KENYA

IMPROVING HEALTH SYSTEMS

PUBLIC SECTOR HEALTHCARE SUPPLY CHAIN STRATEGIC NETWORK DESIGN FOR KEMSA

Driving Service Improvements through Supply Chain Excellence

January 2009

THE WORLD BANK
About the Authors

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<table>
<thead>
<tr>
<th>Acronym</th>
<th>Description</th>
</tr>
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<tbody>
<tr>
<td>CSO</td>
<td>customer service officer</td>
</tr>
<tr>
<td>DfiD</td>
<td>Department for International Development</td>
</tr>
<tr>
<td>DC</td>
<td>distribution center</td>
</tr>
<tr>
<td>GIS</td>
<td>geographic information system</td>
</tr>
<tr>
<td>ICT</td>
<td>information, communication, technology</td>
</tr>
<tr>
<td>KSCID</td>
<td>KEMSA Supply Chain Intelligence database</td>
</tr>
<tr>
<td>KEMRI</td>
<td>Kenya Medical Research Institute</td>
</tr>
<tr>
<td>KEMSA</td>
<td>Kenya Medical Supplies Agency</td>
</tr>
<tr>
<td>MOH</td>
<td>Ministry of Health</td>
</tr>
<tr>
<td>RDC</td>
<td>Regional Distribution Center</td>
</tr>
<tr>
<td>SDPs</td>
<td>Service Delivery Points</td>
</tr>
<tr>
<td>UBW</td>
<td>Unified Budget Workplan</td>
</tr>
<tr>
<td>UNAIDS</td>
<td>The Joint United Nations Program on HIV/AIDS</td>
</tr>
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Background

Kenya Medical Supplies Agency (KEMSA) was established as a state corporation in the year 2001, to contribute to the improved availability of medicines and supplies and to the reversal of the decline of the health status of Kenyans. The agency was mandated to manage the procurement and distribution of the public sector healthcare supply chain. Over the seven years, regardless of the countless operational setbacks it faced, the organization has implemented a centralized supply chain network, established scheduled deliveries to all of its 4001 customers through outsourced transport and continued to serve its customers. However, the supply chain functions are hampered due to lack of appropriate funding for the procurement of the medicines and supplies to meet the needs of the customers.

Substantial assessments and efforts continue to find the right solutions which would allow KEMSA to achieve its intended mandate. Most of these are aimed at addressing the operational bottlenecks and improving core internal processes. The agency is overwhelmed by the day to day challenges of meeting basic mission requirements (procurement, receiving, storage, distribution), and has had little opportunity to take a step back and conduct a strategic and quantitative analysis of its supply chain network, with the aim of finding an optimum solutions.

Together, KEMSA staff and the World Bank team\(^1\), embarked on addressing this key knowledge gap in KEMSA’s supply chain network. The analysis of the investigation focused on the system’s design, inputs and outputs, as well as finding an optimal solution to meet the desired service level.

The scope of the assignment was to use an advanced supply chain modeling software to answer critical strategic questions on how best to design the supply chain network. The software can manage vast amounts of data at once and provide optimized solutions. This enables the end user to make decisions based on hard data and consider the trade-offs of making a design change. In the commercial sector the trade-off is usually between costs and profitability. In the case of public health, the trade-offs could be between achieving a hundred percent fulfillment versus the financial cost of achieving such rates.

The study is also relevant to the META initiative as the analysis provides visibility in the supply chain for improving accountability and governance. In addition, the use of UBW funds was also appropriate, as the Kenya supply chain manages all healthcare commodities, including HIV supplies and improvement in the overall system would also benefit the HIV/AIDS program. Finally, Kenya Medical Supplies Agency (KEMSA) has struggled in fulfilling its mandate of serving as the procurement and distribution agency for the public sector. It was viewed that potentially a strategic review of the supply chain could help in getting a better handle on some of the issues faced by the agency. In addition, the agency was specifically exploring the possibility

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\(^1\) To assist with the analysis, the World Bank hired a software company specializing in the development of advanced optimization and simulation supply chain software, known as LLamasoft, USA. The company’s software, Supply Chain Guru™ was used to conduct the analysis.
of decentralizing its supply chain and creating regional depots. The use of advanced software is ideal to answer these types of strategic questions.

Supply Chain Defined

The basic function of **Supply Chain Management** is managing and coordinating all of the supply chain activities necessary to support the organization’s strategy of getting the right quantity of the product to the right place at the right time. In the case of the healthcare sector, this includes sourcing, procurement, transport, warehousing and treatment of patients. It also includes coordination and collaboration with channel partners, which can be funders, suppliers, intermediaries, third-party service providers, and customers. Supply chain management usually includes **supply chain planning**, a process of analyzing, evaluating and defining the supply chain strategies, including network design, sourcing, transportation and inventory policy.

Supply chain planning can be focused at three levels:

*Operational*: planning of the day to day operations (loading trucks, placing replenishment orders, creating pick lists)

*Tactical*: planning of the week to week / month to month orders (when to build up supplies, how much transportation capacity is needed, what warehouse locator system to use)

*Strategic*: planning a year or more (how is the network structured, where are the facilities, impact of a push versus pull inventory systems)

In the case of the healthcare public sector program of Kenya, most of the analysis has focused on the first two types of supply chain planning. This analysis is focused on the third type of planning – strategic. The strategic planning was the appropriate response, given the fact that KEMSA was in the midst of determining two major strategic issues: first, should KEMSA decentralize their supply chain operations and create regional depots to better meet the customer demands? Second, should KEMSA implement a pull inventory system and what would the implications to the inventory requirements for that policy compared to the current push inventory system be?

Purpose of the study

The study focused on three major aspects of strategic analysis:

1. Structural design of the network
2. Supply and demand analysis
3. Demand profiling, variability and inventory
Specifically, the objectives of the analysis were to:

1. Provide strategic analysis on the optimum network designs for decentralization.
2. Predict the impact on supply chain operations if throughput (volume of products) increases.
3. Identify the impact of push and pull inventory strategies in centralized and decentralized network scenarios.

**Methodology**

The methodology included a four step process:

- Collection and organization of data: electronic data on location of customers, products the system delivered to each customer, the infrastructure the network used for the delivery and the cost\(^2\).
- Creation and analysis of key performance metrics.
- Creation of a baseline model, using an advanced optimization and simulation software, Supply Chain Guru\(^\text{TM}\).
- Analysis of optimized models.

Specifically for Kenya:

- **Facilities**: Geographic location information for all the customer sites and warehouses triangulated using GIS MOH/Kemri-Welcome and public GeoData datasets.
- **Products**: Orders (all recorded orders and shipments extracted from Navision database, from 2008\(^3\). KEMSA Supply Chain Intelligence database (KSCID) was exported to ACCESS and provided visibility into recorded orders, shipments for any product, period or customer.
- **Financials**: Costs (extracted from the financial audit report, unpublished)

**Current Supply Chain Network**

Kenya has a population of 38 million people with an average population growth of 2.6 percent. The population is dispersed throughout the country in densely populated urban, peri-urban and in rural areas. All the major cities and towns are connected by a road network and can be reached within one day’s drive (about 250km). However, the rural areas are harder to reach, especially

\(^2\) Data collection is the most critical step in the exercise and requires a team member who is proficient in excel and access databases, and cleaning up raw data to make it user-friendly.

\(^3\) Due to a system crash, daily transaction data was only available in the system from July 2007 – to date. While all agreed that the year 2008 was an abnormal year, it was the most comprehensive dataset available; hence it was used in the analysis.
during the rainy seasons. KEMSA’s 4001 customers, like the population distribution are also located all across Kenya and include all tiers of healthcare from primary to tertiary for current network and customer locations (see Figure 1 and Figure 2).

Figure 1: Locations of Customers

Figure 2: Design of the Current Network

The system handles 1173 products ranging from essential drugs, donated program drugs, medical consumables, and other specialty consumables such as X-ray and dental materials. The organization operates a centralized model, serving all its customers directly from its three Nairobi warehouses, two of which are leased. The organization also owns eight regional depots, ranging from 2000 – 8000 sq. ft and currently is mainly used for storing slow-moving items. The total warehouse space available is 292,810 sq ft and is reported to be operating at maximum capacity (Table 1).

Table 1: KEMSA warehouse space

<table>
<thead>
<tr>
<th>Location</th>
<th>Area (sq ft)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nairobi</td>
<td>42,000</td>
</tr>
<tr>
<td>Nairobi</td>
<td>51,000</td>
</tr>
<tr>
<td>Nairobi</td>
<td>155,000</td>
</tr>
<tr>
<td>Mombasa</td>
<td>6,160</td>
</tr>
<tr>
<td>Kisumu</td>
<td>8,400</td>
</tr>
<tr>
<td>Eldoret</td>
<td>7,920</td>
</tr>
<tr>
<td>Nakuru</td>
<td>9,120</td>
</tr>
<tr>
<td>Nyeri</td>
<td>2,000</td>
</tr>
<tr>
<td>Kakamega</td>
<td>2,000</td>
</tr>
<tr>
<td>Meru</td>
<td>2,000</td>
</tr>
<tr>
<td>Garissa</td>
<td>2,000</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>292,810</strong></td>
</tr>
</tbody>
</table>
The transport is outsourced to eight companies, serving each region and delivering directly to the service delivery points (SDPs). Orders are received, picked, packed and delivered every two months to major provincial and tertiary hospitals and quarterly to the sub-district and health centers. However, the lead-time variability was found to be three weeks or more. (Figure 3)

Figure 3: Total Supply Chain Cost in Baseline Model

Results

Product Analysis

The KEMSA Supply Chain Intelligence database (KSCID), which was created as part of this exercise provided instant visibility into recorded orders, shipments for any product and customer. It also provided key performance metrics that can be used in the future for a variety of strategic, tactical and operational level analysis. Sample key performance metrics were conducted on the following:

Total Product Value

Of the 1173 products managed by the KEMSA warehouse, the top 100 products represented 80% of the total volume the system shipped. These 80% represented 1billion Ksh of the total 1.2billion Ksh the system shipped. (See Figure 4)
Fill rates

The average aggregate fill rate for the top 100 products shipped was 21%, suggesting chronic shortages of almost all major items, with the exception of x-ray film processors which were fulfilled at 120% (this is due to the fact that once the processors were received, and were immediately forwarded to customers (Figure 5).

Figure 4: Total Product Value for Top 100 Products

![Figure 4: Total Product Value for Top 100 Products](image)

Figure 5: Order Fill Rate for the Top 100 Products

![Figure 5: Order Fill Rate for the Top 100 Products](image)
Total cost of the supply chain.

Based on the unpublished financial data provided, a total of Ksh478,952,992.00 (approximately $6.5m) was spent in FY 2008 for the KEMSA supply chain costs. Transport and warehousing represented the largest cost in the supply chain, about 41% and 40% respectively.

Decentralization

Optimum models for consideration of decentralization of the supply chain

In order to determine the optimal network, the study team with KEMSA created a measure of service defined as “how many delivery points can be served within one day?” While it was understood that network service measured as all facilities within one-day of a resupply point is not a true measure of service, it was agreed that it was a reasonable measure. By using this definition of service level, facilities would be placed closer to the supply points, allowing for emergency replenishments and decreasing the amount of stock outs. The analysis took the following aspects into account in conducting the analysis:

- Impact on service
- Financials
- Inventory considerations
- Estimation of warehouse space

The decentralization scenarios that were considered for optimization analysis included the following (see: Table 2)

1. Current baseline of one central Distribution Center (DC)
2. Opening of three additional regional DCs, keeping the regional depot the same size.
3. Opening of three additional regional DCs, but expanding the warehouse size.
4. Converting all existing eight depots into regional DCs, but keeping them the same size.
5. Converting all existing depots to regional DCs and expanding the warehouse size of all eight repots
6. Conducting a “Greenfield” analysis to determine the optimum location of a single warehouse.

---

4 In the commercial sector supply chain, optimal network usually is measured as minimization of cost and maximization of profitability.
Table 2: Decentralization Scenario Plan

<table>
<thead>
<tr>
<th>Decentralization Models</th>
<th>Number of Distribution Centers</th>
</tr>
</thead>
<tbody>
<tr>
<td>Adding 3 Regional Distribution Centers (RDC) to Existing Network</td>
<td>4</td>
</tr>
<tr>
<td>Adding 3 RDCs to Existing Network, Expand Capacity</td>
<td>4 (Large)</td>
</tr>
<tr>
<td>Converting All Depots to RDCs</td>
<td>8</td>
</tr>
<tr>
<td>Converting all Depots to DCs, Expand Capacity</td>
<td>8 (Large)</td>
</tr>
</tbody>
</table>

The map below shows the results of adding three additional regional depots with the existing capacity. The optimization showed that most of the health facilities would still be serviced by the Nairobi warehouse as this location has the largest capacity (see Figure 6).

**Figure 6: Network with Four Distribution Centers**

The map below shows the optimization of converting the existing eight facilities into regional depots, without expanding their warehouse sizes. A significant amount of customers would still be served by the Nairobi location (see Figure 7)
The financials of the five scenarios shown below suggest that as more warehouses are included, the cost of inventory will increase, but the cost of transportation will decrease. The analysis does not include the cost of upgrading and expanding the existing regional warehouses (see Figure 8.)

The optimum model for decentralization

The chart below shows the trade-off between cost and service for each of the decentralized scenarios. The data shows that operation of one DC is the cheapest in term of cost but only 50% of the facilities are within one day of driving reach. The cost of eight expanded DCs is
$680 million and 89% of the facilities are within one-day service. The most expensive model is the creation of eight regional depots with existing warehouse space. This is due to the fact that many of the customers would still have to be serviced from the Nairobi warehouse and the cost-gains from the use of bulk lanes would not be achieved in this scenario.

The financial analysis does not include the operational cost of decentralization - the capital investment costs required for upgrading the warehousing spaces (see Figure 9).

**Figure 9: Total Supply Chain Costs vs. Service Levels**

![Total Supply Chain Costs vs. Service Levels](image)

**Optimum regional depot**

The results of the study show that some level of decentralization of the supply chain may be beneficial. This should be tested with a pilot project. To determine the ideal location to consider for the pilot, the optimization analysis was run eight times. Kisumu, Eldoret or Kakamega were found to have the highest impact on service, i.e. the maximum number of health facilities within one day’s drive to the resupply point. Adding a facility in Kisumu would increase service levels to 59%, Eldoret to 60%, and Kakamega to 59% (see Figure 10).
Greenfield Analysis

A Greenfield analysis was conducted to determine the optimal location for a warehouse or DC based on the overall demand in the network. The analysis determined that midway between Nairobi and Nyeri would be the ideal location if only one warehouse were to be added. The feasibility of this location would be dependent on land availability, economic and political considerations which are beyond the scope of this study (see Figure 11).

Figure 11: Result of Greenfield Analysis
Supply and Demand

Impact of a 100% Order fulfillment

The current supply chain is meeting about 21% of the demand, however, if KEMSA were to ensure a 100% fulfillment rate, increasing the throughput from 1.2billion Ksh to 6.0billion Ksh, the estimated warehouse space required would be 2-3 times the current 250,000 sq ft., around 500,000 – 750,000 sq. ft. (see Figure 12).

Figure 12: Total Supply Chain Cost in a Network with 100% Fulfillment

Cost of Distribution

Based on the current throughput, the rate of distribution cost is 29%. Other published reports have suggested that the total throughput is about 1.8billion, which would reduce the supply chain rate to 21%. In order for the rate to significantly drop to 8 – 5%, the throughput volumes would have to be in the range of 6.0billion Ksh (estimated to meet the 100% order fulfillment rate) to 9.2billion Ksh 9estimated to meet the total forecasting need for 2009 for all drugs and supplies for Kenya for the public sector). The study does not distinguish whether the current supply chain costs incurred by the system are efficient (see Figure 13).
Table 3: Percentage cost of logistics based on throughput

<table>
<thead>
<tr>
<th></th>
<th>Value of Goods</th>
<th>Distribution Cost</th>
<th>Total SC Cost</th>
<th>Supply Chain Cost Rate (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Baseline Shipment Value</td>
<td>1,173,953,574</td>
<td>478,952,992</td>
<td>1,652,906,566</td>
<td>29%</td>
</tr>
<tr>
<td>Initial Estimated Shipments</td>
<td>1,800,000,000</td>
<td>478,952,992</td>
<td>2,278,952,992</td>
<td>21%</td>
</tr>
<tr>
<td>Revised Estimate</td>
<td>3,400,000,000</td>
<td>478,952,992</td>
<td>3,878,952,992</td>
<td>12%</td>
</tr>
<tr>
<td>100% Fulfillment Rate</td>
<td>5,590,255,113</td>
<td>478,952,992</td>
<td>6,069,208,105</td>
<td>8%</td>
</tr>
<tr>
<td>Quantification Study</td>
<td>9,200,000,000</td>
<td>478,952,992</td>
<td>9,678,952,992</td>
<td>5%</td>
</tr>
</tbody>
</table>

Figure 13: Supply Chain Costs Based on Different 2008 Throughput Levels

Demand profiling, variability and inventory

The third objective of the study was to calculate the necessary safety stock required to achieve a desired service rate and analyze inventory deployment requirements under different circumstances (push or pull). Given the fact that the system does not have enough inventory, the study team used “quantity ordered” as a basis for demand, characterized demand variability and estimated lead time and lead-time variability.
The team estimated that in order to achieve a 95% service rate, 116 days of supply would be required to protect against demand variability. To achieve a 100% service rate, inventory on hand would need to increase by an additional 20% (see Figure 14).

**Figure 14: The Effect of Inventory and Demand Variability on Days of Supply and Service Levels**

![Inventory and Demand Variability](image1)

Lead-time variability also has an impact on the inventory that the system would need to hold (see Figure 15).

**Figure 15: The Effect of Lead Time Variability on Inventory Levels Assuming a 99% Service Rate**

![Effect of Lead Time Variability on Inventory](image2)
To analyze the regional versus centralized inventory policies, daily orders for 2008 were analyzed and demand variability profiled for one region. The average daily demand was calculated and an assumption was made for the lead-time to be 30 days, plus or minus one week. The days of supply required to achieve 99% service rates were calculated. The analysis was conducted for the coastal region where a pull inventory management system has been put in place. The demand variability of the coastal region on its own was found to be higher than all the regions pulled together, requiring more inventory than a centralized model, which benefits from risk pooling (see Figure 16: Demand Variability for the Coast Region vs. the Rest of Kenya).

Figure 16: Demand Variability for the Coast Region vs. the Rest of Kenya

Inventory simulation of the top 10 products was conducted to visualize and validate the results of the inventory analysis. The simulation model took into account the initial inventory and future shipments. The simulation showed that significant inventory was available at the beginning of the year (see annex 1).

Conclusions

Shortages in the system

The system appears to have massive shortages of supplies and is only meeting 21% of the current demand. Given the shortages experienced in the system, the debate on push or pull inventory systems is moot. The shortages must be addressed first.
**Improving KEMSA’s performance metrics**

KEMSA could improve its performance metrics by ensuring that the new ERP system is set-up with the following:

- Ensure that the products standard weight and volumes are incorporated in the database in order to enable improved logistics analysis.
- Acquire and integrate complete GIS data for the current customer database (currently only have 60-70% match with the GIS data publicly available)

**Decentralization of the supply chain**

Decentralization to regional DCs appears promising and could be piloted at a single location. It is likely to improve service levels, especially for remote customers. The creation of bulk lanes will reduce transportation costs, but will certainly increase warehousing and inventory costs. The regional depots would also provide a better response for “pull systems”, provided that additional inventory investment is provided and deployed.

However, creation of regional depots will present operational difficulties and additional capital investment will be required for facilities improvement and additional inventory. Roll-out of a decentralized model needs to be rolled out gradually, keeping the current centralized model as the back-up plan. And finally major customers, such as provincial hospitals would still need to be serviced through the centralized warehouse, in order to reduce demand variability.

**Policy Implications**

The efficiency and effectiveness of a supply chain system are highly impacted by unpredictability and shortages of drugs and supplies. The Kenya public sector supply chain system is currently meeting about 21% of the current demand, not taking into account the projected forecasted demand. Addressing **adequate financing** for drugs and supplies needs to be a key policy priority.

In order to improve the procurement practices and reduce the downstream negative impact to the supply chain, policy makers need to make the **necessary financing available**, enabling KEMSA to implement a 2-3 rolling procurement plan.

Donors and partners need to provide **adequate financing for the logistics services** provided by KEMSA.
### Appendix 1: Reference Chart.

<table>
<thead>
<tr>
<th>Item Number</th>
<th>Item Description</th>
</tr>
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<tbody>
<tr>
<td>PHA0004</td>
<td>Aminophylline 25mg/ml 10ml</td>
</tr>
<tr>
<td>PHA0013</td>
<td>AmoxyClavulan 156mgx100ml</td>
</tr>
<tr>
<td>PHA0014</td>
<td>Ampicillin/Cloxa. Drops,10ml</td>
</tr>
<tr>
<td>PHA0017</td>
<td>Atropine Inj 1mg/ml</td>
</tr>
<tr>
<td>PHA0019</td>
<td>Benzathine Inj 2.4 MIU,Vials</td>
</tr>
<tr>
<td>PHA0028</td>
<td>Ceftriaxone Inj 250mg</td>
</tr>
<tr>
<td>PHA0031</td>
<td>Chloramph Susp 125mg/5mlx100ml</td>
</tr>
<tr>
<td>PHA0035</td>
<td>Chlorpheniramne Inj 10mg/ml</td>
</tr>
<tr>
<td>PHA0038</td>
<td>Chlorpromazine Inj 50mg/2ml</td>
</tr>
<tr>
<td>PHA0044</td>
<td>Clotrimazole 1% Cream x20g</td>
</tr>
<tr>
<td>PHA0085</td>
<td>Furosemide Inj 20mg/2ml</td>
</tr>
<tr>
<td>PHA0094</td>
<td>Hartmann's Solution x 500ml</td>
</tr>
<tr>
<td>PHA0123</td>
<td>Hydralazine Inj 20mg/ml</td>
</tr>
<tr>
<td>PHA0124</td>
<td>Hydrocortisone Inj 100mg</td>
</tr>
<tr>
<td>PHA0127</td>
<td>Hyoscine Butyl Bromide Inj</td>
</tr>
<tr>
<td>PHA0130</td>
<td>Ibuprofen Tabs 200mg x 1000's</td>
</tr>
<tr>
<td>PHA0142</td>
<td>Ketamine 50mg/ml 10ml</td>
</tr>
<tr>
<td>PHA0154</td>
<td>Methylated Spirit x 5 litre</td>
</tr>
<tr>
<td>PHA0159</td>
<td>Metronidazol Tabs 200mg x1000s</td>
</tr>
<tr>
<td>PHA0163</td>
<td>Neostigmine Inj 2.5mg/ml</td>
</tr>
<tr>
<td>PHA0170</td>
<td>Nystatin Susp 100,000iu/mlx30ml</td>
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<tr>
<td>PHA0171</td>
<td>Omeprazole Capsules 20mg x 20’s</td>
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<td>PHA0249</td>
<td>Hydrocortisone 1%Ointmentx20gm</td>
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<tr>
<td>PHA0263</td>
<td>Levonogestrel 0.75mg,EC Pillx2</td>
</tr>
<tr>
<td>PHA0285</td>
<td>Ceftriaxone Inj 1g</td>
</tr>
<tr>
<td>PHA0331</td>
<td>Ketoconazole Tabs, 200mg x 30s</td>
</tr>
<tr>
<td>PHA0345</td>
<td>Medroxyprogesterone 150mg</td>
</tr>
<tr>
<td>PHA0388</td>
<td>Artemether Lumef.20+120mg x24s</td>
</tr>
<tr>
<td>PHA0421</td>
<td>Dextrose 10% x 500ml</td>
</tr>
<tr>
<td>PHA0424</td>
<td>Povidone-iodine x 1ltr</td>
</tr>
<tr>
<td>PHA0479</td>
<td>Plastic Dispens Bott.60mlx pcs</td>
</tr>
<tr>
<td>PHA0554</td>
<td>Fluconazole 50mg Caps/Tabsx100</td>
</tr>
<tr>
<td>PHA0556</td>
<td>Levonogestrel 0.03mg (pop) pcs</td>
</tr>
</tbody>
</table>

*Note: Full data set available on Kenya: Raw Data CD*
Appendix 2: Inventory Simulation of the Top 10 Products

- Amoxicillin Caps 500mgx500s
- Amoxicillin Caps 250mgx1000s
- Benzylpenicillin Inj 1MU
- Co-Ttrimoxazole Tab 480mgx1000s
- Dextrose 5%, x 500ml