Informed Design:
How Modeling Can Provide Insights to Improve Vaccine Supply Chains

Well-performing immunization supply chains play a fundamental role in improving the coverage and equitable delivery of lifesaving vaccines. Simply put, vaccines only work when they are available. Vaccines that protect against diseases such as rotavirus, pneumococcal pneumonia and cervical cancer are reaching more children than ever before. Yet these new vaccines stretch the capacity of systems that are also facing demands to increase performance and efficiency. Recognizing these challenges, the World Health Organization, UNICEF and Gavi, the Vaccine Alliance recommend intensifying efforts to ensure that supply chains can meet existing demands and are flexible enough to respond to future demands.¹

Many countries have adopted an approach called system design to optimize their immunization supply chains. A system design approach looks beyond incremental improvements, examining all supply chain components and how they interact to overcome barriers. In some countries, the design of an EPI supply chain has not changed much in decades. When one considers that the majority of the cost of a supply chain is determined by its overall design, it is clear that improvements are needed to maximize efficiency.

Modeling Can Influence a Range of Supply Chain Components

An array of activities and tools can help supply chain managers gain a full understanding of an existing system. Supply chain modeling is one option that can contribute insights needed for informed decision-making. Modeling uses data analysis software to create a representation of a country’s existing supply chain. This model then can be manipulated to test potential changes to the supply chain and find the optimal mix of cost, performance and risk based on a country’s context and priorities.

Modeling provides decision-makers an opportunity to see how changes will affect the overall system without making changes in the actual supply chain. Coupled with data gathered through other supply chain assessment tools as well as contextual factors, decision-makers are better informed about the risks and benefits of each design choice. Modeling results can lead to practical short-term changes, such as moving cold chain equipment, while guiding decision-making for longer-term changes.

The validity of modeling results is dependent upon the quality of data used to inform these results. This includes data that may be easily accessible (e.g., product storage requirements) and data that are more challenging to obtain (e.g., consumption data by product by facility by month). See figure 1 below.
Stakeholders typically prioritize potential design scenarios based on perceived impact, and each scenario will likely require specific types of data. For example, in the Democratic Republic of Congo, one question in a remote province was whether it was possible to include other commodities and even integrate the supply chain at lower levels. This required data related to product and packaging dimensions, transport type and transport capacity.

Modeling can provide insights about many supply chain components, particularly network design, transportation, and inventory and equipment allocation. It can also guide decisions around human resources and data gaps and needs. It is less useful for guiding decisions about specific budget needs or policies and processes. See figure 2 below. However, implementing changes discovered through modeling can have direct implications on vaccine availability and

In Mozambique, the Ministry of Health uses modeling to identify opportunities to improve vaccine delivery. Credit: Paul Joseph Brown

Figure 2: Modeling’s relevance for evaluating supply chain components
distribution costs, the efficiency of the distribution system and the geographic equity of the supply chain. Furthermore, by reviewing modeled scenarios of the supply chain in conjunction with other data such as Demographic and Health Surveys (DHS) and equity studies, socioeconomic inequities in the immunization supply chain can be better understood and addressed.

**Modeling in the Context of System Design**

Modeling activities take place within the framework of a broader system design approach. See figure 3 below. While many activities occur prior to planning, modeling can influence other stages of the process. For instance, even before providing evidence to inform decision-making around potential supply chain improvements, modeling has the potential to align stakeholders—encouraging them to examine the supply chain holistically and reinforcing a culture of continuous improvement. The consolidation of data during modeling can begin to identify gaps and weaknesses of the existing system. Once a deeper understanding about a supply chain is held, stakeholders are engaged in evaluating progress over time, looking for areas of further refinement. Similarly, less-intensive modeling activities can be used later in the process or even to help make the case for expanding a supply chain design to new geographies.

**Figure 3: Modeling in the Context of System Design**

Modeling can take from several weeks to more than a year. Scope varies greatly with the software used, partners involved, geography, available data and more. The process usually includes workshops to introduce the topic and align on scope, as well as to consider results.
Modeling in Action: A Case Study

In line with its Immunisation Supply Chain Vision 2020, the Democratic Republic of Congo Ministry of Health sought a properly functional, affordable and sustainable health supply chain that would guarantee timely and uninterrupted access to vaccines. Stakeholders first asked whether modeling could help identify potential supply chain improvements in Equateur, one of DRC’s most remote provinces. Equateur has low immunization coverage, in part due to daunting logistic challenges: Not only is it isolated but its “highway” is the Congo River. Medicines first must be transported on a plane or boat from the DRC’s capital, Kinshasa, to the provincial capital, Mbandaka, then by boat for 10 more days to reach the zonal health office. From here, medicines are distributed by canoe, motorcycle or bicycle or on foot to the health centers that serve the local communities and sometimes even farther, directly to where patients live.

In partnership with the Ministry of Health of DRC, VillageReach coordinated a modeling exercise to develop a picture of the existing supply chain and test scenarios based on priorities identified by stakeholders. The key question centered on how to efficiently access hard-to-reach areas while increasing availability of vaccines and other health products. Several iterations of data collection and validation helped ensure the models accurately reflected the situation. Working with LLamasoft®, several scenarios were evaluated, resulting in the following recommendations:

- **Direct delivery by a person trained in logistics:** Centralizing distribution duties means that health workers no longer have to close their clinics to travel long distances to pick up products.

- **The optimization of resupply locations for hard-to-reach areas:** Inaccessible service delivery points are recommended to be resupplied via the closest/least costly site with cold chain equipment, whether it is a zonal warehouse or another service delivery point.

- **Lengthening resupply intervals in hard-to-reach areas with sufficient cold chain capacity:** Modeling showed sufficient storage capacity for a three-month distribution cycle. Given historical issues with stock management and cold chain equipment functionality, however, a two-month cycle was chosen as it provides more opportunities for supervision and reduces risks for losing three months of stock.

- **Resource sharing:** Because EPI products use only 10 to 24 percent of available transport capacity, modeling indicated potential resource sharing opportunities with other public health supply chains. Family planning products are being incorporated as a first step.

These changes are being implemented in Equateur, bringing relief to facilities that were stocked out of essential products and unable to conduct clinics. Additionally, groundwork is being laid for future changes that will, over time, contribute to the increased availability of vaccines in some of the most difficult-to-reach health zones across DRC.
Using modeling to actively design supply chains can help ensure vaccines are available where they are needed most.

Tools for Supply Chain Modeling

Supply chain modeling tools vary from simple spreadsheets to more complex software created specifically for supply chain design. Two specialized tools are HERMES and Supply Chain Guru.® HERMES, or Highly Extensible Resource for Modeling Event-Driven Supply Chains, is a freely-available software platform that was designed to generate an interactive simulation model of vaccine supply chains. It can compare the performance of various supply chain configurations based on cost and product availability. See figure 4. Supply Chain Guru® is software application and analysis platform made by LLamasoft®. The application is available via subscription and is widely used in the private sector across many industries. For example, Supply Chain Guru® was used to assess multiple supply chain designs in Zambia, and showed not just how one scenario could generate cost savings but also how time could be saved by health facility staff who no longer would have to go pick up vaccines at the district level. See figure 5. Both products have been used to help design immunization supply chains in many countries. Determining the appropriate software will depend on the skills of those using it, the desired output of the model, timelines and repeatability, amongst other factors.

Figure 4:
The outputs of a HERMES model detail how the current government distribution system in Gaza Province, Mozambique, compares to alternate systems in terms of availability and cost.¹

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¹ VillageReach. “Lessons Learned in Reaching the Final 20: Building a Next-Generation Immunization Supply Chain in Mozambique.” August 2016.
A Valuable Approach for Supply Chain Improvement

Modeling contributes to supply chain improvements by helping define the best solutions to critical supply chain barriers. Models must be adapted to a specific context but, done correctly, provide evidence for the feasibility and impact of potential changes to a supply chain. Supply chain modeling also can be used to engage stakeholders, evaluate the current supply chain and encourage supply chain improvements. Using modeling to actively design supply chains can help minimize costs while ensuring vaccines are available where they are needed most.

Figure 5:
The outputs of a Supply Chain Guru® model demonstrate how a new supply chain design in Zambia could improve cost and decrease the time spent on vaccine logistics compared with the current supply chain.³

Considerations for Modeling

Understanding the limitations and requirements of modeling can guide its usage within system design.

**Models are:**

- **Decision support tools.** Modeling is part of the larger ecosystem of tools and strategies for supply chain optimization and cannot address all aspects of supply chain improvement.

- **A structured, repeatable approach to supply chain improvement.** Models can be built upon over time to support continuous improvement.

- **Useful in testing scenarios with political support to implement.** Decision-makers must support modeling to make the results a useful mechanism for change.

- **Ultimately only as good as their input data.** The time and resources required to collect data might be a barrier to an effective modeling exercise.

**Models are not:**

- **Capable of predicting the future.** They must be validated against the actual operations of the supply chain and cannot account for unknown or undefined risks.

- **Capable of closing data gaps on their own.** The modeling process can, however, help assess the current quality and availability of data.

- **Decision-makers.** Modeling results must be considered within a wider context: the ease with which recommendations can be implemented, whether there is support for these improvements, whether government policies require revision and more.

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**Additional Information**

For more information on designing the best solutions to supply chain barriers email info@villagereach.org

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