OPTIMIZE

Lessons learned from an operations research assessment of new supply chain demonstrations in four countries

A framework for decision-making: Albania, Senegal, Tunisia, and Vietnam

OPTIMIZE Immunization systems and technologies for tomorrow

PATH World Health Organization

This report was commissioned by Optimize: Immunization Systems and Technologies for Tomorrow, a collaboration between the World Health Organization (WHO) and PATH. The report was authored by Michelle Desmond of PATH.

Contact information:

Michelle Desmond
Monitoring and Evaluation Associate, PATH
mdesmond@path.org

PATH addresses:

Mail
PO Box 900922
Seattle, WA 98109 USA

Street
2201 Westlake Avenue, Suite 200
Seattle, WA 98121 USA

www.path.org

World Health Organization address:

World Health Organization
20 Avenue Appia
CH 1211 Geneva 27
Switzerland

www.who.int

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Acronyms

The following acronyms are used in this document.

DPM	Department of Pharmacy and Medicine
EPI	Expanded Programme on Immunization
FGD	focus groups discussions
IT	information technology
LMIS	logistics management information system
PATH	Program for Appropriate Technology in Health
PCT	Central Pharmacy of Tunisia
PNA	National Supply Pharmacy
PRA	regional procurement pharmacies
WHO	World Health Organization

Introduction

In 2012, project Optimize completed an assessment to explore the acceptability and feasibility of the innovative supply chain interventions the project had demonstrated in four collaborating countries. To understand the demonstrations' challenges and opportunities and inform future implementations, we asked implementers, stakeholders, and decision-makers in Albania, Senegal, Tunisia, and Vietnam what they perceived contributed to the acceptability and feasibility of introducing the new vaccine supply chain interventions in their health system. This effort was to attempt to learn about future implementations, and to understand the current challenges and opportunities in the implementations.

Background

Begun in 2008, project Optimize is a five-year World Health Organization (WHO)–PATH collaboration funded by the Bill & Melinda Gates Foundation to identify ways in which supply chains can be optimized to meet the demands of an increasingly large and costly portfolio of vaccines.

We work directly with vaccine and cold chain equipment manufacturers, partner agencies, national governments, and other institutions to identify problems in the vaccine supply chain and develop, test, and demonstrate innovative solutions.

Our goal is to help create technologies, systems, and practices that lead to stronger, more adaptable, and more efficient logistics systems, extending the reach of lifesaving health technologies to people around the world.

This report focuses on the acceptability and feasibility of demonstration interventions carried out in collaboration with four countries: Albania, Senegal, Tunisia, and Vietnam. The demonstrations sought to develop and pilot innovative strategies to improve country supply chains and logistics. Table 1 describes each intervention referenced in this paper.

Table 1. Interventions by country

Project Optimize interventions by country		**Definition**
Albania	Immunization information systems	A computerized immunization registry that can be used to schedule and record all child immunizations in the country, as well as manage vaccine stock and storage.
Senegal	Integration of supply chains	The transfer of responsibility for vaccine storage and transport from the Department of Pharmacy and Medicine (DPM) to the National Supply Pharmacy (PNA) and from the medical regions to regional procurement pharmacies (PRA) resulting in the PNA supplying both vaccines and medicines to the Saint-Louis PRA.
	Moving warehouse	A vehicle loaded with vaccines, consumables, and drugs that departs from the PRA and directly serves the health units and health centers in the Saint-Louis Region on a regular delivery circuit.

Project Optimize interventions by country		Definition
	Solar and other new technologies	Installation and monitoring of new, low-maintenance solar refrigeration systems that do not require batteries in the medical regions, health districts, and health units of Saint-Louis.
Tunisia	Streamlining and integrating supply chains	Streamlining the vaccine supply chain by demonstrating an alternative supply chain network design that avoids unnecessary or inefficient steps.
	"Net-zero energy" solar supply chain	An environmentally friendly vaccine supply chain at subnational levels, which uses solar energy, electric vehicles, and a series of conservation measures to achieve zero net-energy consumption without relying on nonrenewable energy.
	Improved information systems	A computerized logistics management information system (LMIS) that can track and trace vaccines in real-time throughout the supply chain, mitigating the risk of overstocking, expiry, and vaccine wastage.
Vietnam	Passive cooling at commune level	A new cooling technology that can function without electricity allowing vaccines to be stored in closer proximity to the children who need them.
	Mobile technology for tracking immunizations	A computerized immunization registry that can be updated on computers or mobile phones to track individual children due for immunization and record the vaccinations the children receive.
	Computerized LMIS (VaxTrak)	A computerized LMIS, called VaxTrak, that can manage vaccine stock and record aggregated immunization data.
	Fee-based immunization system	A web-based application that enables users to report fee-based immunization services.

For the purposes of this assessment, we are using the following working definitions of acceptability and feasibility: Acceptability designates a situation that is considered satisfactory and approved and refers to that which the participant appreciates or does not appreciate (the benefits and drawbacks) in the context of an operation. Feasibility designates the degree of achievement or fulfillment of a situation or a situation that can be achieved, fulfilled, and accomplished. It refers to the level of difficulty or ease with which the stakeholder can implement the necessary operations and activities.

Methods

An assessment[1] of the acceptability and feasibility of the demonstrations was conducted in four countries (Albania, Senegal, Tunisia, and Vietnam) to explore the perceptions of the stakeholders engaged in their development and implementation. The acceptability and feasibility assessment sought to identify the

[1] This assessment was deemed "non-research" in accordance with PATH's Research Determination Committee policies.

benefits and challenges associated with implementation and used qualitative methods including focus groups discussions (FGDs) and interviews. Specifically, the assessment focused on the factors that made operations acceptable or unacceptable and feasible or unfeasible and how the operations affect the health system.

Local researcher teams conducted semi-structured interviews with a variety of stakeholders; interviews lasted 60 to 90 minutes and were recorded with the consent of participants. Three to twelve participants participated in each FGD using pseudonyms to ensure anonymity during group discussion. The FGDs lasted approximately 90 minutes and were also recorded. One member of the research team moderated the FGDs, while another took notes. Both interviews and FGDs followed a semi-structured guide.

Instrument creation

The Optimize Monitoring & Evaluation (M&E) team drafted the assessment instruments, which were tailored to fit country-specific needs by the in-country study teams. The instruments were then translated into the primary language used for data collection, back-translated to English, and verified by the team leads. Necessary changes were made after field testing in all four countries. None of the data collected during the pilot tests were used in the analysis. Details about the study team participants can be found in Table 2 below.

Table 2. Study teams

	In-country team members	Primary language used in data collection	Dates of data collection
Albania	2 researchers, 1 research assistant	Albanian	September–October 2012
Senegal	1 manager, 2 researchers, 1 research assistant	French, Wolof	October–November 2012
Tunisia	2 researchers, 1 research assistant	French (some Arabic)	October–November 2012
Vietnam	1 project staff	Vietnamese	May–September 2012

Respondents

We chose a purposive sample of respondents in each country based on their relation to the project. The sample size represented the categories of respondents and the number of interventions in each country; it was adjusted when a saturation point was reached. Respondents were classified into four categories (with some possible overlap):

- **Decision-makers.** Senior national immunization program managers who made the decision to implement a given intervention.
- **Designers.** Staff from senior levels who were involved in the design of the intervention.

- **Implementers.** Expanded Programme on Immunization (EPI) staff at all levels of the system who helped implement the intervention.
- **Third-party stakeholders.** Representatives of collegial public health–oriented agencies that do not fit in the above categories but have sufficient knowledge of one or more interventions to provide useful insights.

We made provisions in the demographics to balance the participants from rural and urban settings and, in some cases, by health profession (doctors versus nurses) and gender. Table 3 displays the total number from each category by country. In Albania, a total of 18 semi-structured interviews and four focus groups were conducted. In Senegal, 60 interviews and four focus groups took place. In Tunisia, 30 interviews and two focus groups were conducted. In Vietnam, 47 interviews were conducted; focus groups were not chosen as an appropriate data collection method in that country. Each respondent gave informed consent to participate and for the recording of focus groups and interviews. Informed consent was kept separate from the data, and both were kept in secure locations with the recordings to preserve the respondents' anonymity.[2]

Table 3. Type of respondents by country

	Decision-makers	Designers	Implementers	Third-party stakeholders
Albania	9	24 (15 in FGDs)		0
Senegal	5	3	69 (23 in FGDs)	6
Tunisia	12 (1 in FGD)	0	31 (12 in FGDs)	0
Vietnam	10	2	35	0

Abbreviation: FGD = focus group discussion.

Analysis

In-country research teams transcribed qualitative data collected through interviews and focus groups in the primary data collection language. The transcriptions excluded the names of respondents and any personal identifiers. Each document was assigned a unique identification number based on a system used to maintain the anonymity of respondents. Transcripts were translated using a third-party translator. At least 10 percent of transcriptions were checked to ensure quality and reliability. The transcriptions were then imported into the ATLAS.ti v.7 software application for coding based on a classification tree that included the major variables corresponding to the objectives of the instrument questions and structure.

After data collection, all audio recordings were transcribed in the language of the recordings (French, Vietnamese, and English). These transcripts were then translated using a translator/translation service and verified. Five to ten percent of the translated transcripts were back-translated for quality control. The team analyzed the translated transcripts with a predesigned codebook that was adapted for each country context. ATLAS.ti v. 7 was used to assist with coding and data management. The data were then

[2] The study was submitted to all in-country institutional review boards, which classified this assessment as "non-research" or approved.

categorized by acceptability, feasibility, unacceptability, and unfeasibility and the interrelationships between these categories were explored across the analysis of all four countries.

Results

The analysis found common themes related to the acceptability and feasibility of the interventions in all four demonstration countries. After analysis, the same themes were represented among the various categories of respondents as well. The predominant findings across the demonstration countries are presented below.

Acceptability

The aspects of the demonstrations that were found to be acceptable in all four countries aligned under four main themes: data quality, efficiency, immunization quality, and issues pertaining to workload.

Implementers and decision-makers alike perceived data quality to be an important aspect of acceptability for a new demonstration activity. Before the interventions were implemented, countries experienced challenges with data quality for stock management, immunization, inventory, and compiling reports. The following quotes illustrate the way the respondents viewed the intervention as improving or enhancing the quality of data in a way that caused the intervention to be acceptable:

> *"I think that it is essential to better manage the subjects [patients] of immunization and now we have the software provided with quality and feasibility."*
>
> —Vietnam, designer, Immunization Registry Software and Passive Cooling interventions, urban area

> *"For instance, in terms of statistics we save a lot of time, because before we needed around two weeks to collect data and prepare statistics reports, adding here one day for stock management (stock balance). Also it took time for us to monitor [the] vaccination process for health centres. While now we are able, through the system, to evaluate the progress and problems of each health center. With this system, the amount of papers (registers) is reduced, and now we will be reducing the paper stocks that have filled/stocked out the archives of health centres and our rooms here."*
>
> —Albania, implementer, Immunization Information Systems intervention, urban area

> *"Exhaustive information is available in the system; it's all well organised and simplifies the working organisation. The cold chain is better organised thanks to the Log Tag. Back-up stock is known, and no vaccines are lost. I think that this is extraordinary."*
>
> —Tunisia, implementer, LMIS software intervention, urban area

> *"There has, of course, been an improvement, especially at regional and district levels, because the health system had many problems with collecting reliable data. I think the intervention also allows timely and reliable data, especially that part of the logistics where people do not take account of stock use levels. I believe that it is critical and normal that the region and district and even the health district must improve inventory management and the use of the products."*
>
> —Senegal, implementer, Moving Warehouse intervention, urban area

With regard to efficiency, the respondents noted cost, time, and the ability to do their work effectively as factors that contributed to an intervention's acceptability. Stock management—specifically, the efficiency of vaccine management—was also a key theme. This respondent shared some of the improvements made by the LMIS software intervention in Tunisia:

> *"Before, we were not sure of the correct storage of vaccines, but now there is a good control of vaccines, from the economic point of view and also for transport. In addition, there is good management of orders and stocks of vaccines: therefore, less waste. All these are advantages."*
>
> —Tunisia, implementer, LMIS software intervention, urban area

Implementers mentioned the efficiencies that came from improving the systems and function of the health system overall and the cascade effect of efficiency in the system. It is notable that another key aspect of acceptability was the effect of the system's efficiency on the care given to patients. Respondents in more than one country commented that efficiency gains allowed staff to provide better care to patients:

> *"It also facilitates our job as well, because everything is focused in our health center. Before, we had to gather data from different vaccinators. We are doing the same thing now, but the main unit of vaccination system for our area is located here. We also have the contact numbers of caretakers (mother/father) and now we are better connected with caretakers as well."*
>
> —Albania, implementer, Immunization Information Systems intervention, rural area

> *"The new system helps us to organise work and guarantees the quality of the cold chain. It has benefits for the health of both mothers and children, [so] why not continue? We cannot go backwards now."*
>
> —Tunisia, implementer, LMIS software intervention, urban area

> *"[It] allows us to care for our patients. If it saves time… we will be able to see more patients and to monitor our patients… in short, to focus on other activities of the position."*
>
> —Senegal, implementer, Moving Warehouse intervention, urban area

Another theme that arose from the analysis about acceptability pertained to issues of immunization quality. This was broadly defined as aspects that improve the quality or care of the vaccine itself or the delivery of the vaccine to a child through the immunization system. The quote below highlights all the ways that the combined interventions in Senegal contributed to improving immunization quality:

> *"In this light, it is totally beneficial because there is already a delivery to your door in safer conditions. The vaccine is kept in conditions that offer better management. Before, district health post logistics was mainly motorcycles. Now there is a 4x4 vehicle for the moving warehouse, which performs delivery. I think there is improved safety of products carried in these vehicles. Also, there is better traceability of products given the equipment used to track shipments. I think it also allows for better traceability of products and also improved product availability."*
>
> —Senegal, implementer, Integration and Moving Warehouse interventions, urban area

Respondents from Tunisia shared ways that the interventions contributed to immunization quality that were unique to their country, as expressed in this quote:

> *"The vaccine arrives in good conditions of cold chain, in a specific car to the refrigerator. Also, with the log tag the vaccine is well guarded; we can know the power cuts. Before, this went unnoticed. Now I can guarantee the vaccine arrives to children in good condition. From the regional warehouse to the child, it is monitored/controlled from the warehouse until the child."*
>
> —Tunisia, implementer, Net Zero Energy Supply Chain intervention, rural area

Immunization quality was an important factor for acceptability in Vietnam. A range of aspects were noted as contributing to immunization quality:

> *"Firstly, it enhances the rate of immunization; secondly, it enhances the quality of immunization. Children will be immunized in accordance with proper schedule."*
>
> —Vietnam, designer, Immunization Registry Software and Passive Cooling interventions, urban area

Finally, many respondents felt that the interventions reduced their workloads or burdens and improved their efficiency. Simply put in the quote below, the interventions allowed for workloads to shift to other pressing matters:

> *"It helps reduce the burden on our staff so one can carry out several tasks."*
>
> —Vietnam, implementer, VaxTrak software intervention, urban area

Most respondents reported that the immunization software tracking programs and vaccine stock software programs reduced workload and improved work tasks. This was also found with the moving warehouse intervention in Senegal:

> *"Yes I think it is acceptable… because as I said earlier it reduces the burden of staff work. As I said, we no longer need to send staff to pick up vaccines so this really reduces the staff workload. And it also allows vaccines to be available at delivery points. And it does not result in additional cost to the patient. Therefore I find it acceptable."*
>
> —Senegal, decision-maker, Moving Warehouse and Integration interventions

In an interesting finding, some participants had the perception that interventions increased their workloads and/or the workloads of their staff, but this was reported as acceptable due to the benefits offered by the interventions.

> *"I can't say that has made my job more difficult, but let's say extra workload. But this was something expectable [expected] as this is for our best; I mean it is an affordable workload. We are aware that now we are overloaded, but in the future will simplify and facilitate our job."*
>
> —Albania, implementer, Immunization Information Systems intervention, urban area

> *"Workload has increased, but the tasks have improved…Tasks are now better organised. We used to exclusively use mobile cards, which were not easy to work with. Things are now more organised."*
>
> —Tunisia, implementer, LMIS software intervention, urban area

The main themes of acceptability found across all four demonstration countries—data quality, efficiency, immunization quality, and reduced workload—are all issues that would be anticipated to affect how implementers perceive new interventions. Although there was variation across countries, the findings affirm that these are important implementation issues that need to be included in supply chain interventions.

Feasibility

Equipment, support, and logistics were the most salient factors affecting feasibility, according to the analysis. While respondents from each country described these three factors differently, their answers and interpretations shared a number of similarities.

Respondents said their intervention-related work was feasible due to the supplies, resources, and equipment provided. Although they were primarily referring to technical equipment and supplies, human resources were also a contributing factor, as shared by a project implementer:

> *"This is feasible because all the elements necessary for the feasibility are available. There are human resources in place; there is equipment in place. So I think it is very doable. Now feasibility can be problematic, but that is another issue of organization. But with the equipment, with human resources, it is feasible."*
>
> —Senegal, Integration intervention, third-party stakeholder, national level

Another way that equipment contributed to feasibility was by helping participants achieve goals to increase vaccination coverage. This finding was specific to interventions used, such as solar refrigerators to ensure immunization quality and mobile warehouses to increase vaccine availability.

Tunisian interviewees also stated that technical physical resources contributed to feasibility, as did systems, collaborative efforts, and information sharing. For instance, when asked about what made the project possible, a respondent from a senior decision-making position answered:

> *"The system at the PCT [Central Pharmacy of Tunisia] level: we have logistics, the means of transportation, so as a result there is an improvement… [with] even minimal commitment of each person to better collaboration and a minimal amount of information [there is an improvement]. In my opinion we must now go to other regions."*
>
> —Tunisia, Streamlining and Integrating Supply Chains intervention, decision-maker, national level

Given the perspective of the aforementioned decision-maker—who was motivated to suggest that the intervention be replicated to other parts of the country due to the value of the resources—as well as other respondents, we conclude that equipment is a significant factor of feasibility. Other respondents reported that not only was equipment important to feasibility, but that feasibility depended on progress with related technology and the human resource capacity to use the technology. An interviewee working in a rural commune said:

> *"I think it's the human. We must have good knowledge to advance. That's important. We also need the computer because it's a means of work. It's a condition to do the work. We must have the brain combined with the machine; they must go together."*
>
> —Vietnam, implementer, Immunization Registry System intervention, rural area

A number of types of support encouraged feasibility, according to respondents. The analysis revealed that support is primarily related to political buy-in, including securing resources and commitments to national goals, but the term also encompasses financial backing and training for human resource capacity.

In Tunisia, support coming from policymakers was reported as having a significant impact on the feasibility of interventions. An implementer working at the district level said:

> *"I am for this project, and I hope the state supports and helps the project and encourages it with resources, because for us, what is our objective? It is that the child is properly vaccinated and protected. [W]e must do our best to achieve this objective.*
>
> —Tunisia, implementer, Net Zero Energy Supply Chain intervention, urban area

Interviewees said that political buy-in comes from various actors, including local governments, national governments, and external nongovernmental organizations (NGOs) and donors who have a stake in the new interventions. Uniquely, Senegalese implementers also emphasized collaboration among this range of actors when discussing the viability of continuing projects. When asked what factors would ensure the continuation of a project, an implementer of solar refrigerators responded:

> *"I think it's [partnering]… partner integration is good, but the idea behind is so that it might be sustainable, so that if Optimize withdraws, this project can be sustainable, that the government of Senegal can continue this work that is already seen from this perspective… This question of sustainability must be in place, try to manage this from the central level… because the partner is there for a while and then he'll leave. And I think we should work to sustain the enthusiasm brought to us by Optimize."*
>
> —Senegal, implementer, Solar Refrigeration intervention, urban area

Participants also said that support came more from a policy standpoint and not only from higher-level decision-makers. For instance, support to create and implement procedures with technological interventions contributed to the viability of the interventions. An implementer and designer shared insight on what policies supported the development of a fee-based immunization project at the urban level:

> *"It should be highly feasible everywhere. The authority supports it and we have favorable policies, regulations, and related documents as well as staff… First, is legal framework, procedures, and regulations. Second, is working methods. We only have to submit documents to them [the authorities] and then we can implement it. Third, is simpler administrative procedures relating to the approval of projects on this software—they [the authorities] support it."*
>
> —Vietnam, implementer and designer, Fee-Based Immunization System intervention, national level

Another theme that emerged is that systems, structures, and logistics make work more feasible according to respondents.

> *"This is what drives all this, because we have this desire and willingness, we make vaccines available, and we make available the logistics and everything. From the aspect of the health personnel we… welcome the moving warehouse in a friendly manner, we do everything we can to do to receive [the vaccines] and when we receive them we manage the vaccines in a very efficient manner to truly manage all of this."*
>
> —Senegal, implementer, Moving Warehouse intervention, rural area

Tunisian implementers participating in a focus group discussed how better organization eased their work. For example:

> *[It's] easy in the sense that it means organizing better, we must simply change the way of doing it. It does not require sophisticated hardware, what we did was to reverse delivery routes—before, the nurse came to fetch his supply of vaccine, it is more logical to reverse the delivery route. The regional and district levels ensure supply now with other thermo sensitive drugs."*
>
> —Tunisia, implementer, Net Zero Energy Supply Chain intervention, rural area

As implied above, reorganization of structures did not require new technology, but rather, the new interventions reworked the systems to increase the ease of tasks.

In our analysis, we observed the interaction of the feasibility factors described above in at least three of the four countries. First, there was a relationship between equipment and reorganization of delivery routes and procedures—thus the interaction of supplies and logistics is a salient aspect of feasibility. Creating delivery routes and procedures in the cold chain supply relates closely with the use of equipment in each intervention. On the other hand, reworked logistics also necessitates different supplies and resources to ensure there is greater ease in day-to-day tasks.

Second, we saw that equipment and support intertwined in Senegal, Tunisia, and Vietnam, and that the relationship between equipment and support make for greater potential for feasibility. While equipment is a significant element of viability, support for political buy-in, financial resources, and policy implementation are closely linked to the interventions' feasibility. On the other hand, financial support and commitment from decision-makers are means to acquire supplies and resources as well as the resources for training to use new technologies. Thus, the links seen between these two factors of feasibility make interventions in cold chain supply more promising for implementers, designers, and decision-makers.

Unacceptability

The factors that contributed to the unacceptability of the interventions (or aspects of the interventions) were similar across all four countries. These included technical challenges, issues with logistics, difficulty of use, and too short of a time period for an adequate evaluation.

The technical challenges experienced by demonstration countries centered around issues related to the Internet and equipment maintenance, as described below. This is a finding that will affect the roll out of any information system intervention and is vital to consider in terms of interventions that require a technician to maintain servers or other mechanics.

> *"Yes, there have been some problems, such [as] power interruption, slow Internet, or network disconnection. Often our vaccinators have been enforced to work overtime, in order to accomplish the work plan."*
>
> —Albania, implementer, Immunization Information Systems intervention, rural area

> *"When the refrigerator breaks down or when there is a problem of transport this disturbs my work. I had a problem with the log tag that worked for just a week; I swear it only worked for a week, then it became nonfunctional."*
>
> —Tunisia, implementer, Net Zero Energy Supply Chain intervention, rural area

While concerns about logistics were evident in all countries, they varied widely based on the intervention. This demonstrates that logistical issues are primarily a concern of those using the interventions, especially the health workers who are the main implementers. Aspects of logistics that contributed to unacceptability included road travel, supply, space, and overstocking, as shared by these implementers:

> *"I think there may be problems for this car on unpaved roads. I believe there is a plaque there that can be damaged or something like that."*
>
> —Tunisia, implementer, Net Zero Energy Supply Chain intervention, rural area

> *"Another issue is in the absence of ice source, as we have been testing [the cold box] so it [ice] is available for purchase. [T]he health station will have certain difficulties in acquiring ice source, given the costs are not compared yet at this point."*
>
> —Vietnam, implementer, Passive Cooling intervention, urban area

> *"Regarding the collection of safety boxes… there is a small snag, because currently… the collection is not done correctly. Currently, arriving in Pale, you will find at least 30 safety boxes. Just last night we picked up and brought back four full safety boxes, because Pale was a center of… disposal of safety boxes."*
>
> —Senegal, implementer, Moving Warehouse intervention, rural area

Another aspect of unacceptability is the perception that the interventions were difficult to use by the users/respondents. This is a risk with any new intervention and especially one involving the need to learn a new skill or software program. This issue was particularly prevalent with the software-based interventions. Low computer literacy levels made it difficult for some health workers to become proficient in the intervention's functions.

"At first, usual control with naked eye, it is easy to read temperature from the thermometer. But reading the results on curves with the computer, it becomes difficult; these are scientific things controlled by computer, which requires very specific monitoring."

—Tunisia, implementer, Net Zero Energy Supply Chain intervention, rural area

"There are difficulties with facilities, staff, and the software itself. The computer proficiency of staff in other provinces is not as high as our staff's."

—Vietnam, implementer, Fee-Based Immunization System intervention, urban area

The last unacceptability factor, which was expressed in all four demonstration countries, was insufficient time for implementation and evaluation. Because of the short time period during which the interventions were fully implemented in some areas, it was difficult or impossible to tell if the interventions had value in a broader area or in varying contexts. As shared below, respondents felt a need for more evaluation to be done after a longer period of implementation in order to judge the acceptability and usefulness of the interventions.

"I do not know [if the use of electric vehicles for the distribution of drugs and vaccines will be continued in the Kasserine areas], we must first make an assessment of the use of these cars where they are used to be able to recommend them or not; if they have improved work we recommend generalization. Generalization must be made after the evaluation period and the places where they have been used, these cars have difficulties in paths and bad roads."

—Tunisia, implementer, Net Zero Energy Supply Chain intervention, rural area

"I think we should evaluate the progress of the implementation after two years and see how [it] has gone. If results are not promising, then why we should continue to implement this program, in order not to spend more time, energy, money, and other resources. So, after the evaluation we will see positive and negative aspects of implementation, and then decide whether should be continued or not."

—Albania, implementer, Immunization Information Systems intervention, rural area

"The problem is that although the software is highly acceptable, it hasn't been implemented in all regions. So we cannot see its 'full-effect'."

—Vietnam, implementer, VaxTrak software intervention, urban area

The factors of unacceptability, as revealed by the analysis, enable us to see the full picture of costs and benefits that are weighed during implementation. The logistical and technical challenges were major sources of frustration for users of the new interventions—solutions were often not found in a timely manner or with in-country expertise. A steep learning curve for skill adaptation occasionally stalled the users' motivation to successfully implement a new intervention, even if the long-term effects were attractive. Lastly, respondents in all four countries emphasized the need for interventions to run a sufficient amount of time to demonstrate their full effects on the system.

Unfeasibility

The analysis revealed that in three of the countries the most salient factors related to unfeasibility were cost, logistics, infrastructure, and management. Respondents described these factors differently based on their direct experience with the range of interventions.

Comments from interviewees that pointed to unfeasibility due to cost were expressed as concerns about sustainability, donors, and financing to start a new intervention. Comments about cost also suggested that the initial funds for the interventions could not have been provided by governments without significant outside support. This respondent expressed this concern succinctly:

> *"The issue of the quality of funding, how to ensure that it is self-sufficient and self-funded."*
>
> —Senegal, implementer, Integration intervention, urban area

A senior-level decision-maker from Tunisia shared that the cost of solar cars made the intervention unfeasible. In addition, this respondent also expressed concern that technical issues with repair and maintenance make it impossible for the operation to continue:

> *"I would like to mention two aspects: what does the future hold for these electric cars? These cars are expensive; their batteries are also expensive; repairs are practically impossible in Tunisia. How can they be maintained? This may represent an obstacle for the operation."*
>
> —Tunisia, implementer, Net Zero Energy Supply Chain intervention, urban area

An implementer using VaxTrak software described how the high start-up costs for new interventions made their work less viable:

> *"It's not difficult to train them [the health workers using the intervention]. The only problem is budget. When we implement a new software or anything new, we need the budget to encourage them. When they've got used to it, then they can carry on without financial assistance. So we need the money in the first stage. [W]hen they're not familiar with the software then they are reluctant to use it, so should encourage them at the first stage."*
>
> —Vietnam, implementer, VaxTrak software intervention, urban area

It is evident that there are links between costs, training, resources, and motivation for staff involved; funds are necessary for human resource capacity-building and for using new technologies.

Key findings from the analysis included concerns about the logistics of mobile warehouses and the effects on staff, timing, logistics of vehicle use, and technicalities.

> *"For me, according to what I have seen, it is a logistical problem because the guys are tired. They take two days for delivery. Couldn't we increase the number of boxes? In this case, one vehicle could provide fully for each zone, and for each district. Those who have problems with fridges and batteries like me—I have a refrigerator problem and no battery—I would like you to intervene on these issues.*
>
> —Senegal, implementer, Mobile Warehouse intervention, rural area

Our analysis found that vehicle logistics are not a single problem—time delays and problems with technical equipment may contribute to staff workload and low morale. This respondent discussed the cost problem from a macro-level perspective:

> *"We are in an economic crisis… and in the future as I prefer to stop here for it to be feasible in the long term I find that logistically this project has a high cost. We are in an economic crisis and each cent counts."*
>
> —Tunisia, implementer, Net Zero Energy Supply Chain intervention, rural area

The interaction between insufficient infrastructure, resources, and systems emerged as another factor linked to unfeasibility. When discussing concerns about expansion to other parts of the country, this respondent said:

> *"If it must cover the entire country let's say that it is not feasible… because it needs more men, it needs more logistics. If it's throughout the national territory… at this point in time, it is not feasible… The means do not exist. We need more men, we need more storage space. Put simply, if you take just the vaccines, if it was other products, essential drugs can be put in trucks; we could even rent trucks if you want. But the cold chain that is required by mobile warehouses, that, anyway, we can't do in the current situation."*
>
> —Senegal, implementer, Integration intervention, urban area

Another respondent pointed out the link between infrastructure and equipment needs:

> *"If there is integration of other drugs it will be difficult; for example, the cars used can't carry vaccines and drugs at the same time. The van carrying the vaccine now comes 'full.' Moreover who will receive the other drugs in our warehouse? It is a whole system to review. So I think this integration will be difficult."*
>
> —Tunisia, decision-maker, Improved Immunization Systems intervention, national level

For implementers, the software intervention was difficult to use without the technological infrastructure in place. This implementer, who worked at the national level in Vietnam, stated that Internet unreliability and training staff on the software were problems:

> *"This software requires computer and Internet connection, but Internet connection is quite unstable in several remote districts. It's unfeasible there. They have staff and facility but Internet connection is bad. We can train staff but if they get rotated later, we'll have to spend time training the new ones again, so it badly influences reporting."*
>
> —Vietnam, implementer and designer, Fee-Based Immunization System intervention, national level

Finally, management was raised as a factor for unfeasibility. Respondents said that management of the interventions was often time consuming and required more energy than the previous systems. This was especially the case for monitoring staff in performance management.

> *"Yes on my side, on the performance management, which is what I do… It takes a lot of time, energy, must spend time with people, etc."*
>
> —Senegal, implementer, Integration intervention, national level

Another respondent working in an urban setting expressed the need for more management and oversight:

> *But the fact remains that [if] policymakers decide [to adopt] the application [intervention]; some improvements can be made. I also wish there is someone else who supervises me, because if you work without supervision, we can get into routine and you can have a bit of letting go. Our mentality is like that. Control every week or once a month."*
>
> —Tunisia, implementer, Integration intervention, urban area

The above quote also indicates that there is a need for more policy and procedures to ensure regularly scheduled monitoring, an important factor related to improved management.

An implementer using VaxTrak software in an urban region of Vietnam stated that challenges with insufficient staffing were associated with the unfeasibility of the workload for management and staff:

> *"To deal with problems in the provincial level where the staff don't have the right capacity and we should help them. Our staff is limited in number and have so much work to do. But I think investing for this, it will bring long-term benefits in the future. Hard in the early stage, but long-term benefits."*
>
> —Vietnam, implementer, Immunization Registry software intervention, rural area

While this respondent had concerns about the lack of staff available to operate the project, he also showed optimism that future investments would make up for insufficient capacity in the intervention's initial phases.

There were clear interactions between all four factors of unfeasibility in the three countries studied. Our analysis revealed that cost had much to do with financing supplies and equipment. Cost also had much to do with human resource capacity-building and logistics, especially in hiring, training, and motivating staff members, all of which had impact on management workload and administrative time required. More importantly, funding was particularly linked to long-term concerns about feasibility, as demonstrated by the respondents who discussed the challenges of in-country financial sustainability and technological infrastructure.

Discussion

This assessment offers a number of lessons that have implications for the implementation of new vaccine supply chain interventions. The respondents reported a range of factors contributing to the acceptability, feasibility, unacceptability, and unfeasibility of the project Optimize interventions, some of which overlapped. Most of these factors could be anticipated, but it was notable that they were present in all of the countries despite the diversity of contexts, interventions, and current supply chain challenges. Some findings were a surprise, such as the acceptability of an increased workload, as long as it improved patient care.

The dynamic aspects of the equipment, logistics, and technical challenges experienced point to basic requirements for future supply chain intervention programs. If an intervention requires the Internet to run, but the Internet and electricity are unreliable, the program has little chance for improving the efficiency of the system.

If we disaggregate to the intervention level across demonstration countries, we learn that information technology (IT)-based interventions may increase acceptability if the implementers are trained sufficiently, including in computer skills. In addition, implementers of IT-based interventions received ongoing feedback based on continuous use and suggested changes for the systems, which may have improved acceptability. This integration of regular feedback may have differed from the other interventions, which were planned demonstrations with less likelihood that modifications could be made immediately based on user feedback. Both the IT-based interventions and the supply chain integration interventions required adapting to a new system, but users of the IT-based interventions were more receptive to the new system, even though it may have increased their workload. On the other hand, implementers and stakeholders involved in the supply chain integration interventions were more likely to report skepticism about success and sustainability.

While logistics was a challenge across all interventions and ranked as a factor of unacceptability, the logistical challenges for IT-based interventions centered around Internet availability and, in some cases, electricity. For solar-based interventions, such as solar refrigerators in Senegal and solar panels in Tunisia, logistical issues involved maintenance of installed devices.

From a program implementation perspective, convincing users to adopt a new intervention is key to success. In this assessment, users praised the interventions for efficiency, data quality, and immunization quality improvements. The respondents also shared key areas to consider in the design of new interventions and training, for example, supporting users to learn interventions that may require more training and that may be perceived as more difficult to use. Perhaps the most valuable lesson learned was that in order to convince users of the usefulness and effectiveness of an intervention, it should be demonstrated in an area representative of the country context and given sufficient run time to be evaluated.

From a project Optimize perspective, feedback from Senegal, Tunisia, and Vietnam made clear that equipment and support are intertwined and that a positive relationship between equipment and support creates greater potential for feasibility. As countries now begin to adopt some of the interventions that project Optimize demonstrated, the opportunity shared by respondents is for countries to find a way to sustain support and provisions for equipment.

Limitations

This study used qualitative methodology with a purposive sample of respondents to elicit rich information from those who were knowledgeable about the interventions implemented by project Optimize. By choosing our sample this way, we may have limited the opinions of those who observed the interventions without being directly involved or benefiting. Study implementation challenges included primary analysts who were not proficient in the language of data collection in any of the countries. These analysts relied on translations, which, although carefully checked, may have led to misunderstandings of the meaning of

respondents' statements. In addition, in-country data collection challenges unique to each setting limited the sample of respondents to a smaller number than anticipated.

Conclusion

The respondents to this assessment provided important lessons about the acceptability and feasibility of interventions demonstrated by project Optimize in four countries. These lessons can be used to inform the preparation and implementation of future interventions for improving supply chains. Notably, user buy-in matters more to implementers than increases in workload. Respondents were concerned about the basic start-up requirements—such as equipment, staff, and necessary skills—needed for an intervention to succeed. With adequate funding, as was the case with project Optimize, these essentials can be provided. The implementers of new supply chain interventions such as the ones addressed here, can learn from the issues raised by respondents in this assessment, in order to apply these lessons to ensure success in implementation. In addition, overall, IT-based interventions require training, and equipment-based interventions require maintenance support. Finally, interventions need to be implemented for an adequate time period for users to determine their acceptability and feasibility.