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Logistics Brief

Putting Cost into the Equation: Case Examples of Economic Evaluation of Public Health Supply Chains in Three African Countries

The examples in this brief describe how the USAID | DELIVER PROJECT applied principles of economic evaluation to contribute significantly to supply chain design and decisionmaking in three African countries. In all three countries, studies compared the costs and the consequences of alternative approaches to public health supply chain management.

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Introduction and Background

Decisionmakers in developing countries often face critical choices about how to strengthen commodity supply chains to yield more accessible, affordable, and higher quality health products and services. Although economic evaluations—studies that compare costs and consequences of alternative supply chain investments—can inform these decisions, they are underutilized. The USAID | DELIVER PROJECT (the project) developed a framework to facilitate the application of principles of economic evaluation to public health supply chains. This brief describes how the project used this framework to inform supply chain design and decision making in Nigeria, Tanzania, and Zimbabwe.

An Approach to Applying Economic Evaluation to Supply Chains

Economic evaluation compares both the costs and the consequences of alternative courses of action to guide decisions about efficient use of scarce resources. Economic evaluation includes two broad categories of analysis: cost-effectiveness and cost-benefit analyses, sometimes referred to as "return on investment" analysis.

As applied to public health supply chains, a cost-effectiveness analysis relates the costs of different approaches to supply chain management to a common measure of supply chain effectiveness, such as stock status, order fill rate, or a composite performance measure. The analysis might consider broader measures that relate supply chain performance to service use, such as couple-years of protection, numbers of children vaccinated, or clients treated or

tested. Or, it might suggest a relationship between use of services and one or more health outcomes, such as births averted, deaths averted, or disability-adjusted life years averted. To make informed choices, decisionmakers need to know the costs that each function or intervention will require, as well as the consequences (effectiveness) that result.

Similar to a cost-effectiveness analysis, a cost-benefit analysis measures costs and consequences of alternative supply chain approaches, but considers the consequences (benefits) solely in monetary terms. These benefits include savings to the supply chain that result from better system performance, such as lower drug costs when inventory is reduced, fewer expired or spoiled products, or lower transportation or labor costs. Benefits might also include savings from better health outcomes, such as health costs averted when clients receive prompt treatment for illness, thus avoiding more severe sickness or death. However, long-term savings (benefits) must be significantly higher than the short-term investment and operating costs to justify the investment in purely financial terms. This can be simplified into a benefit-cost ratio such as 2.5:1, where a benefit is 2.5 times higher than the cost over a specific period.

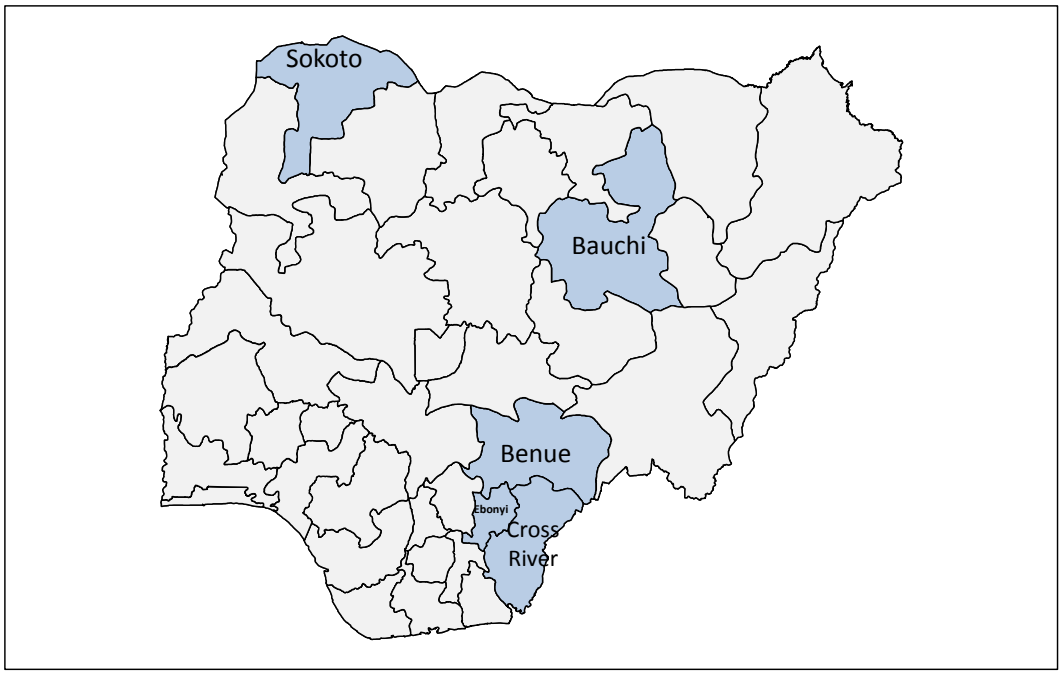
Case Examples from Three African Countries

The following examples describe how the USAID | DELIVER PROJECT recently used techniques of economic evaluation in three African countries.

Nigeria

Nigeria's public health supply chain handles several hundred million dollars of commodities every year. Over the years, Nigeria has tried a variety of systems to deliver contraceptives, anti-malarial drugs, and other public health commodities. A USAID | DELIVER PROJECT study in Nigeria in 2013-14 used cost-effective analysis to compare distribution models in five of Nigeria's 36 states (Figure 1).

Figure 1. States in Nigeria Where Last-Mile Distribution Systems Were Compared



This study compared four different systems:

1. For the review and resupply system (R&R), health facility staff attend meetings in clusters (usually by local government authority [LGA]) to exchange information on consumption patterns and inventory needs and to receive inventory. Public transportation is the main mode of transport for facility staff.
2. The direct delivery and information capture (DDIC) system, known as the "moving warehouse," sends a delivery truck and logistic personnel to each service delivery point to physically count the commodities on hand and then provide the amount that the facility needs.
3. The review and direct delivery (R&DD) system, like the R&R system, sends facility staff to cluster meetings to relay information on consumption patterns and inventory needs. LGA and state ministry of health officials also facilitate these meetings. Inventory amounts are based on information collected during the review meetings, but unlike the R&R system, inventory is delivered to facilities after the meeting.
1. In the information capture and direct delivery (IC&DD) system, LGA personnel visit facilities to capture information on consumption patterns and inventory needs. These personnel attend their own review meetings to submit the information captured. As with R&DD, logistics personnel deliver needed inventory on occasions separate from review meetings and LGA visits to facilities, and need is based on information submitted at the LGA review meetings.

Each system incorporates combinations of key dimensions of supply chain design, including information capture, delivery of products, and timing of information capture and delivery.

The USAID | DELIVER PROJECT study aimed to elucidate the effects that these design choices have on the supply chain performance and associated costs. The study used data collected from the five states to analyze supply chain performance, throughput, cost, and cost-effectiveness for eight combinations of the four different approaches (Table 1):

- With respect to inventory performance, all systems were similarly functional. Stockout rates were in the single digits and inventory availability, given supply, was good.
- Levels of throughput (commodity flow) in terms of value ($US) varied widely, from $173,000 in the Bauchi R&R to $11,750,000 in the Benue IC&DD system. This variation reflected differences in the scope and design of each approach.
- Volume delivered per facility varied widely, from .04 cubic meters in the Bauchi R&R system to 2.05 cubic meters in the Benue IC&DD system.
- Total annual cost for each system ranged from just over $200,000 to $1.6 million, again reflecting differences in the scope and design of each system.
- One measure of efficiency, cost per value of commodity, varied over a wide range, from $0.14 (Bauchi DDIC and Benue IC&DD) to $1.73 (Bauchi R&R).
- Another measure of efficiency, cost per cubic meter, ranged from $20,859 for the Bauchi R&R to $1,858 for the Bauchi DDIC system.

Table 1. Comparison of Cost and Throughput for Nigeria Last-Mile Distribution Systems, by System and State

Parameter	System and State							
	R&R		R&DD		DDIC			IC&DD
	Bauchi	Sokoto	Cross River	Benue	Cross River	Ebonyi	Bauchi	Benue
Total value of commodities delivered ('000 USD)	173	400	207	498	1,959	1,372	4,089	11,750
Total annual commodity volume delivered (cbm)	14	29	28	58	122	129	305	696
Number of facilities served per cycle (max)	394	491	76	92	265	205	165	339
Annual commodity volume delivered per facility (cbm)	0.04	0.06	0.37	0.63	0.46	0.63	1.85	2.05
Total annual supply chain cost	$299,535	$411,887	$216,343	$235,913	$947,983	$450,564	$566,095	$1,606,737
Total costs per cbm of commodity delivered	$20,859	$14,262	$ 7,710	$4,095	$7,757	$3,496	$1,858	$2,308
Total costs per $ of commodity delivered	$1.73	$1.03	$1.05	$0.47	$0.48	$0.33	$0.14	$0.14

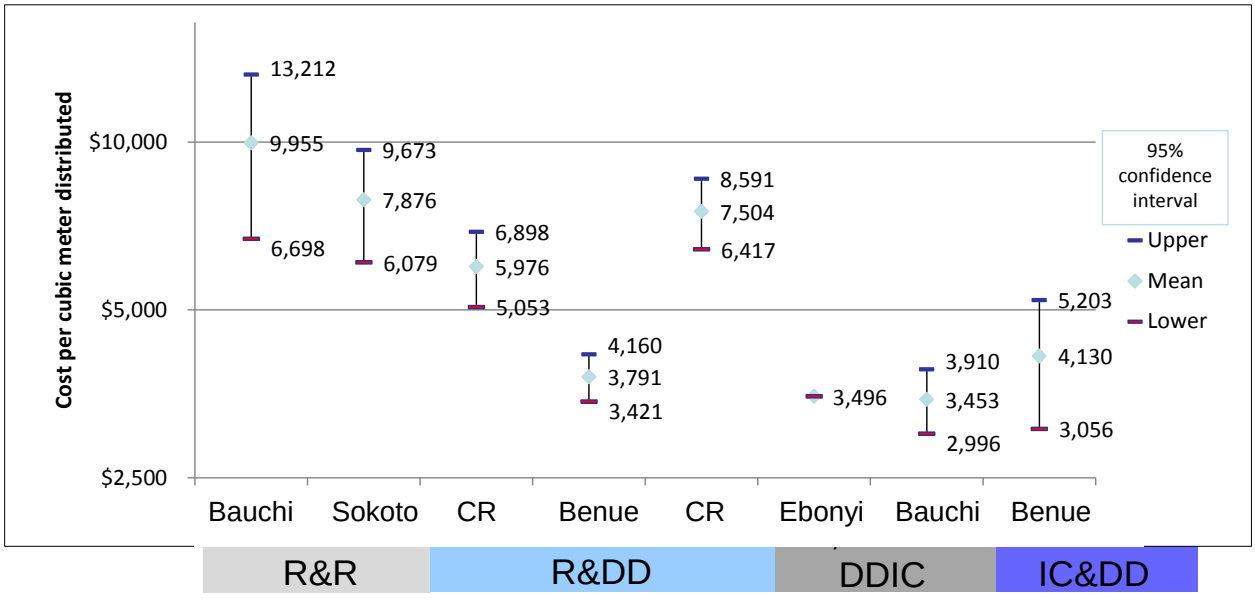
Because each system operated at very different levels of throughput, for a more accurate and helpful comparison across systems, the study modeled what costs would be if all systems operated at the scale of the DDIC in Ebonyi State (205 facilities receiving on average 0.63 cubic meters of product annually). As Table 2 shows, the modeling produced very different results. The DDIC systems in Ebonyi and Bauchi states now showed the lowest cost per cubic meter, and differences between the different systems shrank.

Table 2. Cost per Cubic Meter and per $ of Commodity Delivered of Nigeria Last-Mile Distribution Systems Operating at the Scale of the DDIC in Ebonyi State, by System and State

Parameter	System and State							
	R&R		R&DD		DDIC			IC&DD
	Bauchi	Sokoto	Cross River	Benue	Cross River	Ebonyi	Bauchi	Benue
Total costs per cbm of commodity delivered	$9,955	$7,876	$5,976	$7,391	$7,504	$3,496	$3,453	$4,130
Total costs per $ of commodity delivered	$0.83	$0.57	$0.81	$0.86	$0.47	$0.33	$0.26	$0.24

To account for uncertainty in the estimates, the study included a Monte Carlo simulation[1] to generate a 95 percent confidence interval on the mean of the cost-effectiveness estimates. As Figure 2 shows, the DDIC in Ebonyi and Bauchi states had the lowest mean cost per cubic meter, $3,496 and $3453, respectively. However, the lower bound of the cost-effectiveness estimates for the R&DD and IC&DD in Benue State were within the 95 percent confidence interval of the DDIC estimates.

Figure2. Comparison of Cost-Effectiveness of Four Last-Mile Distribution Models in Nigeria



The project presented the findings to stakeholders in different fora, including a day-long dissemination meeting held in August 2014. An official from the United Nations Population Fund referred to the DDIC system as "the future of integrated last-mile distribution," and recommended it as "a cost-effective model for states to consider." Ministry of Health (MOH) officials in at least two other Nigerian states have expressed interest in the DDIC, which was the model with the lowest cost per cubic meter handled. In one

[1] In the Monte Carlo approach, the values of key parameters were allowed to vary randomly within the limits of a defined distribution. For each parameter, the simulation selected 10,000 times from these distributions. Based on the repeated sampling, the study then derived a mean standard deviation, and 95 percent confidence interval for cost and cost-effectiveness measures.

state, the director of public health expressed interest in implementing the DDIC. In another state, MOH officials requested support from the project to review DDIC operating procedures and to use the software developed for inventory information capture.

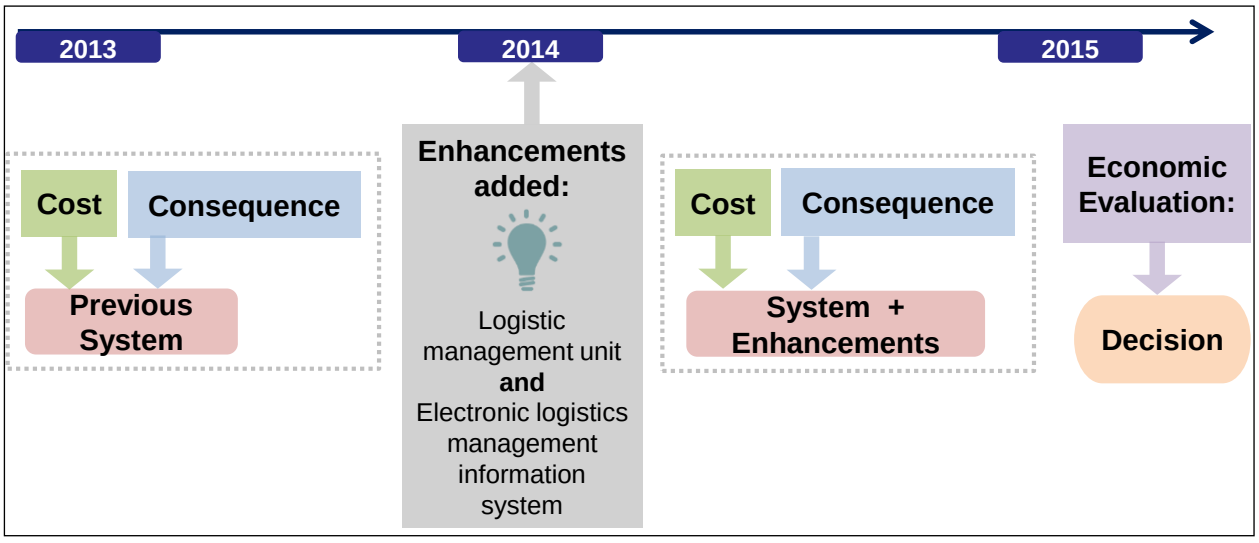
Tanzania

In Tanzania, the government-operated public health supply chain manages about $200 million in commodities for clients who use the country's more than 5,000 health facilities every year. As in many other developing countries, the management of the public health supply chain in Tanzania evolved along product lines associated with specific programs. The result was a fragmented, uncoordinated management system with separate structures for HIV, TB, vaccines, essential drugs, and contraceptives. Information management evolved separately along product groupings. These separate and largely paper-based logistics management information systems (LMIS) did not generate accurate, quality, or timely data. This lack of data visibility contributed to poor system performance that raised costs, hampered stock availability, and made it harder to serve the millions of Tanzanians who rely on public health facilities.

In late 2013 and early 2014, Tanzania embarked on a major enhancement of the management of its public health supply chains. The Ministry of Health and Social Welfare (MOHSW) set up a logistics management unit (LMU) to coordinate, monitor, and support all logistics activities for the various commodity groups. LMU staff identify supply chain bottle-necks and develop solutions and implement interventions to mitigate them. The MOHSW also facilitated the roll-out of a nationwide electronic logistics management information system (eLMIS) to consolidate existing electronic and paper-based systems—a common challenge for many developing nations. Designers expected the eLMIS to improve data visibility by providing accurate, quality, and timely data. The LMU is responsible for active management of eLMIS data.

Proponents of the LMU and eLMIS believed that their introduction would lead to improvements in data and management practices that would produce better supply chain outcomes as measured by indicators such as stockout rate and duration, levels of appropriate inventory, forecast accuracy, and expiry. Recognizing that the upgrades would carry a significant cost, stakeholders were interested in a study comparing the cost and effectiveness of the system before and after the introduction of the LMU and eLMIS (Figure 3).

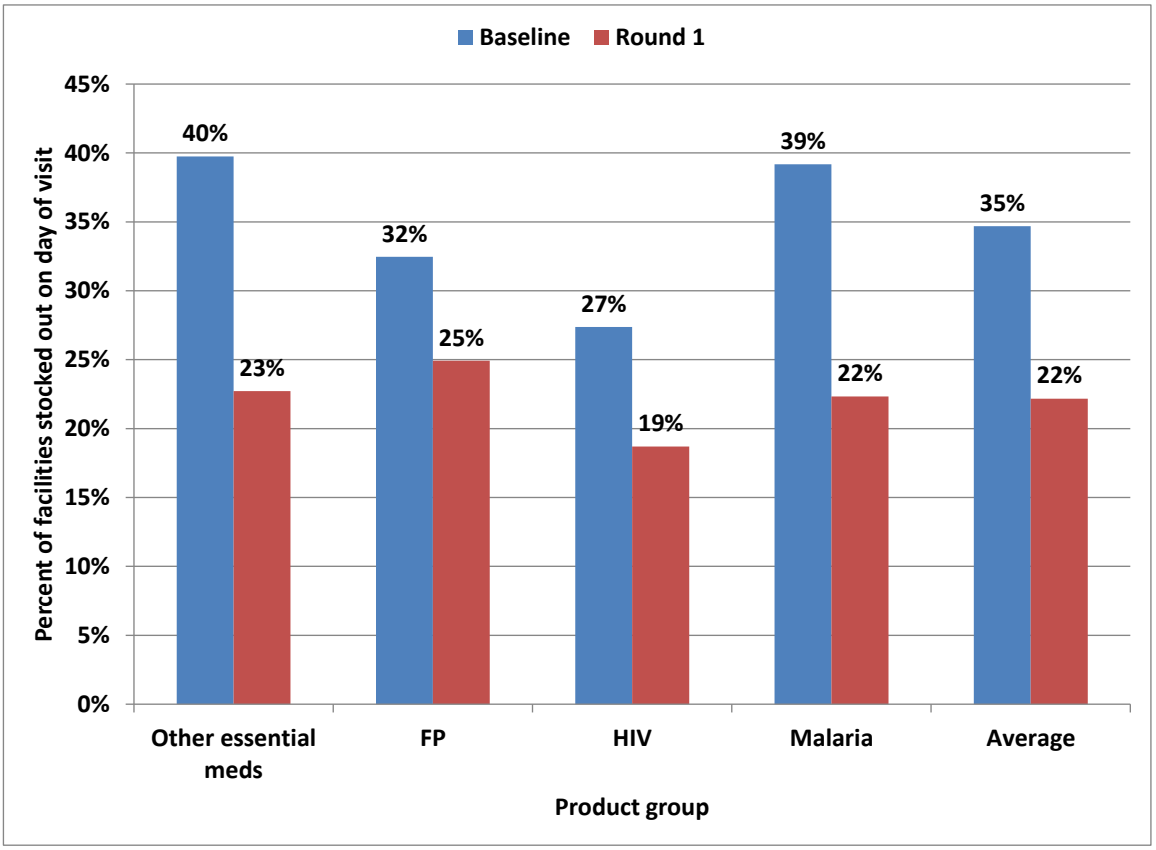
Figure3. Evaluation to Measure the Impact of Management Enhancements in Tanzania



Using a non-experimental, pre-post design, the USAID | DELIVER PROJECT study found that one year after introduction the LMU and eLMIS appeared to be associated with the following positive supply chain performance outcomes:

- *Stockout rates fell.* There was a statistically significant decrease in stockout rates for all four product groups, and rates fell by 13 percentage points on average, from 35 to 22 percent (Figure 3).

Figure 3. Comparison of Stockout Rates, Baseline versus One Year after Tanzania Supply Chain Management Enhancements



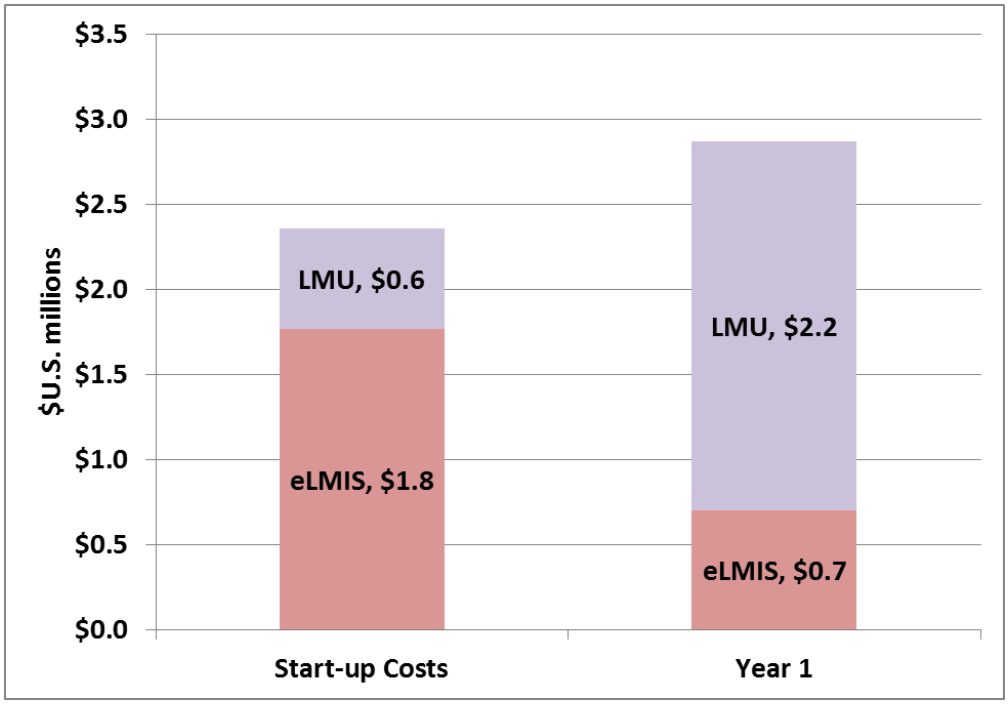
- *Stockout duration fell.* The percentage of facilities reporting stockouts of greater than seven days fell significantly, from 27 to 18 percent on average, for all four product groups between the baseline and Round 1.
- *Forecast accuracy and expiry improved.* The upgrades were associated with a statistically significant improvement in forecast accuracy and a reduction in expiry rates.
- *Total supply chain cost increased, as did throughput value.* The combined systems at baseline handled an estimated annual commodity throughput valued at TSh 342 billion ($US 218 million) increasing by 23 percent to TSh 421 billion ($US 268 million) during Round 1 (Table 3). The annual national cost of public health supply chain operations was TSh 89.2 billion ($US 57 million) at baseline, rising by 10 percent to TSh 98.5 billion ($US 63 million) in Round 1. We can attribute about $US 1.7 million of the cost increase to the cost of the upgrades themselves, with the rest likely a result of the higher throughput that the system handled.

Table 3. Comparison of Throughput, Cost, and Cost-effectiveness, Baseline versus One Year after Introduction of Management Enhancements in Tanzania

	Baseline	Round 1
Throughput measures		
Value of throughput (TSh)	TSh 342.9 billion	TSh 421.0 billion
Supply chain cost measures		
Supply chain cost (TSh)	TSh 89.2 billion	98.5 billion
Supply chain performance measures		
% point product availability	68	78
Cost-effectiveness measures (unadjusted)		
SC cost as a % of value of throughput	26	23
Cost-effectiveness measures (performance-adjusted)		
SC cost as a % of performance-adjusted throughput value	38	30

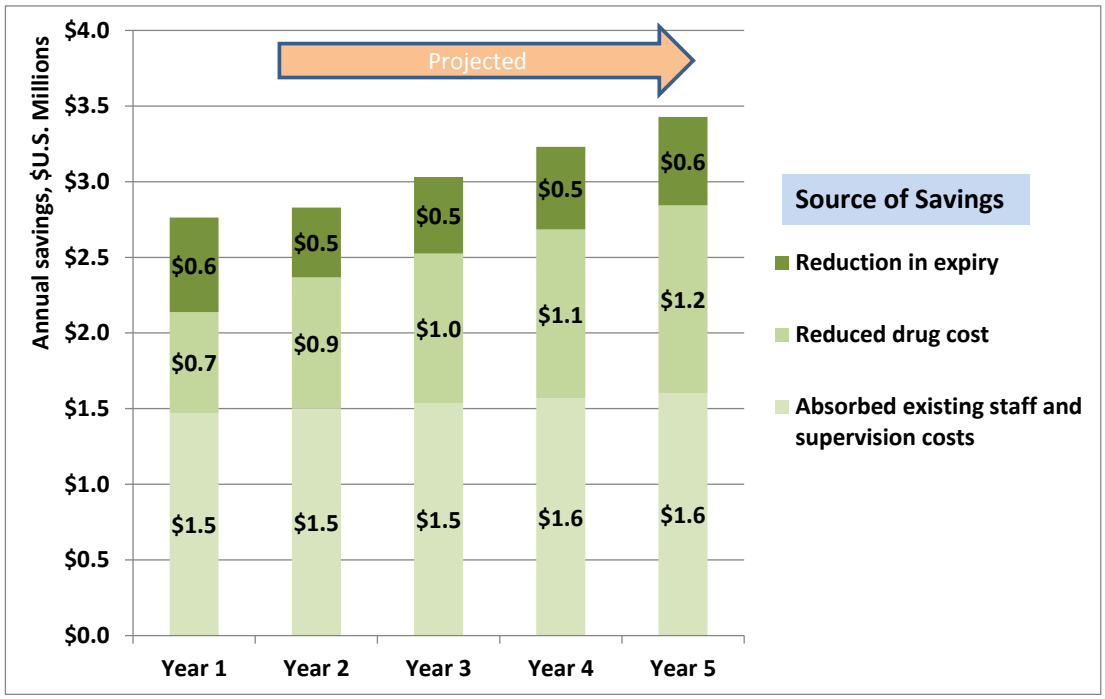
- *The system operated more efficiently post-enhancements.* One measure of efficiency is supply chain cost as a percentage of throughput value. This fell from 26 percent at baseline to 23 percent at Round 1, meaning the system was operating more efficiently. The study calculated a related measure of efficiency that adjusts for the level of performance of the two systems: supply chain cost as a percentage of performance-adjusted throughput. Because the system at Round 1 was performing better than at baseline, the efficiency gains using this measure were even greater, with cost as a percentage of performance-adjusted throughput falling from 38 percent at baseline to 30 percent at Round 1 (Table 3). Results of a sensitivity analysis using Monte Carlo simulation showed that even when taking into account some of the uncertainty underlying our cost-effectiveness calculations, the upgraded system at Round 1 retained its efficiency advantage over the baseline systems.
- *The enhancements generated significant financial savings.* Designers of the eLMIS and LMU thought that although costly, these investments would produce significant savings as a result of improved processes. The study included a cost-benefit analysis to examine the relationship between investment cost and system savings. Upfront costs were $2.5 million, of which the eLMIS constituted about $1.8 million. Year 1 costs of operations totaled $2.9 million, with the LMU accounting for the bulk of those costs (Figure 4).

Figure 4. Up-front and Year 1 Investment Costs for the LMU and eLMIS in Tanzania



The study estimated about $2.8 million savings in Year 1 as a result of the upgrades, with about $700,000 from lower drug costs, $600,000 from lower expiry rates, and another $1,500,000 from shifting of supply chain staff away from other organizational units and into the LMU (Figure 5). Although the measured savings alone did not outweigh the investment costs of the upgrades, they defrayed a large portion of those costs. The upgrades likely generated additional unmeasured savings from, for example, fewer emergency purchases and lower inventory holding costs. The savings were a welcome addition to the supply chain performance improvements.

Figure5. Estimated Cost-savings from the Introduction of the LMU and eLMIS in Tanzania

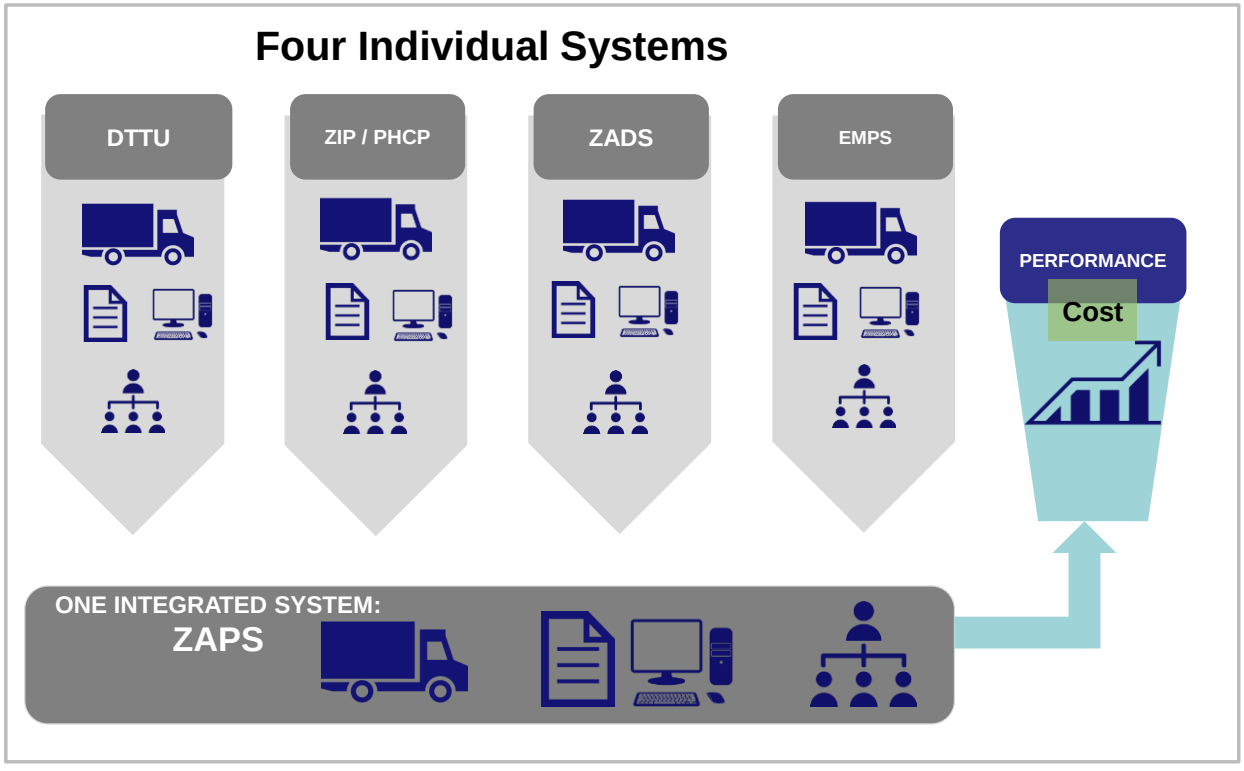


By incorporating the cost dimension into the analysis, we learned that the upgrades—while not cheap—contributed to greater system efficiency and significant savings. Additional measurement rounds at two years and post-implementation would provide greater insight into the impact of these interventions. Stakeholders in Tanzania had already decided to implement the LMU and the electronic LMIS before embarking on the evaluation, so the cost-effectiveness findings were not critical at the initial decision stage. Nonetheless, local stakeholders are using these Year 1 results as they decide on future funding of the system. Moreover, the broader international community working on supply chain strengthening can use these findings in their decisionmaking. Many other countries are considering a shift to web-based, electronic LMIS and LMU like the ones in Tanzania and will benefit from results of the Tanzania analysis.

Zimbabwe

The public health supply chain in Zimbabwe manages about $100 million annually in commodities. A USAID | DELIVER PROJECT study in 2014–2015 looked at the impact of a pilot effort in Manicaland Province (Figure 6). The pilot, called the Zimbabwe Assisted Pull System (ZAPS), consolidated management of four separate health commodity distribution systems: the Delivery Team Topping Up (DTTU); Zimbabwe Informed Push/Primary Health Care Package (ZIP/PHCP); Zimbabwe ARV Distribution System (ZADS); and the Essential Medicines Pull System (EMPS). The USAID | DELIVER PROJECT study compared the performance, costs, and efficiency of the ZAPS to that of the existing distribution systems operating as individual entities.

Figure6. Designers Believed That ZAPS Would Reduce Redundancy and Cost While Maintaining Performance Compared to Previous Systems in Zimbabwe

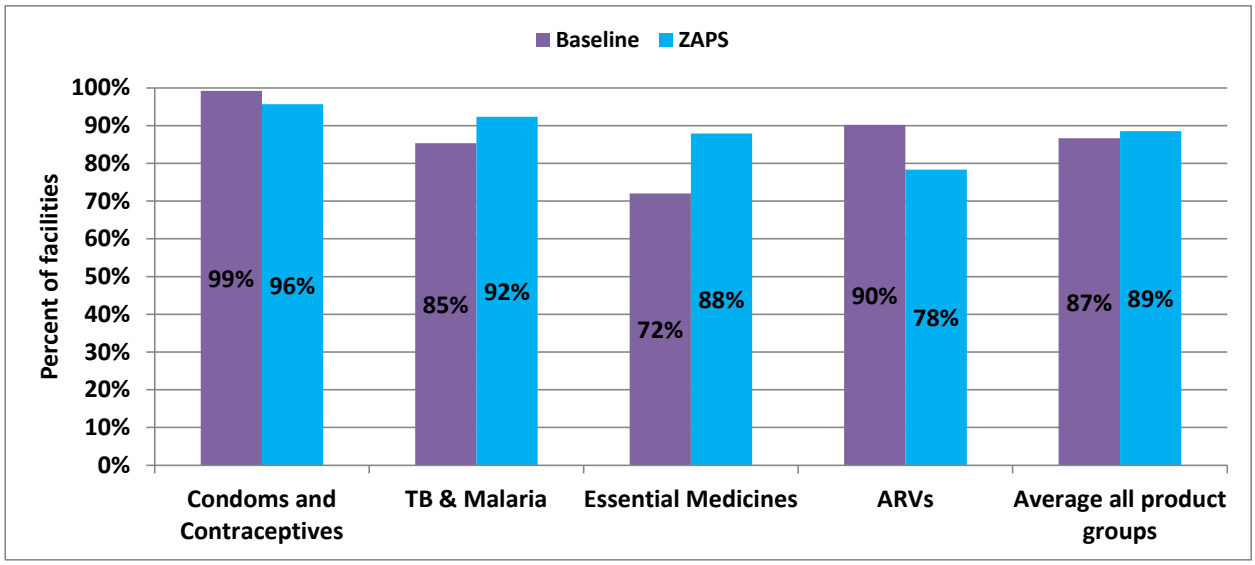


The USAID | DELIVER PROJECT study combined non-equivalent control and time series approaches for supply chain performance indicators routinely collected through the four existing information systems. The study compared the period before the integrated ZAPS pilot with the year of the pilot, April 2014–March 2015, and found the following:

- *In general, ZAPS maintained the same levels of stock availability as previous systems.* Stock availability rates for tracer products during ZAPS averaged 89 percent compared to 87 percent at baseline (Figure 7).
- *The comparison of stockout duration showed mixed results.* Some product groups showed higher average number of days stocked out and some showed lower.
- *The percentage of facilities stocked to plan was essentially unchanged.* The stock status or "stocked according to plan," which measures the percentage of facilities that manage products within the correct range of months of inventory, was similar during ZAPS versus the baseline.
- *Expiry rates fell under the ZAPS.* The combined DTTU, ZIP, and ZADS baseline expiry rate was 0.74 percent. During ZAPS, the expiry rate fell to 0.42 percent.

For the most part, trends in Manicaland mirrored the performance of the supply chain in the rest of the country.

Figure7. Stock Availability by Product Group, Baseline versus ZAPS



- *ZAPS was less costly than the previous systems.* The total annual cost to operate the ZAPS was about $230,000 less than what it cost to operate the previous systems: $1.51 versus $1.73 million (Table 4). Most of the ZAPS savings occurred at the health-facility level.
  - Health workers spent less time managing products under the ZAPS than under the four separate systems at baseline.
  - Health facility workers under ZAPS almost completely eliminated the time and out-of-pocket transport expenses associated with picking up commodities under regular ordering.
  - Central, provincial, and district costs remained roughly the same under ZAPS compared to the baseline.
  - Although operating at a lower total cost, ZAPS handled a higher volume of commodities compared to the baseline systems: 1,955 cubic meters (m^3) versus 1,808 m^3. Similarly, the value of commodities that the ZAPS handled was higher compared to the baseline: $12.3 million compared to $10.4 million.

Table 4. Comparison of Cost, Throughput, and Cost-effectiveness, ZAPS versus Baseline, Manicaland Province, Zimbabwe

	Baseline	ZAPS
Supply chain cost measures		
Supply chain cost	$1,734,961	$1,505,064
Throughput measures		
Value of throughput ($)	$10,377,976	$12,346,469
Volume of throughput (m3)	1,808	1,955
Supply chain performance measures		
% point product availability	87	89
Cost-effectiveness measures (unadjusted)		
SC cost as a % of $ value of throughput	17	12
SC cost per cubic meter of throughput	$960	$770
Cost-effectiveness measures (performance-adjusted)		
SC cost as a % of performance-adjusted throughput value	19	14
SC cost per performance-adjusted throughput volume	$1,107	$869

- *The ZAPS was more efficient*. Because the ZAPS cost less and handled greater volumes and values of commodities at the same level of performance, it was a more cost-effective system compared to the baseline systems (Table 4).
  - Cost per cubic meter of commodity handled was $960 at baseline versus $770 during ZAPS.
  - Efficiency as measured by supply chain cost as a percentage of product value was 17 percent at baseline versus 12 percent during ZAPS.
  - Using a performance-adjusted measure of throughput, cost per cubic meter was $1,107 at baseline versus $869 under the ZAPS. Cost per throughput value was 19 percent at baseline versus 14 percent under the ZAPS.

Results of a sensitivity analysis showed that, even when taking into account some of the uncertainty underlying the cost-effectiveness calculations, the ZAPS retained an efficiency advantage over the baseline systems.

Following the dissemination of the evaluation results, government and donor stakeholders agreed on a nationwide scale-up of the ZAPS, with the cost-effectiveness results a key consideration.

Conclusion and Way Forward

The examples in this brief describe how the USAID | DELIVER PROJECT applied principles of economic evaluation to contribute significantly to supply chain design and decisionmaking in three African countries. In all three countries, studies compared the costs and the consequences of alternative approaches to public health supply chain management. Policymakers incorporated the results of these economic evaluations into decisions about supply chain design. For those considering the use of economic evaluation to inform supply chain decisions, we recommend the following:

Make a case for and build economic evaluation into planning early on. The results from these studies add to the growing international knowledge and evidence for public health supply chain costing and economic evaluation. However, the complexity and cost of such evaluations can be a barrier to its inclusion. Economic evaluation is most appropriate when evaluating new approaches, or when considering design changes that likely will have large cost implications. The analyst must make a strong case for including an economic component where appropriate. These three studies show that when economic evaluation is included early in planning, it facilitates considerations for alternate public health supply chain design.

Be ready to educate stakeholders about economic evaluation. Decisionmakers in the supply chain world are not usually familiar with economic evaluation principles. Analysts should educate and work closely with decisionmakers so that they can use these approaches in their work. Analysts should communicate results with detailed reports, along with clear and simple summaries. Dissemination workshops should include key policymakers and supply chain technical staff.

Insert economic evaluation into the decision processes of international development partners. The main audiences for the examples described in this brief are the stakeholders and decisionmakers in each country. Yet, bringing the same concepts and frameworks to the international arena is also important. International development partners, in particular, are increasingly concerned with "return on investment" of their funds. Economic evaluation can also help answer their questions about which supply chain design promise the greatest return, and how supply chain investments compare to other health systems activities.

Conduct further economic evaluations of public health supply chains. The international community is only beginning to build a strong evidence base for measuring the impact of various approaches to supply chain performance and cost, and more studies that link performance with cost are needed. Although the studies described in this brief did not explicitly set out to examine links between supply chain improvement and health outcomes, it is important to expand the analytical boundaries of such studies to consider how cost and performance might link to use of health services and health outcomes. This will help determine appropriate ways to compare supply chain investments with investments in the other pillars of health system strengthening.

Prudent application of these lessons will improve the quality of decisions and ultimately lead to better, more efficient public health supply chains.

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James E. Rosen wrote this brief, drawing on the detailed reports for each of the country case examples. For more information on the USAID|DELIVER PROJECT's work on economic evaluation and supply chain costing, go to: http://deliver.jsi.com/dhome/whatwedo/commsecurity/csfinancing/cssupplychaincosting.

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