ETHIOPIA

IMPROVING HEALTH SYSTEMS

PUBLIC SECTOR HEALTHCARE SUPPLY CHAIN
STRATEGIC NETWORK ANALYSIS AND DESIGN

Driving Service Improvements through Supply Chain Excellence

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THE WORLD BANK
About the Authors

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**Background**

A World Bank mission visited Ethiopia May 11 to 22, 2009 to continue work on the Health Sector Dialogue and Health System Strengthening (HSS) Support. Ryan Purcell, Senior Consultant at LLamasoft, joined the mission to conduct a strategic supply chain analysis of the public sector healthcare systems on behalf of the World Bank, and at the request of the deputy director of Pharmaceuticals Fund and Supply Agency (PFSA), Ato Wondwossen. The results of the analysis are expected to inform the dialogue on health systems strengthening for supply chain management.

The main purpose of any supply chain management system is to get the right product, in the right quantity, to the right place, at the right time. There are usually two parts of supply chain management: supply chain planning – deciding what to do, and supply chain execution – communicating and executing the plan, as well as identifying and handling exceptions. Approaches to supply chain planning can be operational, planning the day-to-day operations; tactical, planning week-to-week or month-to-month; or strategic, which is conducted once a year or so and is focused on how the network is structured. Since most of the work for the Ethiopia public sector supply chain systems has been of an operational and tactical nature, this study was planned to focus on the strategic analysis.

The tools and techniques used for the strategic analysis include:

- Network optimization – what is the most effective network, subject to rules of “constraint”.
- Inventory optimization – profile the demand and supply and determine the optimum safety stock required for the system.
- Supply chain simulation – evaluate how the network will perform in the real world, including impact on service rates and analysis of the real-time inventory.
- Comparative benchmarking
- GIS mapping of the network – including transportation routes, customers, warehouses etc.

**Objectives**

The objectives of the mission were to: (i) analyze the Pharmaceutical Fund Supply Agency’s (PFSA) Business Process Reengineering (BPR) plan for the future state pharmaceutical supply chain; (ii) determine an optimal expansion strategy for new capital investments; (iii) determine inventory requirements for various service levels and various future network structures; and (iv) give recommendations for the development of PFSA’s planned Management Information System (MIS).
Methodology

Based on the understanding of the country’s situation and the future PFSA plans for the supply chain operations, the consultants focused the investigation in the following areas:

a) Understanding the current state of the supply chain  
b) Understanding PFSA’s plans for the future state supply chain  
c) Supply chain data collection, analysis and data sources  
d) Strategic network structural analysis  
e) Safety stock inventory analysis  
f) Financial benchmarking for pharmaceutical distribution  
g) MIS system recommendations

Current State Supply Chain

According to the national census completed in 2007, Ethiopia has approximately 74 million inhabitants, 85% of which are under the age of 35. With a population that has more than double in the last 20 years, 80% of it being rural, and many parts of the country inaccessible via paved roads, Ethiopia is faced with a difficult logistics process.

The country is split into eleven ethnically-based Regions, which are divided into a total of 68 Zones. The Zones are further split into over 700 Woredas. The health network is complex, with the policy guidance provided by the federal government and the operations managed by Regions, Zones and Woredas, making communication between the various ministries and offices crucial.

An organization called Pharmid operated in the country for over fifty years, until 2007. Pharmid was only responsible for non-program drugs, and co-existed with the private sector in supplying some of the pharmaceuticals needed throughout the country. In mid-2007, the Pharmaceutical Fund Supply Agency (PFSA) was created with a larger mandate: to supply the entire country with both Program and Essential drugs, as well as serve as the distribution entity for vaccines, other health facility supplies, and laboratory equipment. The end goal is for PFSA to be the sole distributor of health-related materials to all public facilities within the country.

PFSA’s current supply chain starts with the import of most drugs via the port of Djibouti. These products are then trucked into Addis Ababa, before being distributed to the various distribution centers (Hubs) and on to the hospitals, clinics, and health centers (together termed Health Facilities).

Today, there are approximately 750 Health Centers operating in Ethiopia, with a planned expansion to 3,500 (1,500 are planned to be operational by July 2010). There are also 6,000
Health Posts operating, with a planned expansion to 15,000. The ultimate goal of this expansion is to have a Health Facility within a two hour walk of every Ethiopian citizen.

Under Pharmid, the system was fully a “push” supply chain, as donated and purchased drugs were sent to the Hubs whenever they were available, and the Health Facilities took them when they could get them. Today, under PFSA, the system is still largely “push” as demand profiles (a requirement for a “pull” model) are unknown. The exception being HIV drugs and supplies managed by the Partnership for Supply Chain Management (SCMS) program on behalf of PEPFAR, for which a “pull” system has been implemented in the past six months. In addition, the USAID | DELIVER project has implemented some basic inventory management tools at some hospitals and clinics. While there is currently no MIS system in place in Ethiopia, PFSA plans to implement one in the future.

When it was established in 2007, PFSA had its mandate, mission, and objectives outlined for clarity. These are listed below:

Mandate:

- Sole provider of forecasting, procurement, storage, inventory management and distribution of pharmaceuticals to the public health sector in Ethiopia.

PFSA Mission:

- To ensure availability and affordability of quality pharmaceuticals to all public health facilities by using a revolving drug fund (RDF)

PFSA Objectives:

1. Improve availability of program and non program pharmaceuticals nationwide from 55% to 100%
2. Reduce wastage rate from 8% to less than 2%
3. Reduce cycle time (forecasting, procurement, storage and delivery to public health facilities) from 491 days to 165 days on average
4. Establish a quality complaint system and ensure rational use of pharmaceuticals
5. Improve customer satisfaction in terms of availability and quality of service at public health facilities from 51% to 100%

**PFSA Planned Future State Supply Chain**

As outlined in the objectives section above, the future state supply chain will be expected to procure, warehouse, and distribute both program and essential drugs to all people throughout
Ethiopia. To accomplish this, PFSA executed a Business Process Reengineering (BPR) study during 2007 and 2008. The resulting recommendations call for a total of 23 Hubs (in 17 separate locations), 9 will be “Primary” and 8 will be “Secondary” Hubs. This structure can be seen in Figure 1: PFSA Future State Supply Chain Network, March 2009. The Supply Chain will be a “pull” system, with the local Health Centers serving as the demand point for all Health Posts in a specific area. The future state supply chain will also have a fully functioning Logistics Management Information System (LMIS), which will aid PFSA in its core functions of demand forecasting, inventory management, procurement, fulfillment, and transportation planning. Finally, PFSA will implement a revolving drug fund (RDF) to aid in the purchase of the requisite quantities of pharmaceuticals.

**Figure 1: PFSA Future State Supply Chain Network, March 2009**

![Supply Chain Network Map](image)

**Supply Chain Data**

**Data Sources**

The mission included identifying the data sources, collecting the data that could be utilized during the analysis portion of the project. This data collection phase proved to be quite difficult, as very limited information was electronically available. The team did have access to benchmark data from past project work in Kenya and Lesotho. This data was leveraged during the inventory and financial analysis portions of the project. Below is a brief list of the data collected by the team. All of this information is available to those interested from PFSA.

Collected information

a. High-level Pharmid Financials from 2005-2007 (from PFSA)
b. Woreda level populations from 2007 Census data (Central Statistical Agency)
c. PFSA Future Warehouse location list (PFSA)
d. SCMS Program drug transactions Nov/Dec ’08 (SCMS)
e. 2007 SCMS Hub Analysis (SCMS)

Calculated/Processed information

f. GIS data for Woredas and Warehouses (LLamasoft)
g. Population-based GIS demand Profile (LLamasoft)

Similar project work has been done by the World Bank and LLamasoft in Kenya, Lesotho, and The Dominican Republic. In all other cases, transactional-level data on orders, receipts, and shipments was available, thus allowing for more detailed/accurate analyses in those locations. Hence, the importance of electronic LMIS is critical for future supply chain analysis project work.

**Results**

**Strategic Network Structural Analysis**

It became immediately apparent to the team that no historical demand data was available. As a result, it was decided that population would serve as a proxy for demand, and a distance-based strategic service analysis would be performed. To do this, census data was collected at the Woreda level, and then geo-coded (with latitude and longitude values) to allow for a spatial view of population densities. This view can be seen in Figure 2. In this figure, the size of the circle represents the relative size of the population for a particular Woreda.
Next, the team collected the list of current and future state Hub locations and geo-coded them as well. This allowed service, estimated costs, and Hub throughput to be measured for various network Hub configurations. The first configuration tested was a “Greenfield” analysis with one single Hub. This is done to determine the optimal demand-weighted location for a central distribution point. The results of this analysis can be seen in Figure 3 below.
Figure 3: Greenfield Analysis with 1 Hub

Single Best Location for Central DC (near Addis Ababa)
The subsequent portion of the network optimization analysis consisted of comparing the current state supply chain (Figure 4: Baseline Model (Current State)) to networks with 11 and 17 DCs.

Figure 4: Baseline Model (Current State)

Figure 5: Baseline +5 DCs
After completing all the scenarios, the team performed a service analysis based on the distance between the stocking point (Hub) and customer (Woreda). The three figures below (Fig. 7-9) show equally-scaled histograms of service distances for three scenarios: Baseline, 10 Hubs, and all 17 Hubs. It can be seen that as the number of stocking points increases, the average distance to customers decreases, although minimal gains are seen from 10 to 17 Hubs.
Figure 7: Network with 6 Stocking Points - Current Network

Figure 8: Network with 10 Stocking Points

Figure 9: Network with 17 Stocking Points
Since the total demand was unknown, service distances was utilized as an alternate measure. It was assumed that 400 Kilometers could be driven in one day. Figure 11 depicts the total person-miles (in Millions) travelled to distribute drugs from the local Hub on to the customer. This is the total miles that are travelled within Ethiopia to reach all of the customers given a certain amount of DCs. As can be seen, the more DCs there are, the fewer miles are travelled. It should be noted that again minimal service gains are seen in configurations with more than 10 Hubs.

**Figure 10: Total Person-Miles to Transport Supplies in Various Network Configurations**

![Person-Miles vs Number of DCs](image)

In a network that has only one DC approximately 20 million people are more than 400K away. As the number of DC’s increase, the distance decreases. As can be seen from the graph below, Figure 11, there is a significant decrease until your reach 10 DCs. At this point, the difference becomes minimal.
The final portion of the strategic network analysis was comprised of comparing throughputs on the various Hubs for differing configurations. As would be expected, current throughputs for the existing 6 Hubs are much higher than the future state network with 17 Hubs. More interestingly, there is a relatively large imbalance in the expected throughputs for several Hubs in both the current and future states. Further analysis should be performed to determine the optimal load balancing across all Hubs, no matter how many there are. The data from similar studies in Kenya and Lesotho was leveraged to do this analysis since very limited data was available for Ethiopia. How the team used this data is described in more detail in the Safety Stock Inventory Analysis section. With more Ethiopia specific data, a future study would yield more precise results.
Figure 12: Population Served by Each DC in the Current Network

Figure 13: Population Served by Each DC in the Future Network
Safety Stock Inventory Analysis

In the context of a supply chain, if all information was definite, known and predictable, there would never be a need to hold any inventory. The supply chain managers would know exactly how much product would be demanded when, and how long it would take to get that product from their suppliers. Thus, they would just order the product in advance and when it arrived, ship it on to the customers. In this case the lead times would affect how much in advance the product would need to be ordered, and since in this hypothetical scenario, there would be no variability, there would be no need to hold inventory at any point in the system. In reality, this is never the case. Thus, the team undertook an analysis of lead time and variability associated with both supply and demand. This information was then used to calculate inventory requirements and costs for varying levels of service.

This type of analysis required transactional data. Given the case, that this data was not available for PFSA’s supply chain, the team employed a technique called “bootstrapping.” The basic idea is to use existing data (in this case from Kenya and Lesotho) to serve as estimates for the pieces missing from the Ethiopia dataset. An outline of the required data elements, and the sources used, is given below:

Data Requirements

a. Average Daily Demand by product
   i. SCMS transactional data (2 months)
b. Standard Deviation of Daily Demand by product
   i. Benchmark Data for similar products in Kenya
c. Supply Lead Time by product
   i. Kenya and Lesotho Benchmark Data
d. Supply LT Variability by product
   i. Kenya and Lesotho Benchmark Data

Assumptions

e. Service Rate of 95%
f. Equivalent demand volumes and variability for all stocking points

The data and assumptions outlined above were then used to calculate safety stock requirements and the financial impact of “risk pooling.” The concept of “risk pooling” in the supply chain
context reflects the idea that demand variability is reduced if demand is aggregated across locations, resulting in reduced total inventory requirements (for the same level of service) and reduced number of stocking points. Variability is pooled at fewer locations, thus minimizing the need for safety stock and reducing inventory investment.

Figure 14 (below) demonstrates, for four selected products, the increased safety stock required for increasing numbers of stocking points (Hubs). Table 1 shows the inventory investment cost differences for varying numbers of stocking points. This increased cost must be balanced with service considerations to determine the optimal number of stocking points.

**Figure 14: Safety Stock Requirements for 95% Service**

![Safety Stock Requirements for 95% Service](image)

**Table 1: Inventory Investment Requirements for Various Network Configurations**

<table>
<thead>
<tr>
<th>Stocking Points</th>
<th>Inventory Investment Increase</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Baseline</td>
</tr>
<tr>
<td>6</td>
<td>9%</td>
</tr>
<tr>
<td>12</td>
<td>20%</td>
</tr>
<tr>
<td>23</td>
<td>37%</td>
</tr>
</tbody>
</table>
This inventory analysis could be greatly improved with additional Ethiopia-specific data. The following list suggests some additional information that could be collected for future analysis in this area.

1. Collection of demand data for all products, not just SCMS program drugs,
2. Availability of longer time horizon for demand data (at least 1-3 years)
3. Incorporation of Ethiopia-specific supply data (sourcing data, including lead-times, variability etc)
4. Collection of stock on hand data that is warehouse-specific and inventory requirements and policies
5. Adjustment of variables to see their effects (Service, lead-time, Variability)

**Financial Benchmarking for Pharmaceutical Distribution**

The next portion of the analysis conducted by the team consisted of a financial benchmarking exercise based on available supply chain data from the Africa region – more extensive studies had been done in Lesotho and Kenya. As mentioned earlier, additional data was available in those two countries, allowing for a more detailed study. Since limited data was available in Ethiopia, using this data would allow the team to draw some reasonable conclusions as to what costs should be. Pharmid historical data was collected and compared to similar data from Kenya and Lesotho. Although the team is quite aware that PFSA has a much larger mandate than that of Pharmid in the past, the purpose of this analysis was to give the Agency some perspective on the expected operational costs associated with serving Ethiopia’s large population. Figure 15 shows Pharmid’s financial information for the 2005-2007 fiscal years. During that time, Pharmid spent an estimated $0.03 to $0.05 per capita on supply chain costs. In comparison, Kenya’s supply chain study estimated costs of approximately $0.99 per capita to service the country’s entire population at 100% service. A similar analysis in Lesotho projected costs of $1.75 per capita. Economies of scale are definitely possible, however, it should be noted that for PFSA to meet its mandate (100% service to the entire country), supply chain costs should be expected to rise significantly compared to their current levels. Once more detailed information is available for Ethiopia, a more reliable study could be conducted to determine how much is spend per capita in Ethiopia, how this expenditure is broken down, and what lessons can be learned.
Figure 15: Pharmid Financial Data from 2005-2008

![Historical Supply Chain Costs](image)

Table 2: Pharmid Financial Data from 2005-2008*

<table>
<thead>
<tr>
<th></th>
<th>2005</th>
<th>2006</th>
<th>2007*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Expenses</td>
<td>$21,494,198.00</td>
<td>$26,327,852.00</td>
<td>$31,952,304.00</td>
</tr>
<tr>
<td>(Birr)</td>
<td></td>
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<tr>
<td>Total Expenses</td>
<td>$2,398,906.03</td>
<td>$2,938,376.34</td>
<td>$3,566,105.36</td>
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<tr>
<td>($US)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Expenses ($)</td>
<td>$0.03</td>
<td>$0.04</td>
<td>$0.05</td>
</tr>
<tr>
<td>(US)/Person</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Note: World Factbook 2007 Conversion Estimates of 8.96 Birr to the USD were used
Logistics Management Information System (LMIS) Recommendations

PFSA is in the planning and developmental stages for its first supply chain LMIS system. Based on experiences with public and private sector systems throughout the world, the team thought it could share some suggestions on what types of data to collect with this type of tool.

1. Critical Data
   a. Transactions
      i. Procurement Orders
      ii. Demand Orders
      iii. Inbound/Outbound Shipments
   b. Components of the Data
      i. Product Name and Type
      ii. Price and Quantity
      iii. Date of Order and Receipt
      iv. Locations- Geo-codes of Suppliers, warehouses, Hospitals and HCs

2. Less Critical
   a. Periodic Inventory Snapshots

In addition, the team has seen several systems that were overdesigned and overly complex to the point that they weren’t utilized. As a result, the following recommendations were made about the system generally:

- Simple and usable over big and bulky
  - The easier to use, the more powerful the system
  - Real-time data is nice, but snap-shots can do the job
  - Consistency and Accuracy of data are more important than Quantity

From the team’s perspective, the LMIS system should be designed in such a way that it is simple, functional, and actively maintained. For more detailed analyses to be completed in the future, it is recommended that the system allow for the execution of the following types of periodic figures and reports:

1. Customer Service
   a. Fulfillment % and Lead Times
   b. Service Rates (subject to established criterion)
2. Demand Profiling
   a. Quantities
   b. Variability
3. Supplier Performance
   a. Costs, Lead Times and Variability

**Summary and Recommendations**

PFSA has a difficult road ahead as it expands its supply chain in order to support the large task it has been assigned. In order to support implementation decisions that will need to be made in the coming years, it is recommended that significant resources be put forth in the near future to begin collection of data in an electronic format to fill the large data gap that currently exists. Not only will this data inform decisions in the near-term, it can be used to improve the efficiency of the system over the long term.

PFSA will need to balance the number of Hubs to create in order to bring the a bigger proportion of the population within 400km of a HUB, versus the increased risk of having to carry much higher levels of inventory for the decentralized model.

In addition, the team also recommends the following for areas of inquiry moving forward:

   a) Complete GIS Mapping of Health Network
      a. Use results to help define customer (Health Center) to Hub assignments
   b) Strategically plan network expansion
      a. Structural Analysis can be used to choose investment priorities
   c) Determine financial requirements (inventory levels) to meet PFSA Objectives
      a. Only possible with implemented LMIS system