The procurement and supply chain strengthening project: Improving public health supply chains for better access to HIV medicines, Uganda 2011-2016

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Abstract

With countries moving towards reaching the UNAIDS 90-90-90 goal to achieve HIV epidemic control, there are going to be an unprecedented number of persons tested, treated, and regularly monitored for viral suppression. However, most of the countries with the greatest burden of HIV/AIDS experience regular stock outages which could be detrimental to reaching these targets. Antiretroviral therapy and other commodities such as HIV test kits and laboratory supplies need to be readily and consistently available in order to achieve these targets. Medical Access Uganda Limited implemented several interventions as part of a procurement and supply chain strengthening project with the ultimate goal of supply chain improvement for access to HIV medicines. These interventions were evaluated using performance-monitoring-indicators from 2011-2016. We tested for the significance in the change in scores of performance-monitoring-indicators using the test for difference in proportions. Health facilities were scored on six categories and accredited as bronze, silver, or gold based on their total scores. Kaplan Meier estimates were computed for time to silver and gold ranking and Cox proportional hazards models were computed for time to gold ranking. The 13 sites with a baseline score <50 achieved a final score of (Unranked=0,Bronze(50-69)=2,Silver(70-89)=8,Gold(≥90)=3), 44 sites with a baseline score 50-69 achieved a final score of (U=0,B=0,S=26,G=18), 106 sites with a baseline score 70-89 achieved a final score of (U=0,B=3,S=62,B=41) and 31 sites with a baseline score ≥90 achieved a final score of (U=0,B=1,S=10,G=20). We observed a significant reduction in reported stock outs from 46%-4% (p<0.001). Accurate stock card inventory rose from 79%-91% (p<0.001); adequate stock levels from 54%-71% (p=0.002) and stock reporting rates from 91%-100% (p<0.001). The stock order fill rate improved from 93%-97% (p=0.375). Patient load (medium vs low adjusted hazard ratio (aHR):2.19,p=0.026; high vs low aHR:2.97,p=0.034) and number of support supervision visits (6-10 aHR:3.33,p=0.024; >10 aHR:5.78,p= 0.003) were associated with better stock management ranking scores. Improvements in supply chain management in countries committed to achieving the 90-90-90 goals are crucial to achieving HIV epidemic control. Health system strengthening and mentorship investments in Uganda were feasible and are essential for sustainable disease control efforts.

Background

With countries moving towards achieving the Joint United Nations Programme on HIV/AIDS (UNAIDS) 90–90–90 goal to achieve HIV epidemic control, the number of patients on antiretroviral therapy (ART) is increasing steadily[1,2]. However, a question still remains on the ability of the prevailing systems to reach, treat, and suppress the prevalent cohort of 25.6 million people living with HIV (PLHIV) in sub-Saharan Africa (SSA) [3]. To achieve the ambitious goal of population viral load suppression, it is critical to ensure timely supply of antiretrovirals (ARVs). In SSA, many countries have weak supply chain management (SCM) systems[4].

Despite unprecedented investment in SCM for HIV since 2010, many SSA countries still report widespread stock-outs of essential medications. A pilot study in Ethiopia in 2015, for example, reported 21% of health centers and hospitals having no ARVs and 33% of health posts having no rapid HIV tests[5]. Indeed, a

dysfunctional supply chain impedes the whole HIV test and treat cascade in terms of number of people tested, numbers of people testing positive who can start ART, and risk of disease progression for patients on ART due to supply ruptures. This adversely impacts population HIV suppression and, moreover, may have far reaching implications in terms of HIV drug resistance as a result of suboptimal drug adherence due to ARV stock outs[6].

Many of the problems in SCM can be categorized as either micro level (organizational) or macro level (nationwide constraints, i.e., road networks, accessibility demographics, national medicine policies). At the micro level, the supply chain is made up of a number of steps such as procurement, warehousing, and distribution, there are a number of potential areas to address in order to improve SCM. Whereas a lot has been done to improve the “first mile” (quantification, ordering, production, shipping, customs clearance, and miscellaneous in-country requirements) in national SCM; this on its own is not sufficient. While we find that nationwide stock outs are rare, it is common at the facility and community level[7,8]. We believe that more emphasis needs to be placed on the “last mile” (distribution from warehouses to the final destination in the health facilities and community) of the micro level supply chain to achieve the UNAIDS HIV targets.

SCM is increasingly difficult in SSA due to diversity of ARVs, the large numbers of health facilities, and the reach into remote rural areas[9,10]. Archaic stock management practices and poor national infrastructure further exacerbate the situation. For example, wastage due to expiry and loss due to damage and mishandling are quite common and unacceptable given the need and the costs of these medications. Furthermore, a lack of health workers in SSA, including fewer than one pharmacist per 10,000 population is a barrier to achieving epidemic control[11,12]. Positive patient-level interventions may not achieve favorable treatment outcomes if they are not combined with micro-level SCM interventions[13].

In 1998, Medical Access Uganda Limited (MAUL) was started as a pilot project of UNAIDS in SSA. Since then, MAUL has proven groundbreaking and has developed and implemented public health SCM solutions to ensure access to quality HIV healthcare for the people of Uganda. MAUL is a not-for-profit Ugandan organization that specializes in logistics and supply chain technical assistance and service provision in SSA.

We identified two broad categories of constraints in SCM in Uganda that needed to be addressed: endogenous (within MAUL) and exogenous (stemming from health facility (HF) level) operational constraints. Inadequate use of stock data and expiry dates, as well as a lack of adequate communication between facilities and with the regional and central distribution stores meant that we were missing out on stock redistribution opportunities to prevent stock outs. Lack of a computer, reliable power source, or reliable internet connectivity were communication barriers in a number of health facilities which led to delays in placing ARV and HIV test kit orders. As a result, order reporting rates were below 80% and order timeliness (defined as an order received before the 5th of every month) was 68% in 2010.

Here we present the experience of MAUL procurement and supply chain strengthening project operations in Uganda, the interventions used, and how these interventions improved SCM.

Methods

Setting:

MAUL was awarded a five-year United States (U.S.) President's Emergency Plan for AIDS Relief (PEPFAR) grant in 2011, through the U.S. Department of Health & Human Services (HHS) under the U.S. Centers for Disease Control & Prevention (CDC) to implement the Procurement & Supply Chain Strengthening Project (PSSP). The main goal was to support procurement and logistics management services for HIV/AIDS-related commodities – including ARVs, medicines for opportunistic infections (OIs), laboratory reagents, equipment, and consumables to private, not-for-profit (PNFP) HFs and strengthen institutional capacity for management of HIV/AIDS logistics services. Project funding increased from U.S. dollars (USD) 7.6 million in 2011-12, to USD 46 million in 2012-13 and USD 60 million in 2015-16. PSSP provides ARVs to over 250,000 patients in 216 participating HFs across 62 districts in Uganda in 2015-16.

Overtime, we implemented four major interventions to address these constraints at the HF level, including Mentorship and Technical Health Systems Strengthening (MaTHSS) supportive supervision model in 2011-12, the Field Report on Stock Tracker (FROST), Geographic Information Systems (GIS), and WhatsApp® Messenger in 2014 in an attempt to improve SCM indicators.

Interventions to address the gaps:

The Mentorship and Technical Health Systems Strengthening (MaTHSS) Supportive Supervision Model:

Starting in 2012 and implemented in 198 HFs, we combined on-site mentorship, training on Logistic Management Information Systems (LMIS) and SCM and monthly supportive supervision to achieve defined goals. Regional Field Support Officers (RFSOs) performed on-site mentorship of HF staff during monthly supportive supervision visits. Trainings were performed by a team comprised of supply chain technical officers, monitoring and evaluation, LMIS, and field operations teams.

HFs were assessed using the Supportive Supervision Monitoring Tool (SSMT) that scored them in six broad categories: 1) stock management, 2) product organization, 3) dispensary, lab, and stores management, 4) dispensing aids and tools, 5) ordering and reporting, and 6) expiry tracking. Each category had a maximum score possible and the categories were added up to give a maximum total score. Facilities were graded in each category and their scores added up to give a facility total score. Facilities were then categorized – based on their total score as a percentage of the maximum total score possible – as unranked (<50%), bronze ranking (50-69%), silver ranking (70-90%), and gold ranking (>90%). Direct feedback was provided to HF staff, and senior management to ensure sustainable

improvement in overall performance. Facilities could graduate to a new category if they implemented recommended actions and scored in a higher category on two-three consecutive visits.

Facilities were also assessed using three internal performance monitoring indicators that recorded the number of HF personnel trained in LMIS and SCM, and the number of supportive supervision visits monthly, quarterly, and annually.

Field Report on Stock Tracker (FROST):

In 2014, we developed a field-based tool, FROST, to monitor stock levels at 191 HFs receiving ARVs and laboratory supplies. This field-based tool enabled RFSOs and logisticians to manage commodities by visualizing ARV stock levels at all HFs.

HF consumption rates and physical counts for HIV commodities were updated into FROST on a monthly basis. The tool generated available months of stock, thereby facilitating commodity decision-making for borrowing or lending of HIV commodities to and from nearby HFs.

Geographic Information Systems (GIS):

In 2014, we utilized a four-stage approach of linking LMIS to GIS. Logistics staff members were trained in GIS spatial and temporal analyses. GIS coordinates were then collected from 216 HFs. Confirmation of coordinates was done using mobile-phone reconnaissance and merged into a central-level LMIS database, to form cross-walk tables. GIS data were used together with FROST data to spatially visualize stock-on-hand, stock outs, and other important stock indicators.

WhatsApp®:

For each HF with communication problems, we identified a health worker with a smart phone. WhatsApp® Messenger was installed on the smart phone and health workers trained on how to take pictures of order reports to be forwarded to the warehouse. The image was transcribed into an electronic version and processed for resupply. Acknowledgement of receipt for all orders received at the warehouse was done immediately by warehouse staff.

Performance assessment:

All the interventions were assessed following a pre-specified Performance Monitoring Plan, a set of performance indicators developed in-house to evaluate our achievement of specified goals. These indicators are broken down into seven major categories: 1) product selection, 2) forecasting and quantification, 3) procurement, 4) storage and warehousing, 5) order processing, 6) inventory management and facility reporting, and 7) supervision and training.

Variables and definitions:

For purposes of assessing performance, the following six indicators were used;

A - Percentage of facilities with adequate stock levels of indicator commodities to ensure near-term continuous product availability (*total number of HFs reporting stock levels of indicator commodities within minimum/maximum range divided by total number of HFs*).

B - Inventory accuracy for on-hand inventory at the end of the reporting period (*number of HFs whose physical count tallies the stock card record divided by total number of HFs visited*).

C - Average percentage stock in levels at the facilities (*total number of HFs that did not report a stock out for any indicator commodity divided by the total number of HFs that reported in a cycle*).

D - Order fill rate in terms of customer receipts (*total product ordered minus total product received by HFs divided by total number of product ordered by HFs*). We also assessed timeliness, completeness, and efficiency of the distribution system.

E - Facility reporting rates (*number of HFs that submitted complete LMIS reports according to the defined reporting schedule divided by the total number of HFs reporting*).

F - Number of HF personnel trained in LMIS or SCM and number of supportive supervision visits conducted in HFs.

Data management and statistical analysis:

For this analysis, data were aggregated from several data sources including Excel spreadsheets and electronic databases developed in-house. SSMT data entry was performed using Epidata 3.1[14]. Data cleaning and consistency checks were performed on aggregated data to ensure correctness.

For HF characteristics, categorical variables were described using frequency statistics and proportions and for continuous variables we reported median and interquartile range (IQR). For changes in performance monitoring indicators we tested for the significance in the change in scores using the test for difference in proportions. Kaplan Meier estimates were computed for time to silver and gold ranking and univariate and multivariate Cox proportional hazards models were computed for time to gold ranking. All analyses were done using Stata 12.1[15].

Ethics approval and consent to participate:

All participating HFs, the Ministry of Health, and CDC Uganda co-authors provided their concurrences to publish this information. Ethical approval was obtained from Mildmay Uganda Research and Ethics Committee (#REC REF 0501-2017). This activity was reviewed in accordance with CDC human research protection procedures and determined to be research, but CDC investigators did not interact with human subjects or have access to identifiable data or specimens for research purposes.

Results

Starting with 152 HFs in 2013, by the end of the analysis period in 2016, we supplied a total of 216 HFs which were a median distance of 220 kilometers (IQR: 68, 363) from MAUL headquarters in Kampala, the capital city of Uganda. (*Figure 1*) These HFs were run by 12 PEPFAR-funded implementing partners. One HF (0.5%) was classified as a level 2 health center (HC II), 136 (63%) as HC III, 11 (5.1%) as HC IV, 37 (17.1%) as hospitals and 31 (14.4%) as special clinics. A total of 102 (47.2%) were located in central Uganda, 29 (13.4%) in the East, 31 (14.4%) in the North, 24 (11.1%) in the South West and 30 (13.9%) in the West. Median patient load in the HFs was 245.5 (IQR: 79, 1083). One HF has since been closed. *(Table 1)* The average baseline SSMT score and patient load varied by region. *(Table 2)*

MaTHSS:

Of the 216 HFs supported, 198 (91.7%) HFs received a baseline SSMT score as of June 2016. At baseline, a total of 13 HFs (6.6%) were unranked, 44 (22.2%) were categorized as bronze, 106 (53.5%) as silver, 31 (15.7%) as gold, and 4 (2%) had missing scores. At the end of the study period, 6 (3.0%) were categorized as bronze , 109 (55.1%) as silver and 83 (41.9%) as gold. (*Table 1*)

Once a HF received a baseline SSMT score, it took a median of 7.6 months (IQR: 4.1, 13.2) to achieve silver status and a further 19.2 months (IQR: 12.2, 24.3) to achieve a gold status.

Kaplan-Meier estimates showed cumulative probability of achieving silver status as 100% at 35.5 months. We observed a significant difference in time to silver status by region: Central and Eastern 35.5 months, Northern region 28.4 months, Western region 25.4 months, and Southwestern at 15.2 ($p<0.001$) *(Figure 2*).

Cumulative probability of achieving a gold status was 52.7% at 41.5 months. This was significantly different when stratified by distribution sector ($p<0.001$), region ($p<0.001$), patient load ($p=0.008$) and number of RFSO visits ($p=0.004$). (*Figure 3*)

Multivariate analysis showed that distribution sector, HF level, patient load, number of supportive supervision visits, HF start year, and baseline assessment score were all significant predictors of gold status *(Table* 3*).*

There was a significant improvement from 79% to 91% ($p<0.001$) in inventory accuracy for on-hand inventory at the end of the reporting period. A total of 929 health workers were trained in LMIS and SCM, and 1575 supportive supervision visits were also conducted *(Table 4)*. The average SSMT scores increased between baseline and the end of the reporting period for all regions. (*Figure 4*)

FROST/GIS:

Five hundred and twenty-two stock redistributions had been authorized in FROST as of August 2016 with 162 (31.0%) in 2014, 235 (45.0%) in 2015 and 125 (23.9%) in 2016. A total of 308 (59.0%) were stock redistributions of ARVs, 82 (15.7%) of laboratory equipment, 75 (14.4%) of OI medication and 57 (10.9%)

of HIV test kits. One of the major goals of FROST was to facilitate redistributions between regions; and since its inception, 8% of redistributions were between regions.

We also saw an improvement in the percentage of facilities with adequate stock levels of indicator commodities from 54% (191 HFs) to 71% (215 HFs) which was statistically significant (p=0.002) as well as average percentage stock in levels at the facilities (54% to 96%, p<0.001) over the same period *(Table 4)*.

WhatsApp®

With the introduction of WhatsApp® messenger, we saw a statistically significant improvement in facility reporting (91% (191 HFs) to 100% (215 HFs), p<0.001) as well as a slight improvement in order fill rate in terms of customer (93% to 97%, p=0.375) which was not statistically significant *(Table 4)*.

Discussion

We implemented four interventions MaTHSS, FROST, GIS, and the use of WhatsApp® messenger at the HF level in an attempt to improve SCM indicators. As a result of these interventions, we saw a rise in percentage of HFs with: accurate stock card inventory from 79% to 91%; adequate stock levels from 54% to 71%, and stock reporting rates from 91% to 100%. We also saw an improvement in the order fill rate from 93% to 97%. Most importantly, we saw a significant reduction in HFs reporting stock outs from 46% to 4% in the analysis period.

Whereas SCM is affected by a number of factors, including transportation infrastructure, our findings suggest that with innovative facility-level interventions, improvements are possible. Improvements in national infrastructure typically take longer to implement and therefore innovative solutions at the last mile (at facility level) are needed. Our findings suggest that supportive supervision plays a major role in improving stock management at facility level. Our use of RFSOs (who are all pharmacists) to train HF staff allowed for task shifting (RFSOs tasks were shifted to Trained HF staff) as we were able to use the trained HF staff on the ground and utilize the RFSOs for technical support at multiple sites. Our end goal is to sustain high performance (quality service provision) with supervision visits slowly removed due to cost. It will be important to assess sustainability given that a similar study found that sites revert back to baseline performance once interventions are discontinued[16].

Our findings also suggest that field-based stock management can greatly reduce stock outs at facility level. In addition to this, FROST allowed for quicker decision making as data were real time and stock redistributions could be authorized on the same day as the need was identified. The tool also played a major role in reducing loss due to expiries as short-dated medicines were given highest priority during redistributions. Furthermore, the possibility of stock redistribution between regions was impactful. Before FROST, each region had its own tool, every site needed to be visited before stock redistribution decisions could be made, the old tools updated manually, and past information on distribution was unavailable which made the process quite long and unnecessarily complicated. Furthermore the use of WhatsApp®

and mobile technology greatly improved our outcomes by improving the timeliness of order delivery. Another study has had similar findings using short message service[16].

The difference in time to silver status ranking by region suggests that clinics in different regions were varyingly receptive to supportive supervision, the quality of supervision received, as well as the number of supportive supervision visits. However, without facility-level data, it was hard to tease out what the main drivers for these differences were. Given the different numbers of HFs in each region, it is feasible that this could also account for some of the difference. Furthermore, given that HF characteristics varied by region on variables like the average baseline SSMT score; this could further explain these variances. It is not surprising that sites with multiple visits were more likely to reach gold status given the dependence on multiple visits to achieve gold ranking.

Stock outs remain a pertinent issue since we were unable to completely eliminate them. We must continue to minimize stock outs because we know that both the HIV treatment cascade and patient outcomes are adversely impacted by them[17,18].

We found that other factors played a major role in a facility reporting a stock out. Firstly, high staff turnover, particularly of trained staff, especially at lower level HFs. We also found a problem with fluctuating patient numbers due to high patient mobility.

Strengths and Limitations:

A major strength of this analysis was the high completeness level of data which were routinely collected from all 216 sites. The interventions were implemented in both rural and urban HFs covering a wide geographical area. The findings give a fair representation of the national picture and therefore may be relevant to SCM programs in countries with similar settings.

Given the high financial investment required, routine implementation of these interventions may not be feasible for programs in resource-limited settings like SSA. One low-cost method that can be implemented to improve reporting, transfer of relevant information for decision making, and give the most value for money was the readily available smart phone apps. Results from this evaluation provide proof that if correct interventions are applied, improvement in SCM program performance can be achieved. We also acknowledge the possibility that these analyses were affected by temporal trends.

Conclusions

Health system strengthening and mentorship are feasible at HF level. It is however only possible if the relevant human resources and financial investment in infrastructure are available to ensure its smooth implementation. Also, in cases where internet access is not ubiquitous or reliable, SCM programs should consider the potential of readily available smart phone apps to improve reporting and transfer of relevant

information. SCM programs should endeavor to link data from different facilities to improve stock redistribution potential and the use of GIS can further simplify the stock enumeration process.

Recommendations:

To achieve the UNAIDS 90–90–90 goals in SSA, limited resources will have to be distributed amongst a myriad of competing needs. We must use the available resources efficiently; encourage best practices, and minimize waste. Last mile interventions can vastly improve SCM with much less investment needed to sustain these interventions, enroll and retain more patients on treatment and keep them virally suppressed.

Abbreviations

aHR

Adjusted Harzard Ratio

AIDS

Acquired Immunal Deficiency Syndrome

ART

Antiretroviral Therapy

ARVs

Antiretrovirals

CDC

U.S. Centers for Disease Control & Prevention

CI

Confidence Interval

FROST

Field Report on Stock Tracker

GIS

Geographic Information Systems

HC

Health Center

HF

Health Facility

HHS

U.S. Department of Health & Human Services

HIV

Human Immunal Virus

IQR

Interquartile Range

LMIS

Logistic Management Information Systems

MaTHSS

Mentorship and Technical Health Systems Strengthening

MAUL

Medical Access Uganda Limited

PEPFAR

U.S. President's Emergency Plan for AIDS Relief

PLHIV

People Living with HIV

PSSP

Procurement & Supply Chain Strengthening Project

RFSOs

Regional Field Support Officers

SCM

Supply Chain Management

SSA

Sub-Saharan Africa

SSMT

Supportive Supervision Monitoring Tool

UNAIDS

the Joint United Nations Programme on HIV/AIDS

Declarations

Ethics approval and consent to participate:

Ethical approval was obtained from Mildmay Uganda Research and Ethics Committee (#REC REF 0501–2017). This activity was reviewed in accordance with CDC human research protection procedures and determined to be research, but CDC investigators did not interact with human subjects or have access to identifiable data or specimens for research purposes. Written informed consent was sought from all participating HFs.

Consent for Publication:

Not applicable. All participating HFs, the Ministry of Health, and CDC Uganda co-authors provided their concurrences to publish this information.

Availability of data and materials: The datasets used and/or analysed during the current study are available from the corresponding author on reasonable request.

Competing interests

The authors have no competing interests to declare.

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Authors Contributions:

SM1, RS - provided the project design. DE ran the data analysis. DE, PL, JO - developed structure and initial drafts. SM1, RS, SM2 - provided primary review and SW, KK, PJ, SM2, DE - provided secondary review.

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Tables

Table 1: Characteristics of health facilities analyzed on the interventions put in place to improve supply chain management in Uganda

Column categories are based on the final score	Assessed	Unranked	Bronze	Silver	Gold
Total	198	18	6	109	83
Region (n= 198)	n (%)	n (%)	n (%)	n (%)	n (%)
Central	94 (47.5)	8 (44.4)	5 (83.3)	54 (49.5)	35 (42.2)
Eastern	26 (13.1)	3 (16.7)	1 (16.7)	19 (17.4)	6 (7.2)
Northern	29 (14.6)	2 (11.1)	0 (0)	22 (20.2)	7 (8.4)
South Western	23 (11.6)	1 (5.6)	0 (0)	3 (2.8)	20 (24.1)
Western	26 (13.1)	4 (22.2)	0 (0)	11 (10.1)	15 (18.1)
Distribution Sector (n= 198)					
Sector 1	42 (21.2)	2 (11.1)	1 (16.7)	35 (32.1)	6 (7.2)
Sector 2	16 (8.1)	1 (5.6)	0 (0)	9 (8.3)	7 (8.4)
Sector 3	32 (16.2)	3 (16.7)	1 (16.7)	21 (19.3)	10 (12.0)
Sector 4	73 (36.9)	10 (55.6)	2 (33.3)	24 (22)	47 (56.6)
Sector 5	35 (17.7)	2 (11.1)	2 (33.3)	20 (18.3)	13 (15.7)
Health Facility Level (n= 198)					
HC II	1 (0.5)	0 (0)	1 (16.7)	0 (0)	0 (0)
HC III	120 (60.6)	16 (88.9)	3 (50)	74 (67.9)	43 (51.8)
HC IV	11 (5.6)	0 (0)	0 (0)	4 (3.7)	7 (8.4)
Hospital	35 (17.7)	2 (11.1)	0 (0)	16 (14.7)	19 (22.9)
Special Clinic	31 (15.7)	0 (0)	2 (33.3)	15 (13.8)	14 (16.9)
Patient Load (n= 198)					
Low Volume (< 100)	55 (27.8)		0 (0)	42 (38.5)	13 (15.7)
Medium Volume (100 -999)	87 (43.9)		1 (16.7)	43 (39.4)	43 (51.8)
High Volume (≥ 1000)	52 (26.3)		1 (16.7)	24 (22)	27 (32.5)
Missing	4 (2.0)		4 (66.7)	0 (0)	0 (0)
Supportive supervision visits (n= 198)					
≤ 5	38 (19.2)		6 (100)	25 (22.9)	7 (8.4)
6-10	113 (57.1)		0 (0)	69 (63.3)	44 (53)
> 10	47 (23.7)		0 (0)	15 (13.8)	32 (38.6)
Status (n= 198)					
Active – Ranked at baseline	194 (98.0)		6 (100)	108 (99.1)	80 (96.4)
Not Ranked/Score missing at baseline	4 (2.0)		0 (0)	1 (0.9)	3 (3.6)
Start year (n= 198)					
2013	152 (76.8)		0 (0)	84 (77.1)	68 (81.9)
2014	36 (18.2)		2 (33.3)	21 (19.3)	13 (15.7)
2015	7 (3.5)		1 (16.7)	4 (3.7)	2 (2.4)
2016	3 (1.5)		3 (50)	0 (0)	0 (0)
Baseline assessment score (n= 198) §					
<50	13 (6.6)		2 (33.3)	8 (7.3)	3 (3.6)
50-69	44 (22.2)		0 (0)	26 (23.9)	18 (21.7)
70-89	106 (53.5)		3 (50)	62 (56.9)	41 (49.4)
≥90	31 (15.7)		1 (16.7)	10 (9.2)	20 (24.1)
Missing/classification score at baseline	4 (2.0)		0 (0)	3 (2.8)	1 (1.2)

- *18 Health facilities were not assessed as of June 2016*

Continuous variables
Distance from headquarters to health facility served (Km) (number of sites =204); Median (IQR) 220 (68, 363)
Patient numbers in a health facility served (number of sites = 194); Median (IQR) 245.5 (79, 1,083). In total, 216 sites were listed to receive services, of which 18 were not assessed at baseline and during follow-up (1 closed, 6 inactive, 11 not visited),
4 sites' rank scores at baseline were missing, but had final scores.

Table 2: Characteristics of the 216 health facilities supported to implement the interventions put in place to improve supply chain management in Uganda by region

Region	Central	Eastern	Northern	South Western	Western
	Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)
Average baseline SSMT score (%)	74.32 (13.8)	67.81(16.3)	80.52(10.5)	87.78 (6.4)	70.58 (17.8)
Average Distance from regional office (Km)	74.43 (64.5)	88.36 (63.8)	117.96 (94.8)	107.74 (74.2)	58.83 (40.5)
Average distance from headquarters (Km)	74.43 (64.5)	271.74 (91.4)	455.23 (62.9)	361.08 (59.0)	301.59 (61.9)
	N (%)	N (%)	N (%)	N (%)	N (%)
Patient Load (n=194)					
Low (<100)	21 (20.6)	10 (34.5)	15 (48.4)	5 (20.8)	4 (13.3)
Medium (100-999)	43 (42.2)	6 (20.7)	8 (25.8)	10 (41.7)	20 (66.7)
High (>=1000)	27 (26.5)	9 (31.0)	6 (19.4)	8 (33.3)	2 (6.7)
Missing	11 (10.8)	4 (13.8)	2 (6.5)	1 (4.2)	4 (13.3)
Health Facility Level (n=216)					
HC II	1 (0.98)	0(0)	0(0)	0(0)	0(0)
HC III	60 (58.8)	17 (58.6)	23 (74.2)	11 (45.8)	25 (83.3)
HC IV	5 (4.9)	1 (3.4)	0 (0)	3 (12.5)	2 (6.7)
Hospital	14 (13.7)	6 (20.7)	7 (22.6)	7 (29.2)	3 (10)
Special Clinic	22 (21.6)	5 (17.2)	1 (3.2)	3 (12.5)	0 (0)

Note: SSMT is Supportive Supervision Monitoring Tool
SD is Standard Deviation

Table 3: Factors associated with achieving a gold ranking in the health facilities evaluated on health system strengthening in the procurement and supply chain strengthening project (PSSP), Uganda 2011-2016

Variables	All	Gold	cHR [95% CI]	p-value	aHR [95% CI] (n= 190)	p-value
Total	**216**	**83**				
Region (n= 216)	**n (%)**	**n (%)**				
Central	102 (47.2)	35 (42.2)	Reference			
Eastern	29 (13.4)	6 (7.2)	0.55	0.178		
Northern	31 (14.4)	7 (8.4)	0.52	0.12		
South Western	24 (11.1)	20 (24.1)	2.98	<0.001		
Western	30 (13.9)	15 (18.1)	1.9	0.038		
Distribution Sector (n= 216)						
Sector 1	44 (20.4)	6 (7.2)	Reference		Reference	
Sector 2	17 (7.9)	7 (8.4)	3.38	0.029	4.36	0.012
Sector 3	35 (16.2)	10 (12.0)	2.13	0.144	1.72	0.315
Sector 4	83 (38.4)	47 (56.6)	5.72	<0.001	4.11	0.002
Sector 5	37 (17.1)	13 (15.7)	3	0.026	3.69	0.014
Health Facility Level (n= 216)						
HC II	1 (0.5)	0 (0)	Reference		Reference	
HC III	136 (63)	43 (51.8)	0.83	0.533	2.03	0.152
HC IV	11 (5.1)	7 (8.4)	1.67	0.266	4.70	0.01
Hospital	37 (17.1)	19 (22.9)	1.26	0.507	1.60	0.217
Special Clinic	31 (14.4)	14 (16.9)	1.00	__	1.00	__
Patient Load (n= 194)						
Low Volume (< 100)	55 (25.5)	13 (15.7)	Reference		Reference	
Medium Volume (100 -999)	87 (40.3)	43 (51.8)	2.46	0.005	2.19	0.026
High Volume (≥ 1000)	52 (24.1)	27 (32.5)	2.46	0.008	2.97	0.034
Missing	22 (10.2)	0 (0)	__			
Supportive Supervision Visits (n= 198)						
≤ 5	38 (17.6)	7 (8.4)	Reference		Reference	
6-10	113 (52.3)	44 (53)	1.5	0.319	3.33	0.024
> 10	47 (21.8)	32 (38.6)	2.83	0.013	5.78	0.003
Missing (no visits)	18 (8.3)	0 (0)	__			
Status (n= 216)						
Active	205 (94.9)	80 (96.4)	Reference			
Closed	1 (0.5)	0 (0)	1.00	__		
Not Active	10 (4.6)	3 (3.6)	1.77	0.335		
Health Facility Category (n= 216)						
Accredited	194 (89.8)	83 (100)	Reference			
Accredited (Closed)	1 (0.5)	0 (0)	1.00	__		
For Accreditation	21 (9.7)	0 (0)	0	1		
Start Year (n= 198)						
2013	152 (70.4)	68 (81.9)	Reference		Reference	
2014	36 (16.7)	13 (15.7)	1.49	0.204	4.19	<0.001
2015	7 (3.2)	2 (2.4)	5.04	0.033	31.58	<0.001
2016	3 (1.4)	0 (0)	1.00	__	1.00	__
Missing	18 (8.3)	0 (0)	__			
Baseline Assessment Score (n= 194)						
<50	13 (6)	3 (3.6)	Reference		Reference	
50-69	44 (20.4)	18 (21.7)	1.62	0.44	2.36	0.186
70-89	106 (49.1)	41 (49.4)	1.55	0.465	1.91	0.303
≥90	31 (14.4)	20 (24.1)	3.45	0.046	4.58	0.021

Missing	22 (10.2)	1 (1.2)	__

Note: cHR is crude hazard ratio
aHR is adjusted hazard ratio
HC is Health Center

Table 4: Assessment indicators showing baseline and end line scores

Indicator	Baseline score	End-line score	p-value
Percentage of facilities with adequate stock (A)	54%	71%	0.002
Inventory accuracy (B)	79%	91%	<0.001
Average stock in levels (C)	54%	96%	<0.001
Order fill rate (D)	93%	97%	0.375
Facility reporting rates (E)	91%	100%	<0.001
Number of supportive supervision visits and personnel trained (F)	929 health workers trained and 1575 supportive supervision visits		

Figures

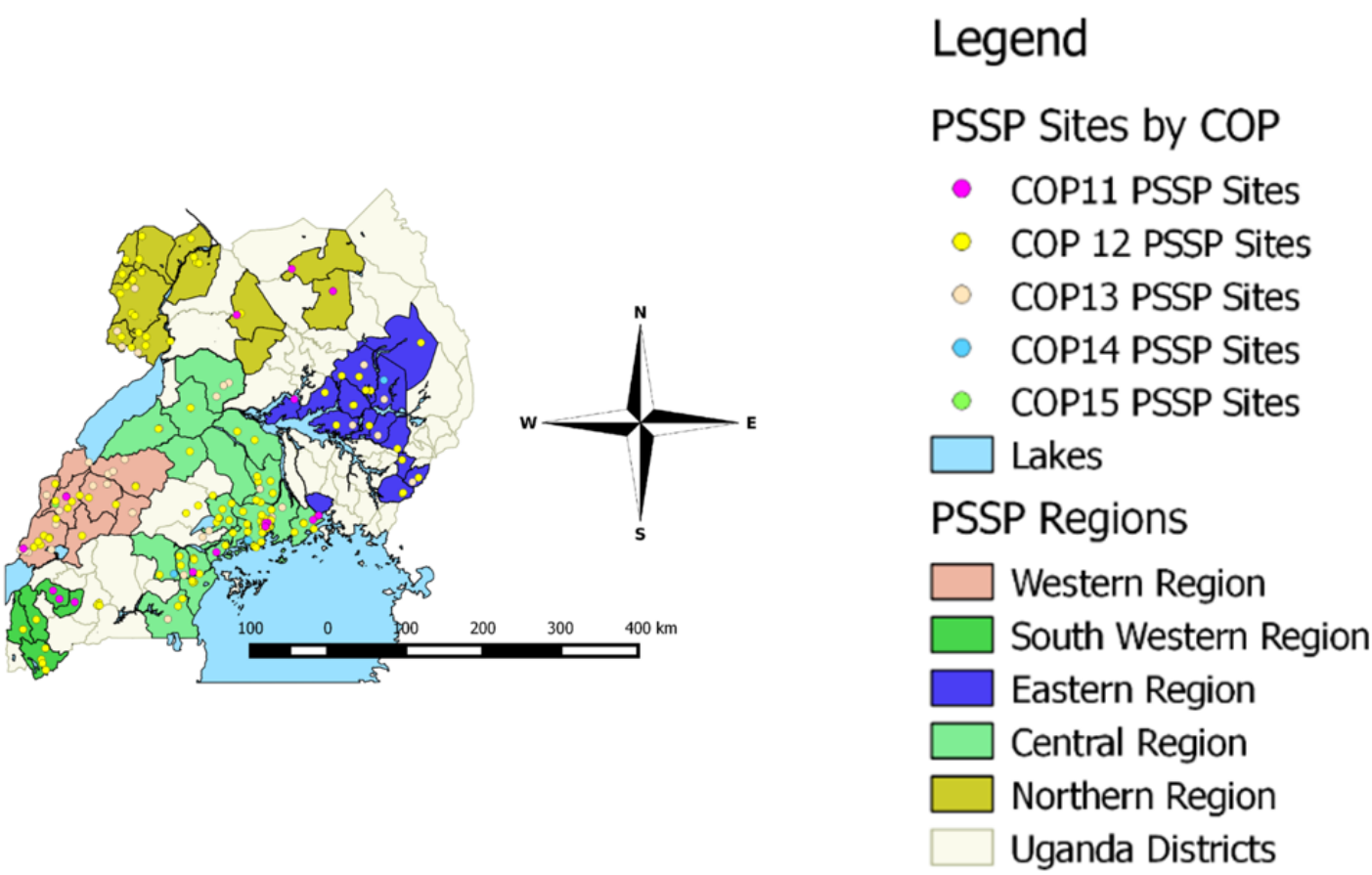

Figure 1

Map of Uganda showing the location of the health facilities and their start year Note: PSSP is procurement and supply chain strengthening project Source: Medical Access Uganda Limited

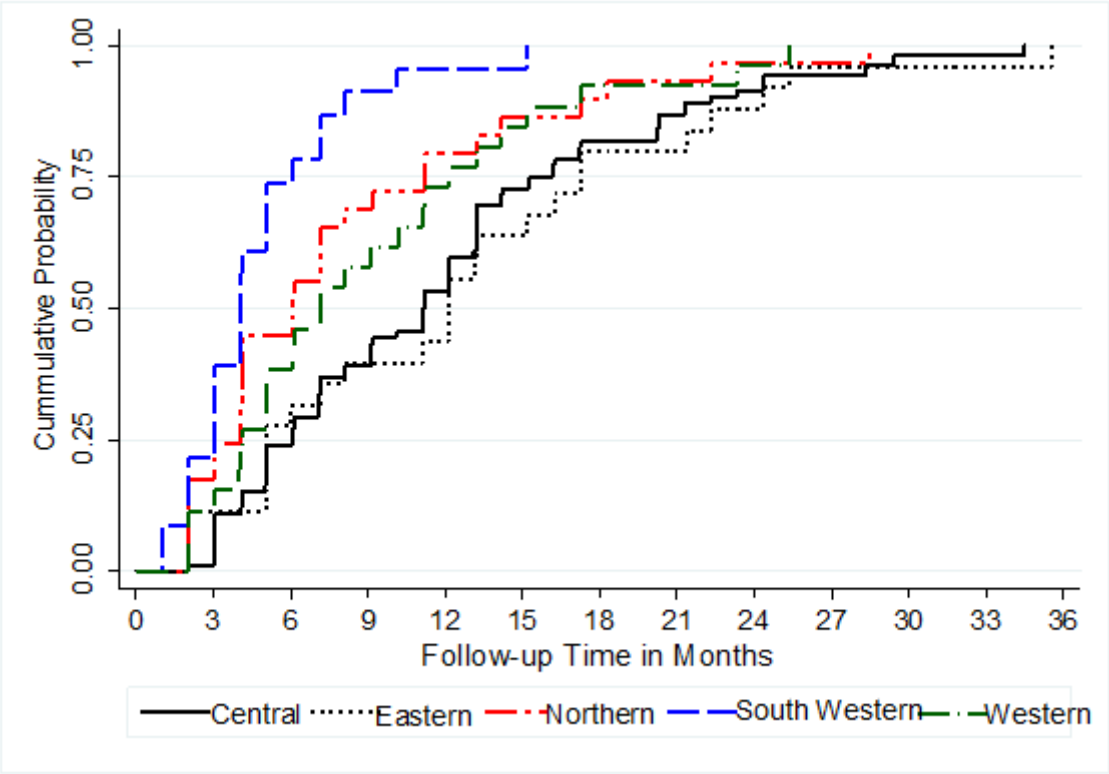

Figure 2

Kaplan-Meier curve comparing time to silver ranking of health facilities evaluated on health system strengthening in the Procurement and Supply Chain Strengthening Project (PSSP) stratified by region, Uganda 2011-2016

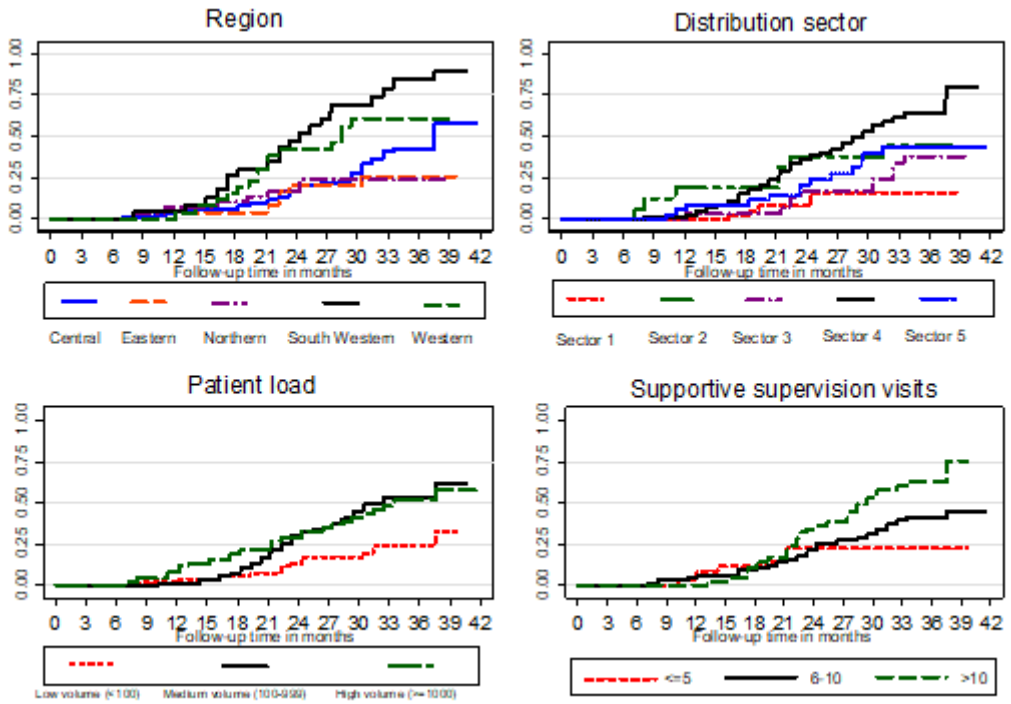

Figure 3

Kaplan-Meier curve comparing time to gold ranking of health facilities stratified by region, distribution sector, patient load, and supportive supervision visits in the procurement and supply chain strengthening project (PSSP), Uganda 2011-2016

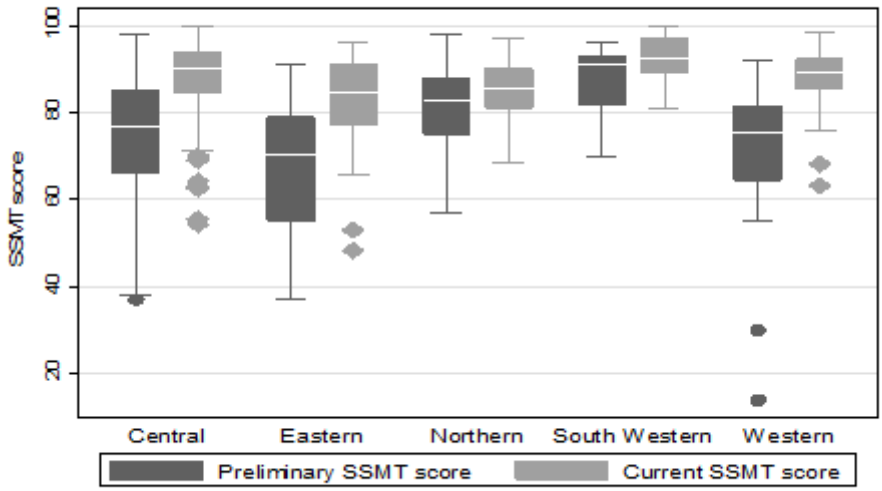

Figure 4

Average baseline Supportive Supervision Monitoring Tool (SSMT) scores and intervention follow-up SSMT scores stratified by region