited

Definition: Percentage of health centers in the province visited during the particular period

Measured as: # of health centers visited / # of health centers in the province

Summary data**: Increased from an average of 61% in 2013 to an average of 74% in 2015. However, rates of health center distribution visits in each province varied depending on available financing for the EPI program in each province, the annual budget cycle, and the province's ability to bring in additional partner or donor support for their programs. Cabo Delgado is a province that has struggled to secure operating budget to maintain consistent distributions which is reflected in the data below. When removing Cabo Delgado and looking only at the other three provinces, this indicator increases to an average of 86% in 2015.**

Health Centers Visited On-Time

Definition: Percentage of health centers visited within a 40-day interval from previous delivery visit of the total number of health centers visited during the particular period
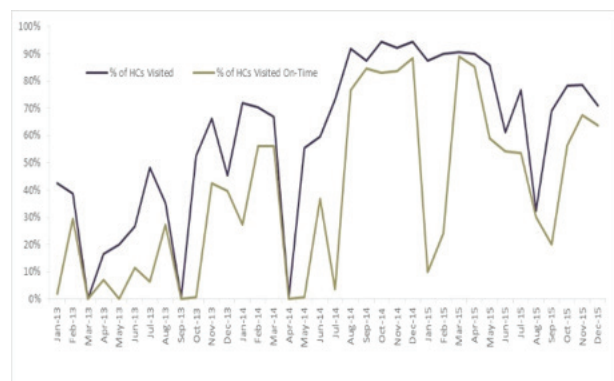
Measured as: # of health centers visited within 40-days / # of health centers visited

Summary data**: Increased from an average of 48% in 2013 to an average of 58% in 2015; when looking at the top three provinces, this increases to an average of 72% in 2015.**
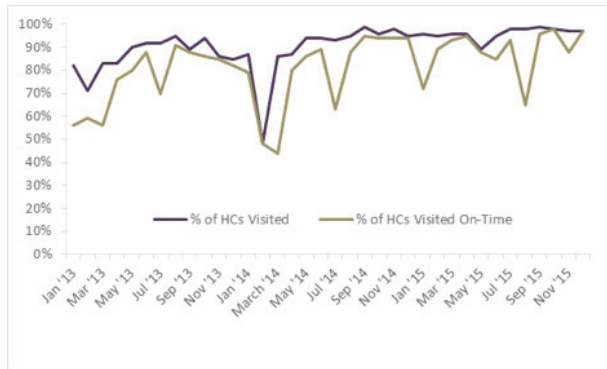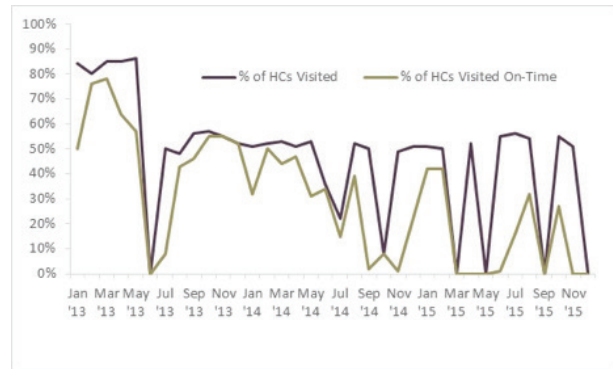
Gaza
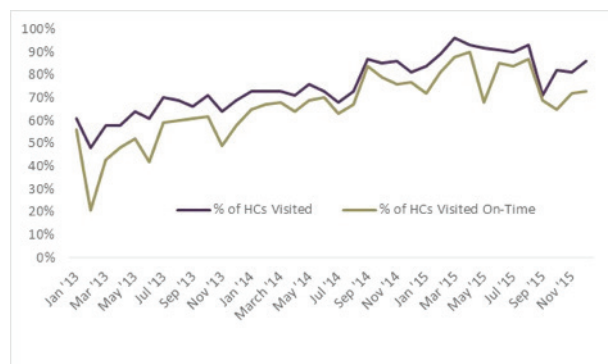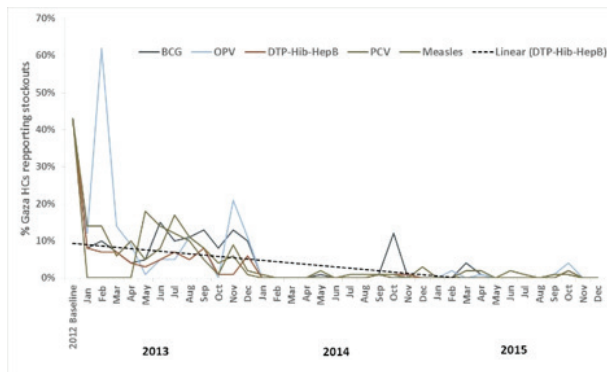

Niassa

Maputo

Cabo Delgado

Vaccine Stockouts

Definition: Percentage of visited health centers during a distribution period that reported a stockout of a specific antigen at the time of delivery (and before restocking by distribution team)
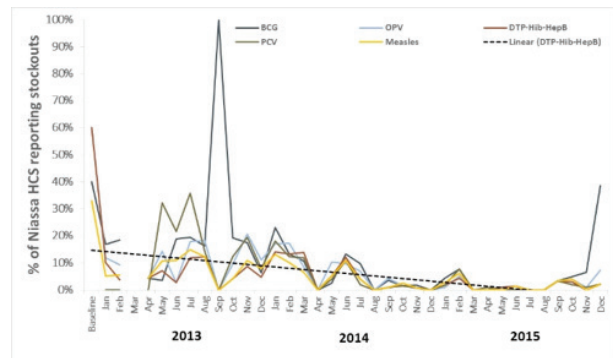
Measured as: # of health centers visited reporting antigen-specific stockout / # of health centers visited

Summary data**: Reduced from an average of 36% in 2010 to 5% in 2015. Cabo Delgado shows some improvement in stock availability but due to inconsistent distributions there are many gaps in data availability.**

Gaza

Niassa

Maputo
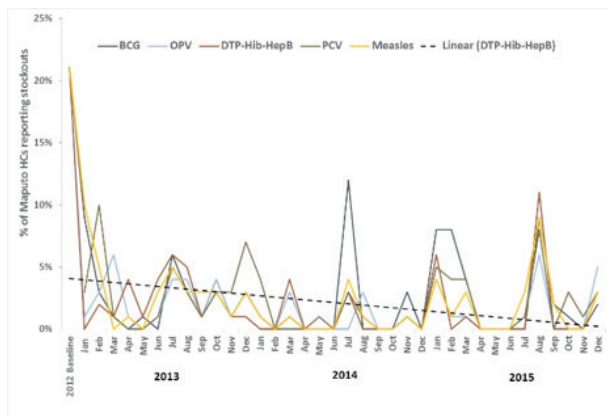
Cabo Delgado
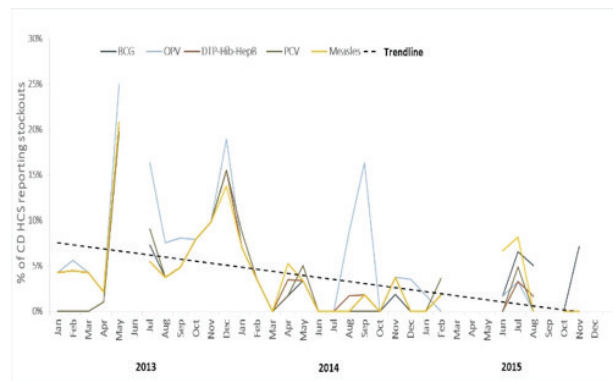
Appendix B: Additional Resources
Available on VillageReach.org

I. Policy paper series
    www.villagereach.org/PolicyPaperSeries

II. Introducing Modeling to the Mozambique Supply Chain, Workshop Report
    www.villagereach.org/ModelingWorkshopReport

III. Evaluation of Health System Transport Capacity and Demand: Mozambique Case Study
    www.villagereach.org/TransportAssessment

IV. Performance Management of Last Mile Vaccine Distribution (November 2015)
    www.villagereach.org/PerformanceManagementStudy

V. Assessment of the Financial Flows in Mozambique (June 2016)
    www.villagereach.org/FinancialFlowsAssessment

VI. Enhanced Visibility, Analytics and Improvement for Mozambique ImmunizationSupply Chain (April 2015)
    www.villagereach.org/VisibilityAnalyticsWhitePaper

VII. OpenLMIS Introduction
    www.villagereach.org/OpenLMISIntroduction

VIII. Evaluation of the Project to Support PAV (Expanded Program on Immunization) in Northern Mozambique (2001-2008)
    www.villagereach.org/ImpactEvaluation

IX. Yearly performance reports of the DLS (including three-year reports)

    1. Performance Report of the Dedicated Logistics System (2015)
    www.villagereach.org/2015PerformanceReport

    2. Performance Report of the Dedicated Logistics System (2014)
    www.villagereach.org/2014PerformanceReport

    3. Performance Report of the Dedicated Logistics System (2013)
    www.villagereach.org/2013PerformanceReport

    4. Performance Report of the Dedicated Logistics System (2012)
    www.villagereach.org/2012PerformanceReport

VILLAGE REACH ®

Starting at the Last Mile

VillageReach is a non-profit global health innovator that develops, tests, implements and scales new solutions to critical health system challenges in low-resource environments, with an emphasis on strengthening the "last mile" of healthcare delivery. VillageReach combines expertise across public health, technology, and business to bring life-saving innovation – new systems, programs and technologies – to scale and sustainability in the world's most underserved communities.

www.villagereach.org