Improving health in developing countries: reducing complexity of drug supply chains

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IMPROVING HEALTH IN DEVELOPING COUNTRIES[1] - REDUCING COMPLEXITY OF DRUG SUPPLY CHAINS

ABSTRACT

Purpose of this paper

Uganda is one of many African countries struggling to develop adequate healthcare, particularly in regard to local treatment and access to drugs. The purpose of this paper is to contribute to the understanding of how reducing supply-chain complexity can improve health in developing countries.

Design/methodology/approach

This study and evaluation included 50 interviews and 27 site visits of the public healthcare system in Karamoja, northeast Uganda. A mapping of drug-supply chains was undertaken to identify causes of stock shortages and possible solutions. A model for logistics process redesign was used for the analysis. Results were quantified with use of a simple tool developed for this specific purpose.

Findings

The main conclusion is that less supply-chain complexity can produce higher customer service in terms of less stock shortages, while keeping costs down. By reducing lead times and uncertainty, increasing order frequencies, and moving order points and safety stocks, there may be better integration between information and goods flows and bottlenecks in the supply chain may be reduced.

Research limitations/implications

While the empirical study is extensive, there are uncertainties in the data that must be taken into account. The effects of the suggested solutions remain to be analyzed and documented upon implementation.

[1]The definition of developing countries and use of the concept is up for discussion (Rosling, 2011). Countries traditionally classified as developing, such as China (see, for example, UNICEF, 2011), are increasingly referred to as emerging economies. What is common for most of these countries is poverty and lack of, or weak, infrastructures compared to others.

Practical implications

The study was rooted in a practical problem and provides practical solutions for developing countries and agencies providing aid.

Social implications

Stock shortages of life-saving drugs are a general problem in countries with lack of financial and technical infrastructure. Improvements will impact the lives of many people.

Value of the paper

The paper provides an understanding of the applicability of traditional logistics principles in a new context. It provides the academic community with a much-needed in-depth understanding of humanitarian logistics. The approach can be used in other studies

Keywords: drug, supply chain, health, Africa, development, stock shortages.

Type of paper: Research paper

1. INTRODUCTION AND PURPOSE

During the past four years, humanitarian logistics has attracted a lot of attention in academia, with an immense growth in published articles. However, the research suffers from a lack of facts and knowledge about humanitarian logistics practice (Kovács and Spens, 2009; 2011a; b; Jahre et al. 2009; Pedraza Martinez et. al. 2011). Little has been published on logistics in long-term development and distribution of goods in developing countries (Kovács and Spens, 2011a). While often seen as limited to disaster relief logistics (see e.g., Tatham and Pettit, 2010; McLachlin and Larson, 2011), recent statements now include ‘development’ as part of humanitarian logistics (e.g., Kovács and Spens, 2011b, p.8). Furthermore, practitioners and researchers increasingly note the importance of linking disaster relief with recovery and development (e.g. IFRC-Strategy 2020, 2011; Kovács and Spens, 2011a; Besiou et al., 2011). Humanitarian logistics research should thus take this into account.

The purpose of this paper is to contribute to understanding of traditional logistical tools and principles to improve development aid. The paper reports a study of drug-supply chains in Uganda, focusing on causes of, and solutions to, frequent stock shortages. As with many African countries, Uganda is struggling to develop adequate healthcare systems (Kumar et al., 2009). A survey reveals that 32–50 percent of medicines essential for treating common diseases, such as malaria, pneumonia, diarrhoea, HIV/AIDS, tuberculosis, diabetes, and hypertension, are not available (Okiror, 2009). Sixty-five percent of facilities across Uganda experienced medical stock shortages in 2008 (MoH, 2009). One critical problem is establishing supply chains for drugs and medical equipment to ensure availability at local treatment facilities (that is, health centers). Stock shortages are a general problem for many drug-supply chains in countries with a lack of financial resources, health system infrastructures, capacities, and competencies (see e.g., GAVI, 2009; Lalvani et. al. 2010;

Kaufmann et. al. 2011). Hence, knowledge of the causes and possible solutions for drug shortages is of interest outside the specific region where this study was undertaken.

This study used a basic model for logistics process redesign (Persson, 1995), supplemented by additional literature, as the conceptual framework to describe and analyze the public drug-supply chain in the Karamoja region of Uganda. This paper provides knowledge on the link between logistics processes, such as ordering and inventory management, and performance (Lodree, 2011, p.52). The research helps fill a gap in humanitarian literature on logistics process redesign while expanding this literature to a new area (see Pedraza Martinez et al. 2011 for similar research in fleet management).

The study took place in 2009–2010 with more than 50 interviews and 27 site visits at health facilities undertaken during a period of four months. Logistics processes and performance such as ordering, warehousing, stock shortages, lead times and management techniques were assessed. Findings suggest that reducing supply-chain complexity and bureaucratic processes resulting in long lead times and instability, can improve integration between information and goods flows to increase customer service, i.e. reduce stock shortages. A simple Excel worksheet model demonstrates how suggested solutions can reduce lead times and costs, making the right drugs available where and when they are needed. The following presents the design of the study, followed by a description of the context. The conceptual framework is presented, whereupon findings from the study are reported and discussed. Finally, conclusions and implications for further research are presented.

2. RESEARCH STRATEGY AND DESIGN

The study was undertaken as a project for UNICEF Uganda and can be characterized as action research. Researchers and clients collaborate in diagnosing the problem and developing solutions, typically focused on real-world, organizational and managerial problems (Bryman and Bell, 2011, p.412; Näslund, 2002; Näslund, 2008).

This study used a mixed-methods approach, combining quantitative and qualitative research strategies (Bryman and Bell, 2011, p.628). It used different sources and types of data for complementarity and to cross-reference information (Ellram, 1996; Yin, 2003). First, an explorative study corroborated secondary and primary data to give an overall description of the health provision in Uganda and specific characteristics of Karamoja. This is the context for the supply chain in question. Second, conclusions from this initial phase were used to choose a suitable conceptual framework from which interview guides and field-study stock-assessment tools were developed. Third, results from this cross-sectional study were used to get an overview of lead times, costs and stock shortages. From this analysis, solutions were suggested, whereupon an Excel worksheet model was developed to demonstrate consequences of the solutions.

2.1 The case and context

The case and unit of analysis is the supply chain for drugs from the national distribution point in Kampala, Uganda, called National Medical Stores (NMS), to health centers (HCs) in five districts in the Karamoja region of northeastern Uganda. Primary data were gathered through interviews with stakeholders in Kampala and Karamoja, and combined with secondary data from the literature review. Approximately 1,500 pages of articles and reports were identified in the interviews and through web searches. These data were reviewed to understand the health system, pinpointing constraints, opportunities, and best practices.[1] The interviewees were identified through snowball sampling (Bryman and Bell, 2011, p.192), starting with a small group of people suggested by UNICEF. This was done to get as many perspectives on the health supply chain and its challenges as possible, covering all main stakeholders.

From a total of 94 HCs in Karamoja, 27 were chosen for site visits, interviews and stock assessments. This provided 28.7 percent coverage, relatively equally distributed across each of the five Karamoja districts. The HCs within each district were selected through convenience sampling to cover both remote and urban areas, and well- and poor-functioning centers. The five district medical stores (DMS) maintaining medical supply stocks were also visited (Appendix 1). Six types of drugs, pre-selected by UNICEF, were used as tracer drugs for this part of the study: artimisinin-based combination therapy (ACTs such as Coartem; malaria pills in four sizes), sulfadoxine pyrimethamine (malaria treatment), co-trimoxazole (antibiotic for bacterial infections, particularly for HIV/AIDS patients, in four sizes), oral rehydration salt (diarrhea treatment), medroxyprogesterone injection (birth control), and measles vaccine.

The interviews were structured using a guide which was tested and revised (Bryman and Bell, 2011, p. 273). Each interview lasted two to four hours, including stock assessment and site visit. Interviews were conducted individually with key informants or in groups, depending on the contact person’s preference and the number of people working in a facility (Appendix 2). Starting with general questions, the interviews covered eight themes, including human resources and staff capacity, forecasting requirements, ordering, receiving and sending routines, inventory management and the physical condition of facilities. Almost all interviews were done by two researchers, one asking and one taking notes. The field context was challenging, with 5,000 km at a speed of 30 km per hour on dirt roads, wearing bulletproof vests and helmets (Jahre, 2010).

The interview guide[2] as well as the study protocol was refined during the process. Data were written up in individual Word documents and Excel worksheets, forming a database. Everything was then compiled in one common worksheet and cross-analyzed for each theme to identify patterns. More detailed analysis of particular issues was undertaken. The results were discussed with stakeholders. Based on the field assessment in Karamoja, together with the explorative study, the supply chain was mapped in accordance with the conceptual framework, and possible solutions were identified. Consequences of the solutions for costs and customer service were then quantified to compare before and after implementation of solutions.

2.2 Evaluation of research design

In spite of the special challenges posed in doing research in this particular context, major efforts were made to ascertain rigor and secure validity and reliability.

Table 1: Securing validity and reliability (adapted from Bryman and Bell, 2011)

Quality measure		Mitigation strategy
Limitations with secondary data	Lack of familiarity with data	Use of experts and establishment of stakeholder reference group.
	Lack of control over data quality	Cross-referencing data from multiple sources. Checked secondary data against primary data through interviews.
	Absence of key variables	Developed model based on existing data to replace missing data sets.

Reliability	Stability: Is the measure stable over time?	Used same data-source for calculation of stock shortages at same point in time. One danger is that lack of reliable data was identified as one of the problems for the supply chain. This was also a problem for the study.
	Inter-observer consistency: Is the measure consistent between observers?	Almost all site-visits and interviews were undertaken by two researchers who swapped roles from one visit to another to secure consistency in interpretation of the data.
Validity	Face validity: Does the measure reflect the concept in question?	Research team constituted a humanitarian logistics practitioner expert and a logistics researcher.
	Measurement validity	Cross-referencing data by using various sources. However, there may be inconsistencies in the reporting that are difficult to detect.
	External validity: Can results be generalized?	Even though similar problems exist in other regions and countries, generalization must be done with great care. Results from this study should be corroborated with other similar studies. The check against previous studies, both in Uganda and other countries, through the document analysis did provide similar evidence of the problems. The assumptions made in the Excel model could not be tested against real results in similar contexts in this study, but should be done in further research.
Replicability	Make it possible for others to repeat the study	Data collection procedures, sampling method and other aspects of the research approach and methodology are well-documented in this paper and even more thoroughly in Global Emergency Group (2010).

Particularly important aspects of rigorous action research projects, as suggested by Näslund (2008, p.72), were taken into consideration. These aspects included defining the unit of analysis, consciousness about the research context and role of the researcher, data collection based on multiple sources, and securing good access to data and respondents.

3. THE CONTEXT OF THE KARAMOJA DRUG-SUPPLY CHAIN

3.1 Overview of the health system In Uganda

With an annual population growth rate of 3.2 percent, Uganda is one of the fastest growing countries in Africa. Of 30.7 million people, 88 percent live in rural areas (MoH, 2008). Since the early 1990s, significant progress has been made addressing the HIV epidemic, but this still remains a leading cause of morbidity and mortality, in addition to malaria and tuberculosis (SCMS, 2009). Major health determinants include low literacy levels, poor sanitation, cultural beliefs, physical accessibility, risky behaviors, and prevailing poverty

(MoH, 2009). The estimated value of all drugs, including imports for sale, donations, and locally manufactured products, is $US 120 million (Elliott, 2008). This accounts for more than 30 percent of total expenditures on health and constitutes 10.7 percent of GNP (MoH, 2007). Uganda's national health system of organizations and entities are depicted in Figure 1.

<insert Figure 1>

Figure 1: Key actors within the National Health System (Numbers from Elliott, 2008)

In addition to public, private not-for-profit, and other private hospitals, there are a large number of public and private HCs, private retail pharmacies and drug shops (Japan International Cooperation Agency, 2008; MoH, 2008). The public and private sectors each account for approximately half of Uganda's health service delivery (MoH, 2009). The private sector accounts for 70 percent of the drug supply (I#1[3]). The public system is organized around HCs, classified at levels II, III, or IV, depending on staff training, services and treatments provided (HCII: parish level served by an enrolled comprehensive nurse; HCIII: subcounty level served by a clinical officer; and HCIV: county level served by a medical officer). The two main national regulatory bodies are the Ministry of Health (MoH) and the National Drug Authority (NDA). MoH provides budgeting, policies, planning, regulations, coordination of services, and performance monitoring. NDA is responsible for registering and analyzing drugs listed as Essential Medicines and Health Supplies (EMHS). To ensure efficient and effective procurement, storage, and distribution of these drugs NMS was established in 1993. The NMS base all procurement on competitive tendering, with approximately 95 percent imported generic products from India, China, Kenya, South Africa, Egypt, and Brazil of which India is by far the largest accounting for 70–80 percent of all imports (I#4). In 2009, NMS got more responsibility for drug procurement, and their annual budget increased from $US4.68 million to $US22.68 million.

3.2 Challenges in the Healthcare System

Two main challenges were identified in this study, based on initial interviews with stakeholders (referred to as I#1 to n) and the analysis of the secondary data. First, the public health system is underutilized. Second, stock shortages and expired drugs occur at all levels in the public system, particularly in rural communities including HCs, DMS, hospitals and NMS (Elliot, 2008; MoH, 2009). Table 2 lists the identified causes for the problems:

Table 2: Problems in the Uganda drug-supply chain

Overall	Examples	Sources
Lack of resources	Funding	MoH, 2009
	Transportation and storage facilities	MoH, 2008; Kimera, 2008; I#1; I#3
	Competent staff	MoH, 2009; Kimera, 2008; AllAfrica, 2009; Okuonzi, 2009; I#5
Limited control of drug quantity, quality, and pricing; leakages	Counterfeiting	Wendo, 2008; I#4
	Mark ups	Elliot, 2008
	Expired drugs	Tebajjukira, 2009
	Lack of transparency and regulation on prices	MoH, 2009; Kiapi, 2008; I#14
	Commissions	I#14
	Pilfering	Kaheru, 2009; I#5
Lack of coordination	In forecasting	Izama, 2009
	Procurement	MoH, 2009
	Parallel production	MoH, 2008
	Overview of stocks	Kimera, 2008; I#5
	Unsolicited drug donations	MoH, 2008

Delivery times from NMS to HCs vary from two to four months (Kimera, 2008; MoH 2009). At NMS, there is a lack of storage space, funding to procure enough drugs, and capacity to handle the substantial volumes of orders. Lack of efficient funding and ordering processes means it can take six months to complete tendering processes (Saturday Monitor, 2009). Although many initiatives (warehouse consolidation, new warehouse management systems, and better planning cycles) have been introduced, NMS acknowledged: “We [NMS] have not been able to supply even 50-60 percent of our mandate.” (I#5).

3.3 The Karamoja Region

With an estimated population of 1 million, Karamoja accounts for 3.25 percent of the total Ugandan population. It is the poorest region, with 87 percent living below the poverty line (UBOS, 2009). Meat from livestock, supplemented by cultivated vegetables, wild fruits, and greens, make up the basic diet. Over the past decade increased cattle raiding has created insecurity in the region. In addition major challenges are poverty, drought, food insecurity, reliance on traditional medicine practitioners, and skepticism for the government and public system (Stites et al, 2007). With an under-5 mortality rate of 177 per 1,000 live births (among the highest in Africa), people in Karamoja has a life expectancy of 47.7 years, as compared to the national average of 50.4. The maternal mortality rate is 750 per 100,000 live births, which is significantly higher than the national average of 435. The main causes of death in Karamoja are pneumonia, malaria, tuberculosis, anemia, meningitis, AIDS, dysentery, malnutrition, septicemia and diarrhea (UNICEF, 2009).

In 2008, four of the five Karamoja districts ranked among the lowest 10 percent in the whole country on health service delivery (MoH, 2008). There are few private pharmacies and drug stores in the region (I#13). Large volumes of unregistered drugs are used (I#13). Food insecurity hinders people from using the system because they often do not have the strength to walk to HCs (WFP, 2009) which are located more than 5 km away for more than 70 percent of the population. There is no public transport, and few people even own a bicycle. Almost nobody except international aid organizations has a car.

4. FRAMEWORK FOR SUPPLY CHAIN ANALYSIS

Constraints in available data suggested a relatively simple conceptual framework to develop interview guides and stock-assessment tools, analyze results from the field study, and estimate consequences of suggested solutions. Figure 2 shows Persson's (1995) model and presents a set of basic concepts to analyze logistics processes involved in flow of information and goods.

<insert Figure 2>

Figure 2: Logistics Processes as Response Cycles (Adapted from Persson, 1995)

Sections 4.1 to 4.3 present the concepts and how they are linked, while 4.4 presents a set of redesign principled for improvements. Section 4.5 presents the logic behind the Excel worksheet model to quantify the impact from the solutions.

4.1 Transaction

Transaction characteristics describe response-cycle behavior, constituting four concepts. Lead time is the elapsed time from identifying a need to satisfying it (e.g., time from when an order is submitted to when drugs are received). Frequencies mean the number of events per time unit (e.g., orders per year). Uncertainties are fluctuations in demand, capacity, lead times, and data accuracy. Expected demand means specific demand patterns (e.g., cyclical variations such as seasonal disease outbreaks). In general, longer lead times, lower frequencies, higher uncertainties, and uneven demand imply bigger stocks to safeguard against shortages, low inventory turnover, and less flexibility for change.

4.2 Structure

The second set of characteristics constitutes three concepts describing response-cycle structure. Complexity is the number of distribution levels (e.g., storage at national, district, and HC levels); and distribution points at the same level (e.g., number of DMS). Divisibility means the degree of dependence between specific products (e.g., storing measles vaccines requires gas for the refrigerator). The more dependence the greater is the need for coordination in procurement and other tasks. Predictability is the degree to which it is possible to specify the task to perform at a given point in time (e.g., how will an outbreak of a specific disease or a large donation of a specific drug impact the existing supply chain and extra tasks that must be undertaken). In general, higher complexity, more dependency, and lower predictability imply bigger stocks to safeguard against shortages, lower inventory turnover, and less flexibility.

4.3 Management

Finally, management of the response cycle is based on three concepts. Principles are methods (such as the pull/push system and forecasting techniques) to manage the supply chain. Tools relate to how information is processed and communicated, and the systems used for inventory and ordering management (for example, stock cards, electronic order forms). The final point addresses how actors are organized in terms of responsibilities regarding specialization and coordination (for example, whether a third-party provider is used, and how a cooperation agreement is set up). Consistent and differentiated principles supported by appropriate tools and organizational balancing between specialization and integration are essential for securing efficient goods and information flows.

4.4 Improving performance by redesigning the logistics processes

The framework proposes a number of strategies to improve performance (Persson 1995):

- Reducing or redistributing lead times
- Reducing or adapting to uncertainties
- Redistributing or increasing frequencies
- Eliminating or adapting to expected demand patterns
- Simplifying structures, systems and processes such as reducing the number of distribution points and/or levels
- Differentiating the way one works with suppliers, products and customers
- Using postponement strategies so that changes in form, identity, and location occur as late as possible in the supply chain
- Improving information processing and decision support systems
- Strengthening internal and external integration.

The strategies are highly linked. Increased order frequency and structure simplification by reducing the number of storage levels can for example reduce lead times which then lowers uncertainties. The goal is to avoid high inventory with according costs and risks of obsolescence and damage, while providing flexibility with short and predictable delivery times.

Typical logistical tools to handle uncertainties include inventory and materials management to get better control, forecasting and/or use of pull principles, and safety stocks to cope with uncertainties in demand (Chopra and Meindl, 2010). Replenishment policies, such as continuous or periodic review, are important to keep overview of stocks. The 1970s, with the simple use of rules of thumb, combined with lack of coordination between stock locations, gave “a bloated inventory system with relatively poor service levels” (ibid, p.334). Recent research has shown that decentralization of decisions concerning inventories makes it is difficult to reduce overall inventory levels in the supply chain (De Leeuw et al. (2011, p.451).

Despite its shortcomings, forecasting is still a critical management tool to reduce uncertainty, particularly if combined with cooperation in the supply chain (Simchi-Levi, 2004, p.32). The accuracy of forecasting in push-based supply chains can improve with shorter lead times and thus limit disadvantages of push such as obsolete inventory and inability to meet changing demand. Shorter lead-times can also make it possible to change to pull (order-based) systems. Disadvantages of pull-based supply chains include less ability to take advantage of economies of scale and difficulty with implementation unless lead times are very short. Hence, solutions that combine push with pull strategies are sought. Postponement exemplifies this. Typically, a portion of the supply chain prior to differentiation is operated with push. The other part of the supply chain then uses pull to adapt to uncertainty (Simchi-Levi et al. 2004, p. 45). This can be done both for manufacturing and distribution. For example, stocks can be located further upstream in the supply chain at one central location, rather than at numerous decentralized locations. This makes it possible to reduce total stocks because of aggregation (Chopra and Meindl, 2010, p.334). This can also allow more accurate forecasting based on aggregate demand so that safety stocks can be reduced (Ibid. p.307).

4.5 Quantifying the impacts of the suggested redesigns

A cost baseline for the supply chain for two of the six tracer drugs was established and compared against the (estimated) costs of the suggested redesigns. The two drugs were selected based on convenience sampling: largest amount, and most reliable data. One was expensive with many stock shortages (ACT). The other was less expensive with fewer stock shortages (Cotrimoxazole). Lack of data on supply-chain costs in general, late deliveries, and emergency ordering costs due to stock shortages, required estimations and creativity. In response, the researchers created a simple Excel worksheet model, based on classical basic formulas that required as little information as possible. The approach is shown in Figure 3.

<insert Figure 3>

Figure 3: Modeling process and approach

This approach provides a baseline cost, assuming no stock shortages to estimate the cost of the current system with all demand fulfilled. The literature recommends using demand rather than sales (Chopra and Meindl, 2010, p.222). Annual warehousing, ordering, stock holding and transportation costs, and average stock value throughout the supply chain for each of the two drugs could then be calculated. This was compared with the cost of the suggested solutions with basis in lead time and safety-stock reductions. As in all modeling, simplifications and assumptions must be made regards data input and links between factors. In this context, where stakeholders had little or no logistics training, it was even more important to choose a simple approach to data analysis and presentation. Figure 4 provides an overview of the model, while Appendix 3 presents inputs, formulas, and assumptions.

<insert Figure 4>

Figure 4: Model for quantification of solutions' impact on performance

5. FINDINGS

Main causes for stock shortages are discussed, while also pointing out positive aspects of the supply chain. This is followed by a presentation of suggested solutions and how they may impact performance.

5.1 The Karamoja drug supply chain

While the study focused on areas in the supply chain needing improvement, the field assessment discovered many positive elements that can be used as a basis for enhancement:

- A number of the HCs throughout the region have motivated staff to provide critical services under very challenging conditions.
- Logistics processes and guidelines established through the HMIS include minimum two-month safety-stock levels, forced ordering frequencies (ref. USAID Deliver 2011, p. 57) of four times per year using a standard set of tools.
- Stock shortages are a problem, but not for all drugs and not in all facilities.
- Receiving processes throughout the system appear to work quite well.
- Some DMS managers seem to have the required formal training, experience, and motivation needed to manage logistics requirements. These individuals could support and develop others within the district and national system.

Table 3 presents common problems across districts and drugs, It shows lack of sophistication in the supply chain and big challenges in each of the processes in the response cycle, as section 4 in the framework notes:

Table 3: Results from analyzing collected data in the field assessment

Logistics Processes & Performance	Results from interviews/stock-assessments at health facilities
Forecasting	No forecasting takes place at any of the four actors at the district level
	No forecasting guidelines are available
Ordering	65 percent do not use ordering guidelines provided by the government
	88 percent have no means for electronic handling of information, some even lack calculators
	77 percent use emergency ordering
	Missing deliveries are not recorded at any level and must be re-ordered
	Ordering are constrained by lack of funding
	Lack of competence to quantify needs and place orders
	Lack of capacity (human resources) to quantify needs and place orders
Inventory management	60 percent had out-of-date stock cards for one or more of the six tracer drugs
	55 percent had missing stock cards for one or more of the six tracer drugs
	77 percent do not use inventory-management guidelines provided by the government
	No use of reference numbers on orders and delivery notes
	Lack of information on deliveries/stock shortages from the supplier NMS
	An abundance of expired drugs without means for safe disposal
	Facilities lack cooling equipment, ventilation, appropriate shelves, and cupboards with locks. Many have no electricity/limited access to water.
Transportation	Few vehicles and lack of funding to operate them; no fuel/maintenance
	Insecure and bad roads
	Lack of coordination in use of transport means
Human resources	One person in the region has a masters degree in supply-chain management
	73 percent of the facilities have vacant positions, most for a long time
Stock outs	50 percent of the health facilities were-out of ACTs on the day of the visit
	86 percent had recorded stock shortages of ACTs for the last 12 months
	Average time of ACT stock shortage was 3.35 months
	Almost all facilities reported inconsistent or no supply of ACTs
	Complexity of handling the ACT considered high because of four variants
	60 percent had stock shortages of other tracer drugs
Costs	No overviews of costs could be provided at any level of the system

Figure 5 depicts the general Karamoja drug-supply chain, including actors, their main activities, and the main lead times for information flow from orders placed by HCs until they are handled be NMS. It also shows the goods flow from picking and packing at NMS until they are received at the HCs. The total average lead time for a drug order to be fulfilled at the HCs was 61.2 days. The ordering process from the HC to NMS accounts for 20 percent of this time, internal lead time at NMS accounts for 61 percent, and transportation from NMS to the HC accounts for 19 percent.[4] The lead time is defined as the elapsed time from when the

HC identified a need to when it received the according drugs and made them available to patients. This included both ordering and receiving, as shown in Figure 5 below.

<insert Figure 5>

Figure 5: Lead times, actors, and activities undertaken in the response cycle

The NMS and HCs have responsibility for flow of information and goods, whereas health subdistricts (HSD) and district health officials (DHO) are responsible only for the information flow through order validation and accumulation from centers within their district before they pass it on to NMS. Due to lack of electronic communication, orders are physically transported from the HCs to the DHO, via the HSD to NMS, where they are submitted into the electronic system and processed. DMS act only as pass-throughs for goods moving from NMS to HCs, but some hold stocks. This seems quite coincidental and not based on any form of analysis of supply and demand.

Together with other variations among and within the districts, this results in unclear division of responsibility between actors. Combined with lack of information exchange, the result is quite a complex system with little coordination between the flows of goods and information. To make up for this complexity and keep secure from stock shortages, the government has decided that all HCs should hold two months' supply of safety stocks of the most essential drugs. However, this does not work: there is not enough supply of important drugs, while others are overstocked. Table 4 summarizes the main findings from the field assessment and analysis, with basis in the conceptual framework.

Table 4: Transactions, structure and management of the response cycle

Conceptual Framework & Supply Chain Concept		**Definition/Measure**	**Main results from field assessment**
TRANSACTION	*Lead Time*	Time from order to delivery	HC - NMS: 61.2 days of average lead time
	Frequencies	How often orders and deliveries occur	HCs order four times a year; that is, every three months
	Uncertainties	In lead times for funding, ordering, and transport Accuracy of data on demand, stocks, etc.	Large variations from one order to the next, between districts and for particular drugs Highly inaccurate data on consumption and stocks, and ordered vs. received quantities (i.e., service level).
STRUCTURE	*Distribution Levels*	Number of actors in information (order) flow at district level Number of storage levels in goods flow at the district level	4: Patient, HC, HSD, DHO 1 or 2: HC and DMS when utilized
	Distribution Points	Number of health facilities	Total of 94 in Karamoja: five hospitals, four HCIV, 29 HCIII, 55 HCII, five DMS, one NMS
MANAGEMENT	*Management Principles*	Which guidelines are used for forecasting, ordering, inventory management , storage, and transport management	No guidelines for forecasting Guidelines for quantification of ordering, storage and transport, but little knowledge and/or use.
	Management Tools	Which tools are used for forecasting, ordering, inventory management ,and transport	Hard-copy forms, no electronic data exchange, stock cards, and little means of communication apart from physically meeting each other. There are three physical flows (requiring transport) involved: bringing the order form to HCs, bringing the filled form back through to NMS, and bringing the drugs back to the HCs.
	Organization	Efficacy of management structure and clear delineation of roles/responsibilities	Lack of clear roles, too many logistics managers without adequate competency/capacity, and lack of management support or coordination.

The findings suggest there are major deficiencies in the management of the supply chain with long and erratic lead times, high supply uncertainty from NMS, and a bureaucratic ordering process involving many actors. The complexity in terms of distribution levels and points is quite high considering the lack of communication, controls, and transport, which poses particular problems for the flow of information, including ordering and feedback regarding stock shortages and deliveries. The process seems to be unnecessarily complicated, allowing inconsistencies in practice, even if the processes and responsibilities are theoretically clear.

With regard to the sharing of responsibility between HSDs, districts and HCs concerning information and goods flows, the supply chain is characterized by inconsistent planning, forecasting, ordering, and inventory management. Appropriate tools are not used. This leads to a lack of coordination between information and goods flows, with the ordering process disintegrated from follow up of medical supply deliveries. This means information is lacking on what is delivered, as compared to what was ordered. As a result, there are significant bottlenecks in the system which, combined with the inability of NMS to fulfill their critical supply role, cause frequent stock shortages, unnecessary expiration of drugs, and seemingly high cost due to emergency ordering, extra transport, and time-consuming ordering processes.

5.2 Suggested solutions with impact on performance

Based on the analysis, recommendations for improvements were suggested and quantified, using the model presented in section 4.5. The purpose was to clarify and demonstrate basic links between logistics processes and performance to the stakeholders, thus providing them with better decision support and means to ease implementation of the suggested solutions. Table 5 shows suggestions, including quick-win solutions that do not require major changes of the system itself but are necessary to rapidly reinforce the system and sustainable solutions that require more profound changes of the system. The impacts are quantified and discussed below.

Table 5: Solutions with impacts on lead time, safety stock and order frequencies

Solutions	Improvement strategies from framework: Impact on lead times, safety	% reduction	% reduction in safety	Order frequency:

	stock and order frequencies	in lead time compared to baseline (61.2 days)	stock compared to baseline (two months)	no. of orders per year
Storage Improvement Kit and Storage Remedies (Quick Win #1)	Improvement in stock-keeping at HCs results in more accurate record keeping and a better basis for correct and more efficient ordering. This reduces uncertainty and order lead time (the part that concerns time spent in HC) to NMS, with reduction in safety stocks.	0.16%	0.08%	4
Temporary Transport Loan Program (Quick Win #2)	Better access to transport reduces uncertainty and transport lead time from NMS to HCs, with according reduction in safety stocks.	2.47%	1.24%	4
Process Guideline Posters and Rapid Training (Quick Win #3)	Training and clear processes will bring an improvement in stock-keeping and stock management at HCs, resulting in correct ordering. This will reduce uncertainty and order lead time to NMS, with according reduction in safety stocks.	12.23%	6.31%	4
Electronic Data Exchange (Quick Win #4)	Electronic submission of orders reduces order lead time to NMS and internal lead time at NMS as well as uncertainties with according reduction in safety stocks.	24.46%	13.09%	4
Incorporation of District Logistics Advisor (Sustainable Solution #1)	Improved forecasting and ordering process while ensuring correct data is entered reduces order lead time to NMS and internal lead time at NMS with according reduction in safety stocks. Through a more efficient order process and with more capacity and competence, order frequency can increase, thus reducing average cycle stock.	50%	29%	8
Establish Forecasting Process and Move Ordering to District Level (Sustainable Solution #2)	As above, but even more reduction in lead time. Simplification of the structure by moving order point and incorporating HSD and district levels with the DMS (i.e., reducing complexity by fewer distribution levels and points and use of postponement). Better forecasting also means adapting to demand patterns.	60%	37%	8
Simplify and Reduce Logistics Workload at Health Centre Level (Sustainable Solution #3)	As above. It will most probably be possible to treat more patients due to increased working capacity, but this does not have a direct effect on lead time.	60%	37%	8

Set Clear Transport Financing Parameters (Sustainable Solution #4)	As above. Better funding for transport may give more secure long-term transportation of both patients and drugs, but has not been taken into account in the lead time estimation here.	60%	37%	8
Move safety stock from HCs to DMS (Sustainable Solution #5)	Because of fewer uncertainties in the system, lead times will be reduced. With reduced lead times, supply and demand uncertainty will be lower. Safety stocks at HCs are replaced by safety stocks at DMS. This means reducing the number of distribution points for stocks and postponing movement of stocks until they are needed at HC. Hence, total number of units in safety stocks decreases (formula in Appendix 3).	71%	50%	8

The purpose of quick wins is to meet problems related to lack of adequate storage facilities in HCs (QW1), transport means (QW2), supply-chain staff competence (QW3), and appropriate ordering systems QW4). Improvements in storage, transport, warehouse management, and ordering makes it possible to reduce lead times and uncertainties. This requires less safety stock and keeps down warehousing and stock-holding costs. It can be debated whether improvement of facilities (QW1) will have an effect without appropriate training (QW3) and vice-versa, as measures are highly linked. Our argument is that QW1 is a visible means of improvement to show that physical storage and control are important and can thus increase health personnel's attention to this part of their job. It becomes a step in capacity building and can motivate personnel to participate in supply-chain management training and adopt principles and routines.

Electronic ordering instead of physical transport of order forms will reduce the time it takes for an order to reach NMS, i.e. at HCs and between HCs and NMS. It will also considerably reduce the time it takes to handle orders at NMS, as well as reducing uncertainties due to mistakes in registration of hard-copy order forms. Hence, safety stock can be reduced without reducing service levels (i.e., not increasing stock shortages).

With a basis in limited capacity and resourcing at the HCs, the sustainable solutions suggest placing less supply-chain responsibility on the HCs. Instead, stronger district supply-chain hubs must be developed. By moving order points upstream to DMS, the system allows for more frequent ordering, thus reducing demand uncertainty. The sustainable solutions proposed are built on the logic that DMS order on behalf of the HCs. This order is based on demand forecasts and HCs' monthly stock reports to reduce uncertainty. These reports use systematic periodic review policies, triggering orders for commodities where stock is at the minimum level accepted (USAID Deliver 2011, p.57). At this point, the DMS receive the medical supplies from NMS for distribution to HCs. The forecast should take into account historic consumption, plus additional data on seasonal demands and population changes for each HC.

Accordingly, more responsibility is given to the districts (along with required corresponding logistics competencies and capacity) for ensuring the last mile of the distribution. This affords the HC staff more time to treat patients and focus on reporting correct information about stock levels. This centralization of inventory control makes it easier to reduce overall inventory levels in the supply chain. Linked with this transfer of responsibility, it is suggested to move safety stock from HCs to the five DMS. This will reduce the total safety stock in the system (See table 6). Because of lack of funding, there is simply not enough money in the system to keep a two-month safety stock at each HC.

Table 6: Estimating safety stock in units with use of postponement (details in Appendix 3)

ACTs - Estimating Safety Stock in Units	**HCV**	**HCII**	**HCIII**	**HCIV**	**Total**
Total safety stock with centralisation of stock					362478
Total safety stock in current system	**610165**	**380742**	**176722**	**89705**	**1257334**
Units safety stock per centre	122033	6923	6094	17941	**152990**
No. Of centres	**5**	**55**	**29**	**5**	**94**
Cotrimoxazole - Estimating Safety Stock in Units	**HCV**	**HCII**	**HCIII**	**HCIV**	**Total**
Total safety stock with centralisation of stock					164747
Total safety stock in current system	**122174**	**305744**	**109451**	**34091**	**571460**
Units safety stock per centre	24435	5559	3774	6818	**40586**
No. Of centres	**5**	**55**	**29**	**5**	**94**

In a context of poor roads, this can be risky in terms of transport times and stock shortages. However, properly managed safety stocks in the DMS (which is not far from the HCs belonging to this district) is a better option than poorly managed or nonexistent safety stock at HCs. When an HC is out of stock it can place an emergency order at the district hub rather than at NMS, which considerably shortens the lead time. While health personnel at facilities can use more of their time for treating patients, staff with supply-chain management training can take care of the logistics. Even if there was funding, it is currently very difficult to find appropriate personnel for the HCs (See table 2 stating that 73 percent of the HCs have vacant positions). The costs of additional personnel and other investments necessary to implement the solutions can be covered by the estimated cost reductions as shown in figures 6 and 7.

<insert Figure 6>

Figure 6: Cost reductions with suggested solutions co-trimoxazole

<insert Figure 7>

Figure 7: Cost reductions with suggested solutions ACT

6. CONCLUSIONS – IMPLICATIONS AND FURTHER RESEARCH

The study identified causes of stock shortages in the Karamoja public drug-supply chain and used the framework to suggest solutions in terms of shortening lead times, increasing order frequencies, and reducing uncertainties. This can be done by simplifying the structure, use of postponement, implementing better information processing, and strengthening integration. Moving ordering upstream based on forecasts, combined with stock reports from the HCs may be viewed as going from pull to push. However, the current pulling from HCs is not based on real demand or on appropriate overview of stock levels. This, combined with long ordering lead times, results in numerous stock shortages at HCs. Moving the safety stocks upstream may seem counterintuitive. However, combined with better inventory management both at the HC and DMS level, aggregation of demand and stocks will reduce uncertainties and the cost of total stock in the system.

The results from the study are very much in line with what Kaufmann et al. (2011) claim is needed: better forecasting and inventory management through integration of the supply chain, reducing complexity by eliminating stocks, and providing better information exchange and stronger supply-chain competence. In contrast to Kaufmann et al. (2011), this study developed an approach with framework and model that can demonstrate why changes improve the performance of the supply chain. Strategies for reduction of inventory as put forward in the literature (e.g., Baker, 2007) are analyzed in a new context and include means for improving visibility of end-consumer demand to all supply-chain participants, compression of total lead time and centralization of inventory.

Recent research on supply-chain complexity (Manuj and Sahin, 2011) suggests that complexity can lead to higher total costs, longer lead times, poor delivery performance, and higher uncertainty. This can be mitigated by use of information technology and training. Results from this study are partly in line with this. However, the reality of the Karamoja drug-supply chain shows that complexity does not have to be taken as a given and can be reduced through relatively simple means.

It may seem counterintuitive to meet big stock shortages with reductions in safety stock. However, by reducing uncertainties and lead times, the need for safety stocks is reduced, while at the same time avoiding under-stocking. This is line with lean principles suggesting that inventories hide problems and are wasted resources (Womack et al. 1990). The two months' safety-stock levels lead to overstocking of some drugs and results in lack of other important drugs because funding is limited. Accordingly, the challenge was to identify causes of stock shortages related to the supply chain and calculate how changes can improve the availability of drugs at the HC level, given specific constraints in terms of physical and financial infrastructures.

The framework and model was developed with simplicity in mind, balanced against the need for rigor in quantifying the impact of the suggested solutions. This is necessary in action research that "strive[s] to contribute to both the practical concerns…and to the goals of science." (Näslund, 2008, p.72).

In line with suggestions by Tatham and Pettit (2010), this study has shown how models developed for the commercial context can be applied to the humanitarian. The application of the basic model for logistics process redesign demonstrates its strengths in terms of simplicity and usefulness when information is scarce, data collection is challenging, and the main stakeholders are not competent in logistics and supply-chain management. Research should continue to focus on simple and applicable tools used in a context characterized by lack of financial resources, infrastructure, competence, and capacity.

The study provides substantial data and knowledge on an issue of great importance in most developing countries. It contributes empirical insight much needed in humanitarian logistics. Further research could link studies like this with another area of research, namely global health supply chains (e.g. Chick et al. 2008). Even though this study focus on a particular part of a specific country in the African continent, similar problems exist in other countries and regions challenged by lack of financial resources, health system infrastructure, capacity, and competence. Causes of the problems and solutions in this study are similar to those noted in other studies (e.g., Kaufmann et al., 2011), and should thus be applicable elsewhere.

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APPENDIX 1: SITE VISITS IN KARAMOJA

District	County	Sub-County	Parish	UBOS Population Projection 2008	Govt *	PNFP *	Name of the Facility		HC V Hospital	HC IV	HC III	HC II	Total no. of facilities assessed
Abim	Labwor				1		District Medical Store	1					1
Abim	Labwor	Abim Town Council	Town Council / Wiawer	5652	1		Abim		1				1
Abim	Labwor	Alerek	Koya	2681	1		Koya					1	1
Abim	Labwor	Lotukei	Awach	4059	1		Awach					1	1
Abim	Labwor	Morulem	Aremo	4707	1		Morulem				1		1
Abim				**17099**	**5**	**0**		**1**	**1**	**0**	**1**	**2**	**5**
Kaabong					1		District Medical Store	1					1
Kaabong	Dodoth	Kathile	Kathile		1		Kathile				1		1
Kaabong	Dodoth	Kalapata	Kalapata		1		Kalapata				1		1
Kaabong	Dodoth	Kalapata	Kamion		1		Kamion					1	1
Kaabong	Dodoth	Sidok	Langaro		1		Kopoth					1	1
Kaabong	Dodoth	Kaabong TC	Central		1		Kaabong		1				1
Kaabong				**281400**	**6**	**0**		**1**	**1**	**0**	**2**	**2**	**6**
Kotido					1		District Medical Store	1					1
Kotido	Jie	Kacheri	Kacheri		1		Kacheri				1		1
Kotido	Jie	Kacheri	Losakucha		1		Losakucha					1	1
Kotido	Jie	Kotido TC	Kotido west		1		Kotido			1			1
Kotido	Jie	Panyangara	Loletio		1		Panyangara					1	1
Kotido				**179306**	**5**	**0**		**1**	**0**	**1**	**1**	**2**	**5**
Moroto					1		District Medical Store	1					1
Moroto	Bokora	Lopeei	Lopeei	5000	1		Lopeei				1		1
Moroto	Bokora	Matany	Lukuwas	13100		1	Matany Hospital		1				1
Moroto	Bokora	Iriir	Iriir	10400	1		Iriri				1		1
Moroto	Matheniko	Katikekile	Natumukale	5300	1		Lopelipel					1	1
Moroto	Matheniko	Katikekile	Tapac	7500		1	Tapac				1		1
Moroto				**41300**	**4**	**2**		**1**	**1**	**0**	**3**	**1**	**6**
Nakapiripirit					1		District Medical Store	1					1
Nakapiripirit	Pian	Lolachat	Lotaruk	4700	1		Lolachat				1		1
Nakapiripirit	Chekwi	Kamkomogole	Tokora	3600	1		Tokora			1			1
Nakapiripirit	Chekwi	Namalu	Loregae	14600	1		Nabulenger					1	1
Nakapiripirit	Pokot	Karita	Karita	13400	1		Karita				1		1
Nakapiripirit				**36300**	**5**	**0**		**1**	**0**	**1**	**2**	**1**	**5**

APPENDIX 2: LIST OF INTERVIEWS

Organization	Interviewee	Position/Location	Interview Date
Chief, Moroto Zonal Office for Karamoja and Teso, UNICEF	Narinder Sharma	Moroto	Various
Admin Assistant, UNICEF	Thomas Ochom	Moroto	Various
Health & Nutrition, UNICEF	Joanna Nikulin	Moroto	Various
HIV specialist, UNICEF	Francis Nyakojoo	Moroto	Various
Health & Nutrition, UNICEF	Charles Wilfred Ochieng	Moroto	Various
Nutrition Specialist, UNICEF	Brenda Akwanyi	Moroto	Various
World Food Programme (WFP)	Rohit Pal	Moroto	Various
UNICEF	Dr. Claudia Hudspeth	Chief, Health & Nutrition	03.10.09
MoH	Ms. Khalid Mohammed	Consultant at Pharmacy Division, Coordinator of the NPSSP Plan	20.10.09
JMS	Mr. Andrew C.W. Nsubuga	Operations Manager	20.10.09
WHO	Dr. Soloman Fisseha	Medical Officer and Emergency Cluster Lead Co-ordinator	21.10.09
MoH	Dr. Martin Oteba	Assistant Commissioner in Charge of Pharmaceutical Supplies, International Health Specialist,	22.10.09

		Pharmacist	
MoH	Dr. Gideon Kisuule	Principal Pharmacist, Pharmacy Division	22.10.09
NMS	Mr. Kamabare Moses	General Manager	23.10.09
Kampala Pharmaceutical Industries Ltd.	Mr. Anthony Kuria	Business Development Manager	23.10.09
Quality Chemicals Industries Ltd	Mr. Nalima Geofrey	Marketing Manager	26.10.09
NDA	B. Pharm Okello Okidi Simmons	Inspector of Drugs	27.10.09
Danida	Mr. Frans Bosman	Medicines Management Advisor	28.10.09
Danida	Mr. Claes Brom	Senior Advisor	28.10.09
SURE	Ms. Birna Trap	Chief of Party	28.10.09
UNICEF	Ms. Anna Spindler	Supply Manager	23. & 30.10.09
ICRC	Dr. Stephane Du Mortier	Medical Co-ordinator	02.11.09
UNFPA	Dr. Ismail Ndifuna	National Programme Officer (Reproductive Health)	02.11.09
UNFPA	Dr. Primo Madra	National Programme Officer (Emergencies)	02.11.09
UNICEF	Mr. Phillips LimLim	Programme Officer, Health & Nutrition	03.11.09
DHI	Dr Martin Lyra	Moroto	09.11.09
OCHA	Kasper Enghorg	Moroto	09.11.09
Health Sub-District Matany Hospital	Achia Debora in the absence of Dr Bruno	Moroto (Matany Hospital)	10.11.09
CUAMM- TA	Dr Bernard Otucu	Moroto	11.11.09
Senior Supplies Officer	Locul Festo	District Medical Store, Moroto	11.11.09
Senior Nurse	Sister Rosario	Matany Hospital, Moroto	11.11.09
Registered Midwife	Irene Apio	Tapac HCIII, Moroto	12.11.09
Enrolled Nurse	David Loitakol	Lopelipel HCII Moroto	12.11.09
Nursing Officer	Koder Joshua	Lopeei HCIII, Moroto	13.11.09
CAO	Walakira Paul	Kotido	16.11.09
Store Assistant	Mary Mudong	Kotido HCIV	16.11.09
Clinical Officer	Joseph Sapurr	Kotido HCIV	16.11.09
Senior Clinical Officer	Ignatius Lodokyo	Kacheri HCIII, Kotodo	17.11.09
Nursing Assistant	Labega Ensio	Losakucha HCII, Kotido	17.11.09
Nursing Officer	Moding Celestine	Panyangara HCIII, Kotodo	18.11.09
DHO	Dr Omeke Michael	Moroto	19.11.09
DHO	Dr Okio Talamoi	Kotido	16. & 19.11.09
CUAMM – TA	Dr Philip Olinga	Kotido	16. & 19.11.09

CUAMM- TA	Dr Rogers Ayoko	Abim	19.11.09
DHO	Dr Kisambu James	Kaabong	19.11.09
CUAMM –TA	Dr Simon Aliga	Kaabong	19.11.09
CUAMM –TA	Tudo John Bosco	Nakapiripirit	19.11.09
Nakapiripirit DHI	Philip Siloi	Nakapiripirit	19.11.09
IRC	Raphael Ogutu & Mr. Epiu Leonard Stephen	Moroto	19.11.09
HCT/PMTCT	Aboka Moses	Moroto	19.11.09
ACF-USA	Edward Kutindo	Moroto	19.11.09
CUAMM- TA Regional	Dr Giovanni Dallogilo	Moroto	20.11.09
Italian Embassy, Development Cooperation Office	Dr Pier Luifi Rossanigo	Moroto Diocese	20.11.09
Store Assistant	Goeffey Okogo	District Medical Store, Abim	23.11.09
Store health Assistant	Owilli John Logira	HCV Abim Hospital	23.11.09
Nursing Officer	Ojum Benson	Koya HCII, Abim	24.11.09
Nursing Assistant	Akidi Christie	Awach HCII, Abim	24.11.09
Accounting Assistant	Basil	Morulem HCIII, Abim	24.11.09
Record Assistant	Bradford	Morulem HCIII, Abim	24.11.09
Supplies Officer	Max Ben	District Medical Store, Kotido	25.11.09
Health Sub-District	Dr Sherif	Kaabong	26.11.09
Senior Supplies Officer	Lokiru Gabriel Tirach	District Medical Store, Kaabong	26.11.09
Assistant supply officer	Ayolo Alex Alinga	HCV Kaabong Hospital	26.11.09
Store Assistant	Betty Ayola	HCV Kaabong Hospital	26.11.09
Senior clinical officer	Angella John Bosco	Kathile HCIII, Kaabong	26.11.09
Nursing Assistant	Chilla Methew	Kamion HCII, Kaabong	30.11.09
Registered Comprehensive Nurse	Omara Alfred Daniel	Kalapata HCIII, Kaabong	30.11.09
Registered Comprehensive Nurse	Okello William	Kopoth HCII, Kaabong	01.12.09
Nursing assistant	Logwe Zakary	Kopoth HCII, Kaabong	01.12.09
Nakapiripirit DHO	Dr John Anguzu	Nakapiripirit	02.12.09
Assistant Supply Officer	Edward Ogwang	District Medical Store, Nakapiripirit	03.12.09
Senior Nursing Officer	Langgin Sisto Assis	Tokora HCIV, Nakapiripirit	03.12.09
Clinical Officer	Turkey Solomon	Karita HCIII, Nakapiripirit	03.12.09
Registered Midwife	Alirach Jane	Karita HCIII, Nakapiripirit	03.12.09
Nursing Assistant	Boniface Chuma	Nabulenger HCII, Nakapiripirit	04.12.09
Enrolled Nurse	Limlim Teddy	Lolochat HCIII, Nakapiripirit	04.12.09

APPENDIX 3: INPUT AND ASSUMPTIONS FOR MODEL

With basis in order frequency, lead time, consumption data and cost estimates (warehousing, order, transport and stock holding cost) the model calculates order quantity, average units in stock and safety stock levels

Input data:

INPUT DATA	SOURCE/ESTIMATION HC
No. of health centers of each level (II, III, IV)	List from OCHA 10th June 2009 excluding 'non-functional' centers.
Consumption in pills/month at different HC levels	From field assessment: Usage last 12 months in each HC divided by the number of months when the drugs are available (12 less no. of months with stock shortages). Consumption per HC-type is then multiplied by no. of the same HCs.
Average Unit cost (Procurement cost per unit)	ACT: Values from HMIS018 form: Average (of the 4 types): 0,115USD per pill. Co-trimoxazole 480gr: Values from HMIS018 form: 0,0120 per pill.
Order cost per order	From field assessment: Time spent on ordering * Wage for HC-personnel*share of total order
Transport cost/order	Based on field assessment and data from UNICEF: Distances and transport costs Kampala to Karamoja and District HCs respectively in MT/km. Conversion ratios to m3/km and share of order for each drug.
Stock holding cost includes interest rate, obsolescence, leakage, etc.	Set at 24 percent of stock value. High because of much leakage; that is, the more drugs in the supply chain, the more leakage.
Safety stock level starting value	HMIS guidelines: Minimum stock level of two months' consumption (real demand; that is, corrected for stock shortages).

Formulas:

Order quantity = annual consumption/order frequency
Average units in stock = (order quantity-safety stock)/2+safety stock
Safety stock units = safety stock level*consumption
Safety stock = starting value safety stock* square root of lead time*starting value lead time
Starting values =
-- Lead times (two months)
-- Safety stock (two months' demand (assuming no stock shortages)
-- Order frequency (four per year)

Assumptions:

Current system is modeled without DMS which is an underestimation of real cost as they do help in ordering and transport as well as some of them keeping stocks. The same assumption is used in the modeling of all new solutions. Full implementation of all solutions is modeled with DMS only as a place for keeping safety stock on behalf of the health facilities adding an uncertainty factor of 25 percent to account for the special circumstances in the region. This has been calculated as follows:

Total stock in new system = 1.25*(square root (no. of storage points in new system; i.e., 5)/square root (no. of storage points in current system, i.e. 94))*(total stock in current system) (see, e.g., Maister, 1976)

Quantification of performance impact from solutions:

Each solution's impact was quantified in terms of percent-reduction in lead times based on the conceptual framework and other literature, secondary sources and the field assessment. The suggested lead time reductions in percent can be debated, but lack of data required assumptions, taking the specific context into account. In the table QW1-QW4 relate to what are commented upon as 'quick-wins' in the text, while 'SS' refers to 'sustainable solutions'. The numbers provided are lead time in days.

Lead time	Current System	QW1	QW2	QW3	QW4	SS1	SS2	SS3	SS4	SS5
Order HC	1.0000	**0.9000**	**0.8800**	**0.8500**	**0.7000**	**0.5000**	**0.4000**	**0.4000**	**0.4000**	**0.2500**
Order to NMS	11.2000	11.2000	11.2000	**9.5200**	**7.8400**	**5.6000**	**4.4800**	**4.4800**	**4.4800**	**2.8000**
Order at NMS	26.1000	26.1000	26.1000	**22.1850**	**18.2700**	**13.0500**	**10.4400**	**10.4400**	**10.4400**	**6.5250**

Pack at NMS	11.3000	11.3000	11.3000	11.3000	11.3000	**5.6500**	**4.5200**	**4.5200**	**4.5200**	**2.8250**
Transport	9.6000	9.6000	**8.4480**	**8.1600**	**6.7200**	**4.8000**	**3.8400**	**3.8400**	**3.8400**	**2.4000**
Receipt HC	2.0000	2.0000	1.7600	**1.7000**	**1.4000**	**1.0000**	**0.8000**	**0.8000**	**0.8000**	**0.5000**
Total Lead Time in days	61.2000	61.1000	59.6880	53.7150	46.2300	30.6000	24.4800	24.4800	24.4800	15.3000
Total in months	2.0400	2.0367	1.9896	1.7905	1.5410	1.0200	0.8160	0.8160	0.8160	0.5100
% change specific lead time (bold)	0 %	10 %	12 %	15 %	30 %	50 %	60 %	60 %	60 %	75 %
Safety stock level	2.0000	1.9984	1.9751	1.8737	1.7383	1.4142	1.2649	1.2649	1.2649	1.0000
Order frequency	4	4	4	4	4	8	8	8	8	8

[1]Although a number of these sources refer to the Ministry of Health (MoH), they were undertaken by consultants and researchers on behalf of the MoH, not by the MoH itself. Naturally, however, care should be taken when it comes to objectivity, which is why data has been cross-referenced. Lack of data is one of the challenges in developing countries. By meeting a large number of stakeholders and working in Uganda on behalf of UNICEF for such a long time, this project had access to data that would otherwise have been inaccessible.

[2]Available from the authors upon request.

[3]For the sake of anonymity, interviews undertaken are numbered and do not correspond to the listing in Annex 2.

[4]Numbers have been calculated from results from previous studies (MoH 2009d), our own field assessment in Karamoja and interviews at district and national level. They represent averages across all drugs and are based on samples of orders and health centers.