Optimizing Ethiopia's Lab Referral Network

Analysis of re-design options for the lab referral network to improve efficiency and increase access, in a sustainable manner

August 2013

SCMS

Providing quality medicines for people living with and affected by HIV and AIDS

PEPFAR
Implementing Partner

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About SCMS

The Supply Chain Management System (SCMS) was established to enable the unprecedented scale-up of HIV/AIDS prevention, care and treatment programs in the developing world. SCMS procures and distributes essential medicines and health supplies, works to strengthen existing supply chains in the field, and facilitates collaboration and the exchange of information among key donors and other service providers. SCMS is an international team of 16 organizations funded by the US President's Emergency Plan for AIDS Relief (PEPFAR). The project is managed by the US Agency for International Development.

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Acronyms

AIDS	Acquired immunodeficiency syndrome
ARV	Anti-retroviral
CDC	Centers for Disease Control and Prevention
CHAI	Clinton Health Access Initiative
EHNRI	The Ethiopian Health and Nutrition Research Institute
EID	Early Infant Diagnosis (for HIV)
GIS	Geographic Information System
LDLRN	Logistically Designed Laboratory Referral Network (Document)
PEPFAR	The President's Emergency Plan For AIDS Relief
PFSA	Pharmaceutical Funding and Supply Agency (in Ethiopia)
PMTCT	Preventing Mother-to-Child Transmission
POC	Point-of-Care
SCG	Supply Chain Guru
SCMS	Supply Chain Management System

Executive Summary

This project was initiated by Supply Chain Management Systems (SCMS) to assess and optimize the laboratory referral network in Ethiopia. With a focus on increasing patients' access to necessary medical testing, many initiatives were underway in-country, mostly relating to adding machine capacity. However, many of the inefficiencies in the system stem from inefficient referral assignments, low machine utilizations, and a general lack of comprehensive data about the current operations and costs of the network. Many related organizations including the Ethiopian Health and Nutrition Research Institute (EHNRI), were involved in guiding the optimization approaches studied in this report, based on policy parameters and near-term plans.

LLamasoft, a leading supply chain design firm, was selected to lead the analysis of the network and provide an optimized solution. In order to make a sound decision based on such an analysis, accurate data is the key element. During the course of this project, the data collection, cleansing, analysis, and validation processes constituted a majority of the effort. Working closely with the SCMS team and other stakeholders, a supply chain model of the current referral network was first generated. This served as a baseline, against which to compare any changes to the network. The main elements of the network were the site locations, current referral patterns, machine locations and capacities, and historical volumes of tests.

After several discussions with key stakeholders, the focal points for the remainder of the analysis were identified. These included:

- Optimal referral assignments
- Postal system as primary collection and delivery transportation mode
- CD4 point-of-care machine deployment considerations
- Optimal considerations in response to incoming traditional CD4 machines

The following analysis shows that the current referral network can be improved significantly by re-visiting the referral patterns within the system, as a first step. It also demonstrates the need for more transparency and collaboration amongst the various stakeholders to gain a more holistic understanding of the network. This is especially important in cases where additional capacity is being introduced to an already inefficient system.

Background

Project Scope and Objective

This project was initiated by The Supply Chain Management Systems (SCMS), a project started in 2005 in order to operate and support operations related to providing care and treatment of people with HIV/AIDS and related infectious diseases. SCMS has been operating in Ethiopia since 2006, and has worked closely with the various Ethiopian national agencies to fulfill its mission. One such government agency is the Ethiopian Health and Nutrition Research Institute (EHNRI), responsible for the nation's medical laboratory service. The testing facilities, test equipment, and assignments of health facilities to lab testing sites, along with the information flows amongst the groups constitute a laboratory referral network.

The current laboratory referral network in Ethiopia was designed by EHNRI and the Regional Health Bureaus. The network has not evolved fast enough to keep up with the changing demands of the country and is proving to be expensive, inefficient, and very difficult to maintain with a proliferation of machines and very low utilization numbers. At the time of its creation, it was designed according to the locations and capacities that were in existence at the time, in addition to regional boundaries. However, this has not been regularly reviewed and updated, even though additional machines (capacity) and collection sites have been introduced to the network. Due to the regional administration of the program, the regional boundaries are enforced within the network leading to additional inefficiencies. One of the main objectives for such a network is to increase access to all those who need it. However, given funding limitations, it is not feasible to simply keep adding capacity to the network. In addition to the initial increase in capital costs this would entail, other costs incurred would be those related to the increase in required commodity stock levels (both at the site of the machine and as buffer stock at the central level), human resources, general operating costs, repair and maintenance costs, and so forth.

Other factors that pose a challenge to a functional referral network include a widely dispersed population base, the adherence rates of patients to testing timeline, and limited central oversight. The population of the country is widely dispersed across the vast agricultural lands, making access to testing and treatment more critical. Since the patient has to travel long distances to reach their testing site, and subsequently, the blood sample drawn must travel a further distance to be tested, there is a high possibility that there will be no follow-up with the patient once the test results are returned a week later. While the operational aspects are handled at the regional level, most decisions around budgeting and capacity are taking place at the central level. However, there is limited data availability at the central level about the current or planned regional operations. This has resulted in an inefficient referral network that is not fully utilizing the benefits of the additional capacity in place.

The government currently plans to procure additional machines in order to increase access to testing. This study is designed to understand the areas for improvement in the current network; to

understand the impact of introducing Point of Care (POC) machines and to provide suggestions on where to place additional capacity. The overall objective of this and any follow-on work is to improve service levels while keeping overhead costs to a minimum.

Other agencies consulted in this study include CDC both in Atlanta and Ethiopia, PEPFAR Ethiopia, BD-PEPFAR PPP, and CHAI.

Methodology

Software for Laboratory Referral Network Optimization

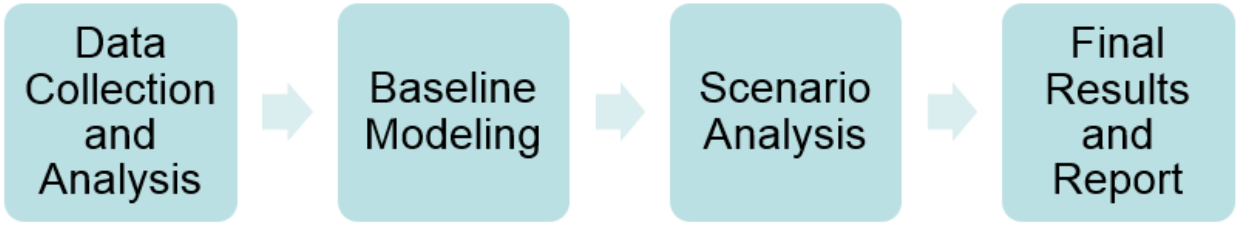
LLamasoft, Inc. is a leading global provider of technology and services for supply chain design. LLamasoft has worked with USAID projects on numerous occasions in the past, in Africa and across the world, to design supply chains for public health applications. Its flagship product, Supply Chain Guru™ provides Network Optimization capabilities that are ideal for a network optimization study of this kind. The software optimizes designs for lowest cost while meeting numerous operational constraints including service times and service levels. A subset of the wide range of questions that can be addressed by building network optimization models using the software include: How many distribution centers are needed and where should they be located? Which customers/health centers should be allocated to which distribution center? What capacity is needed in each distribution center?

In addition to the network optimization capabilities, Supply Chain Guru also has built in GIS capabilities. For the purposes of analyzing the geographical distribution of the lab testing capacities and communicating analysis results, this was considered a must-have for the analysis.

Based on the fit of the software's capabilities and the questions for this project, and LLamasoft's past successful engagements with USAID, LLamasoft was selected as the STTA provider for this project and Supply Chain Guru was selected as the software for the analysis.

Project Phases

The project was planned to be executed from March through June 2013 in the following phases.



Two in-country trips were planned at the beginning (March 3-16 for kickoff and data collection) and towards the end (May 27-31 for discussing results and obtaining feedback) of the project.

Data Collection and Analysis

A network optimization study requires a large amount of data as input. The LLamasoft team travelled to Ethiopia to collect this data from March 3-16, 2013. The SCMS Ethiopia team provided data and guidance on the trip. The trip report in Annex 1 details the activities on this first in-country trip. In the subsequent weeks, the collected data was analysed, and for necessary inputs where no

data was available, gaps were filled with assumptions that were decided in collaboration with SCMS Ethiopia.

A summary of the collected data elements and their sources is provided in the table below:

Table 1: Data Elements Collected for Study

Data	Source	Notes
Sites		
Site location for each test type		In addition to the Geocode (geo location of the site), all sites were updated with Region, Zone, and Woreda information when available.
Current 150+ Chemistry/ Hemotology/ CD4 Testing Sites	SCMS Team: Tesfaye Seifu	The sites were identified from a document titled LDLRN, with information about the referral sites and linkages. These sites were then manually matched (needed due to discrepancy in the site name) with a list of geocoded ARV/PMTCT sites.
Current 700+ Collection sites	SCMS Team: Tesfaye Seifu	The sites were identified from a document titled LDLRN, with information about the referral sites and linkages. These sites were then manually matched (needed due to discrepancy in the site name) with a list of geocoded ARV/PMTCT sites. For the sites that did not have an appropriate matched site in the ARV/PMTCT list, geocoding was done at the Woreda level. This involved additional manual interventions and information collection.
Early Infant Diagnosis/ Viral Load / MDR Labs	SCMS Team: Helen Fikru/Huda Mohammed	These sites were identified as the Regional Laboratories. These were small in number and were located at the specified city in which they are located.
Testing Machines		
Machines by Type (for Chemistry/ Hemotology/ CD4)	Instrument Database	Once again, the site names corresponding to the location of each machine time did not match the ARV/PMTCT list or the total list of sites that we received and used as the Master list of sites. Thus, the names had to be manually matched once again to understand where the machines were present.
Number of Functional and Non-functional	Instrument Database	This information was linked to the master site list
Age of the machines	Instrument Database	This information was linked to the master site list
Machine Information for DNA PCR machines for EID, TB MDR and Viral Load Tests	SCMS Team: Helen Fikru/Huda Mohammed	This information was not available in the instrument database and was provided by the SCMS team.
Capacities of Machines (by Type)	SCMS Team: Helen	All machine capacities were estimated by the SCMS team for previous studies, based on working hours and historical usage.
Cost/Test (Reagents)		All test costs were estimated by the SCMS team for previous studies, and are the landed costs of the reagents and resourced needed to perform one test.
Other		
Transport cost of Referral	SCMS Team and EHNRI	Documentation from SCMS team's data collection efforts specified the referral transportation mode currently in place. Estimations on public transport costs, and labor costs for delivery were used to arrive at the final costs for referral

Variable (Staffing) costs	SCMS Team: Helen Fikru/Huda Mohammed	Specifically, the staffing cost of laboratory technician was used to estimate the opportunity cost of time lost when the lab technician performed duties outside of his/her work description (i.e. transporting samples)
Turn-around-Time	SCMS Team: Tesfaye Seifu (from LDLRN)	This information was available for each site in the LDLRN and was used to estimate the current costs of the referral, and linkages within the current system.
Current referral Pattern	SCMS Team: Tesfaye Seifu (from LDLRN)	This information was available for each site in the LDLRN.
Sample and result Pick-up frequency by facility	SCMS Team: Tesfaye Seifu (from LDLRN)	This information was available for each site in the LDLRN.
Postal Service Transit Region, Times and Costs	EHNRI (Postal Agreement Document)	This information was gathered from the agreement in place between the Ethiopia Postal Service and EHNRI. Currently, this is operational only in Addis Ababa. Costs for the roll-out were estimated to be higher than current costs.
Test Volumes		
CD4/ Chemistry/ Hemotology (Referral)	SCMS Team: Tesfaye Seifu (from LDLRN)	The annual volumes for the time period of Feb 2012- Feb 2013 were available. These were separated by those tests that took place when patients arrived directly at the lab testing site, as well as those that were referred to the lab testing sites from the 700+ collection sites
CD4/ Chemistry/ Hemotology (At lab site)	SCMS Team: Tesfaye Seifu (from LDLRN)	The annual volumes for the time period of Feb 2012- Feb 2013 were available. These were separated by those tests that took place when patients arrived directly at the lab testing site, as well as those that were referred to the lab testing sites from the 700+ collection sites
EID	SCMS Team and EHNRI	Only annual national numbers were available for these tests. Thus, allocation to the individual sites was attained by estimation.
Viral Load	SCMS Team and EHNRI	Only annual national numbers were available for these tests. Thus, allocation to the individual sites was attained by estimation.
TB MDR	SCMS Team and EHNRI	Only annual national numbers were available for these tests. Thus, allocation to the individual sites was attained by estimation.

GIS Data

Several sources were used for visual GIS display purposes. Some of the freely available sources used for roads and admin levels were WHO and UN OCHA sites.

The basemap used for the analysis was made available through ESRI's world administrative map. This map does not display the most up-to-date administrative regions. However, all of the analysis and data collection was done based on the most recent administrative boundaries. The figure below shows a recent version of the administrative boundaries. Thus, all references to regional analysis

follow the newer definition (seen below) of the boundaries, and not the administrative boundaries shown on the outdated maps.

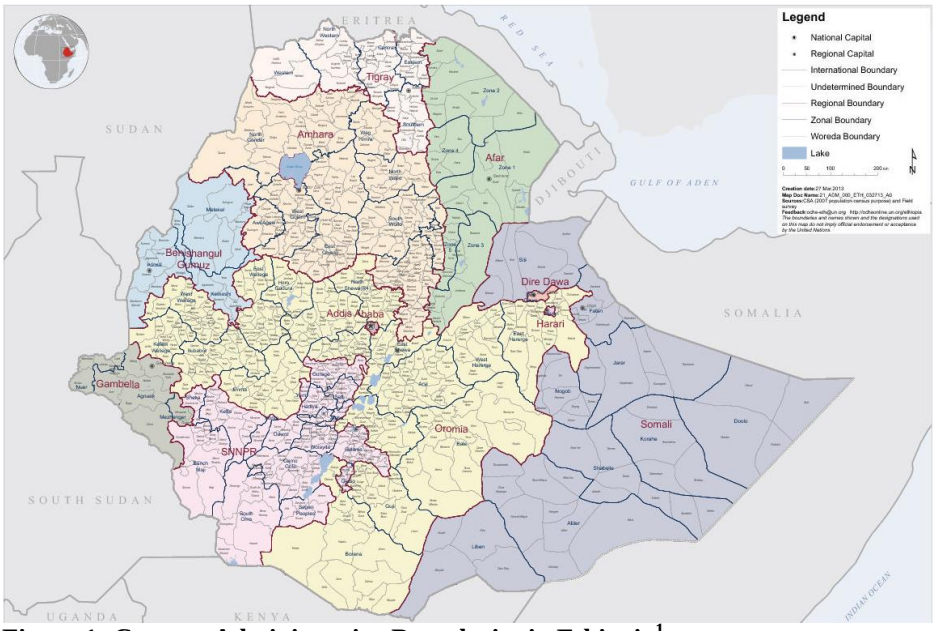


Figure 1: Current Administrative Boundaries in Ethiopia[1]

Baseline Analysis

This is the intial analysis of the current situation and serves as a baseline for all changes proposed in the optimization phase. This analysis provided insight into some of the inefficiencies in the current system, and helped guide the scenario analysis. The results of this analysis are detailed in the next section titled "Current Situation: Lab Referral Network:".

Scenario Analysis

Once the current network coverage was analyzed, the scenario approach provides the required what-if analysis to understand the effects of various changes. This is a very integral portion of the analysis since it provides some insight into the effects of various changes to the network without having to physically make those changes. In this analysis, the primary scenario identified was to determining an optimal collection site-to-lab testing site assignment, based on proximity. An additional focal point of this phase is the placement of the CD4 POC machines. The details of this phase are provided in the section titled "Scenario Analysis Results".

[1] Source: UN OCHA website, administrative map from March, 2013. http://ethiopia.humanitarianresponse.info/visuals/ethiopia-admin-map-27-march-2013. Accessed on 7/29/2013.

Current Situation: Lab Referral Network

The lab referral network is a complex network that handles multiple test types, information flows, physical flows of test samples and results, and in some cases people moving through the network to achieve some of the information and physical flows needed. The figure below depicts the typical workflow in Ethiopia's lab referral network.

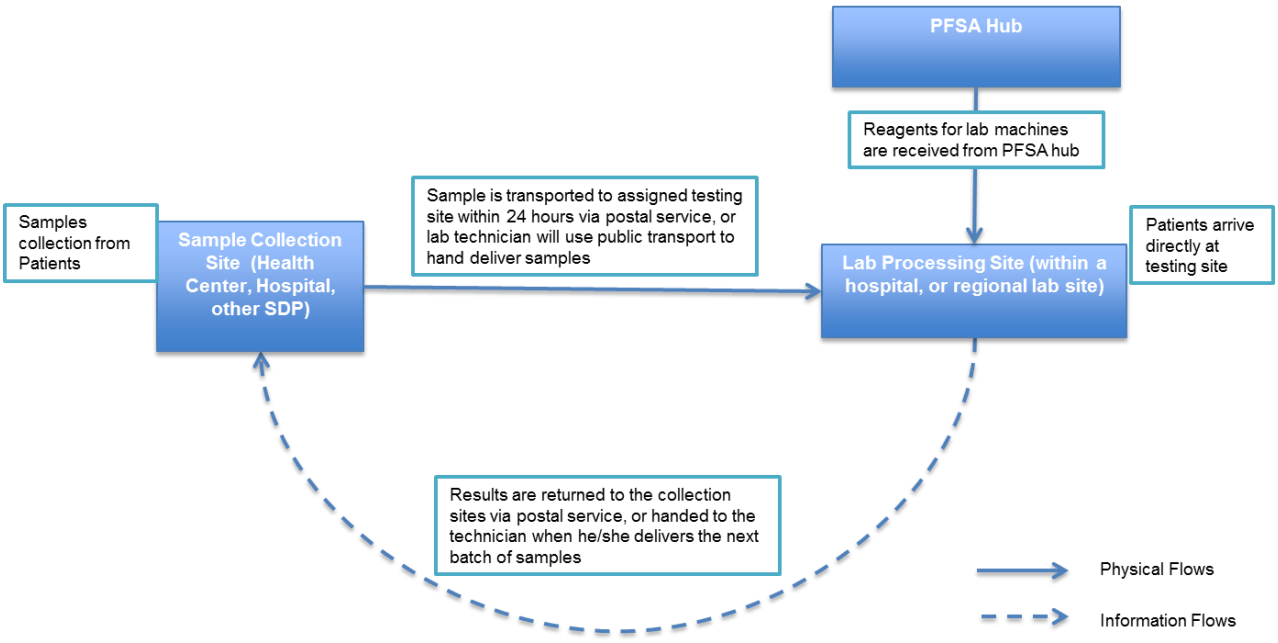


Figure 2: Workflow of Lab Referral Network

Although the referral network serves several types of laboratory tests (with data collected to analyze these additional functions), for the purposes of this analysis, we focused on the CD4 referral network. The primary reason for this is that the CD4 test accounts for over 70% of the laboratory operational spend. As can be seen from Figure 3 the historical SCMS spend on CD4 reagents is high and has been variable across years based on the estimated demand. Spend for 2013 is an estimate based on a portion of actual costs incurred during the first half of the year, and may change. Another timely factor is that there are several on-going studies by various groups in relation to increasing access to CD4 testing via point of care (POC) instrumentation and deploying additional FACS machines within the country. This analysis helps understand the effects of these proposed changes, and offers alternative solutions to increasing efficiencies.

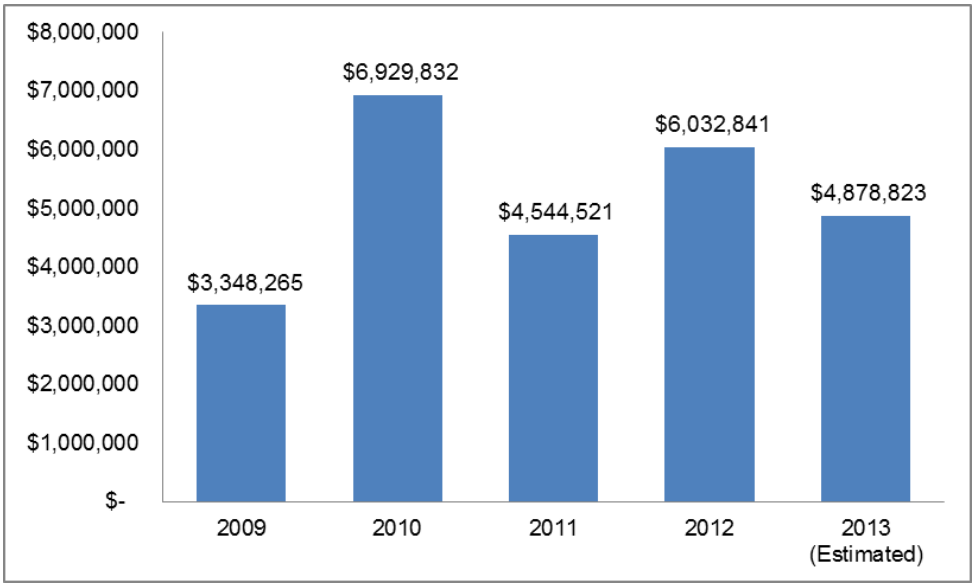


Figure 3: Distribution of Historical SCMS Spend for CD4 Reagents[2]

The current situation, or baseline, data for this study was collected primarily by the in-country SCMS team. The following table summarizes some of the data inputs for the CD4 analysis:

Table 2: Input Data Summary

Data Element	Details
Total number of CD4 tests (in 2012)	~730,000+
Collection Sites	791 (Total for all tests:823)
Lab Testing Sites	125 for CD4 (Total for all tests: 155)
Machines: Functional	FACS Calibur (12), FACS Count (104)
Machines: Non-functional	FACS Calibur (4), FACS Count (36)

Detailed information about the inputs, including sites names and the geo-locations used in the analysis can be found in Appendix A. The figure below provides a map view [3][4]of the collection sites and the lab testing sites.

[2] Figure only includes test-specific costs provided and does not include the costs for supplementary lab consumables.
[3] This map, and all other maps in this document, were created using LLamasoft's Supply Chain Guru ™ technology
[4] In this map and all following, there is limited information for Somali sites due to security concerns for the data collectors

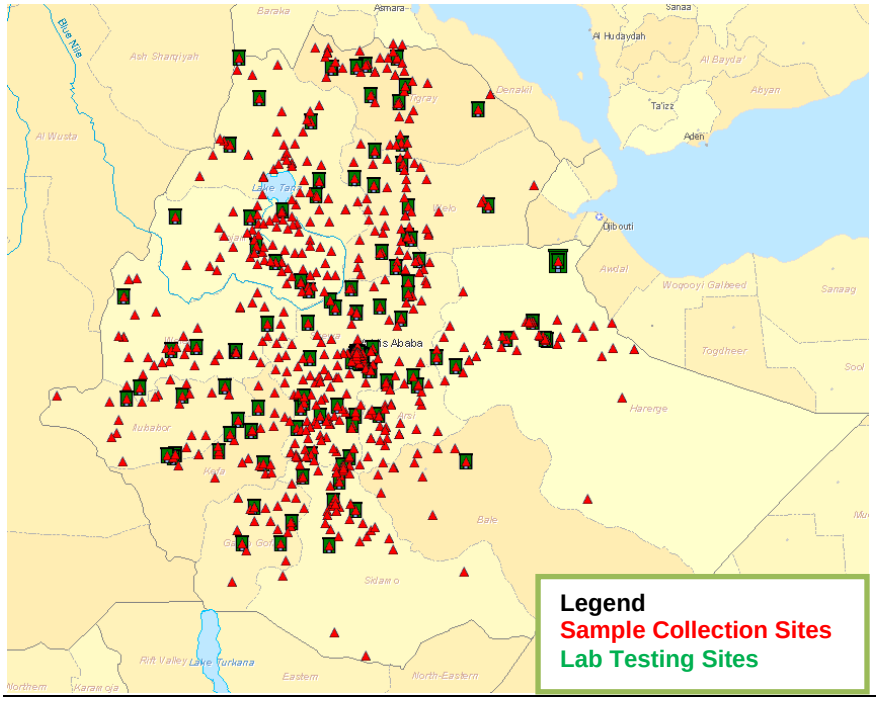


Figure 4: Map of sample collection sites and testing sites

Non-functional Machines

As can be seen from Table 2 there are several existing machines that are currently located in labs across the country that are non-functional. It should be noted that from the data that we have, it is unclear as to the duration of the downtime of the machine. As the data was received from a survey, the machine in question would have been down during the time the data was collected. However, this machine could have been down for a few days or a few months, depending on how long it took for the repair and maintenance crew to be dispatched from a central location in Addis Ababa. Also to note there are limited numbers of repair and maintenance crews for the entire country, and they are primarily located in the Addis Ababa region.

In order to determine if the location of the machine was a factor in its status as a non-functional machine (i.e. was a site more likely to have a non-functional machine if it is further away from Addis Ababa or other populous areas?), we mapped the non-functional machines for Chemistry, Hematology, and CD4 machines. This can be seen in the figure below:

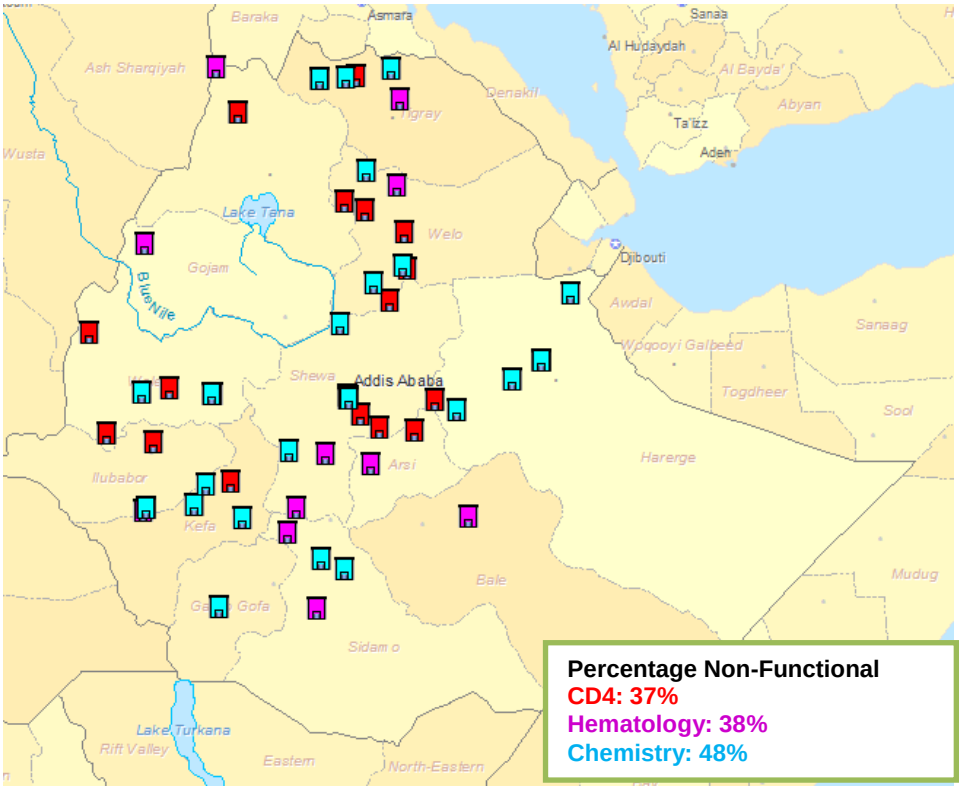


Figure 5: Map of sites with non-functional machines

As we can see from the figure, there are no discernible patterns related to the location of the non-functional machines. The hypothesis that those sites located in remote geographies had a higher likelihood of having a non-functional machine does not seem to hold up. Thus, the conditions that have led to these machines being (and/or remaining) non-functional must be analyzed further.

Regional Analysis

Since the primary question around the CD4 tests at the moment is related to increasing access, and the program is administered at the regional level, a brief look at the regional distribution of capacity is warranted. Using the regional populations and the information regarding the existing functional capacities at each of the sites, we can get a better picture of the access to tests across regions. As the table below shows, the Addis Ababa city administrative region and the Gambela region (green) have the highest capacity of machines per capita. The Oromia region and the Somali region (red), the largest and second largest regions by area, respectively, have the lowest capacity per capita.

The distribution of functional machines by region is provided in the table below:

Table 3: Distribution of CD4 capacity across regions

Region	Population in 1000s[5]	Functional Machines	Machine Capacity[6]	Machine Capacity/ Capita
Addis Ababa (city admin.)	2740	23	522600	191
Afar Region	1411	4	72800	52
Amhara Region	17214	22	1248000	72
Benishangul-Gumuz Region	671	2	62400	93
Dire Dawa (city admin.)	342	2	36400	106
Gambela Region	307	2	36400	119
Harari Region	183	1	18200	99
Oromia Region	27158	28	561600	21
Somali Region	4439	2	36400	8
SNNP Region	15043	21	434200	29
Tigray Region	4317	9	188200	44

However, this analysis does not take into account where the machines are location in relation to the population or the utilization of those machines. When defining access to testing, the distance that one must travel to reach that testing site is a very important factor. Thus, having more machines per capita does not necessarily mean better access. It should also be noted that it is expected that many machines will not have a very high utilization. This is a trade-off that is made in order to provide access. However, there is no reason for extremely low utilization numbers across a number of machines that are located very close to one another.

Access to CD4 testing from SDP

When we think about access, the primary form is the patient's access to a health facility where they can be tested. We know anecdotally that there are several parts of the country where patients have to travel for multiple hours, sometimes by foot, to reach to the nearest health facility. There is insufficient data on this type of access, and locations of potential patients.

From the chart below we can see that a majority of the collection sites, over 61%, are within 50 km of their assigned testing site. Currently, nearly 80% of the collection sites are within 100 km of their assigned testing site. This leaves 20% of the collection sites, most of them small and under-staffed health centers that are more than 100km away from their assigned testing facility. Given the number

[5] From 2007 Ethiopian Census

[6] Assuming 260 working days in the year, the annual capacity of FACS caliber is set at 44,200 and the FACS Count at 18,200

of testing sites, the geographic distribution of those sites, and the size of the country, this should not be the case.

The reasons for this inefficiency are unknown, but there are several possibilities. The first one is that the original assignments made were not revisited once additional capacity was introduced. Thus, the network could have some legacy issues. Another reason could be that the originally assigned lab site may not be available (machine is down, no technician, etc.) and the collection site is not aware of the next closest site, or the back-up site. In cases where there are labor shortages at the lab testing sites, anecdotal evidence showed that some labs simply may have had the machine capacity, but not the human resources needed to fulfill the testing requests.

The issues related to sub-optimal legacy assignments and knowledge of back-up sites are addressed later on in this analysis. Due to scope limitations, human resource issues are not addressed in this analysis.

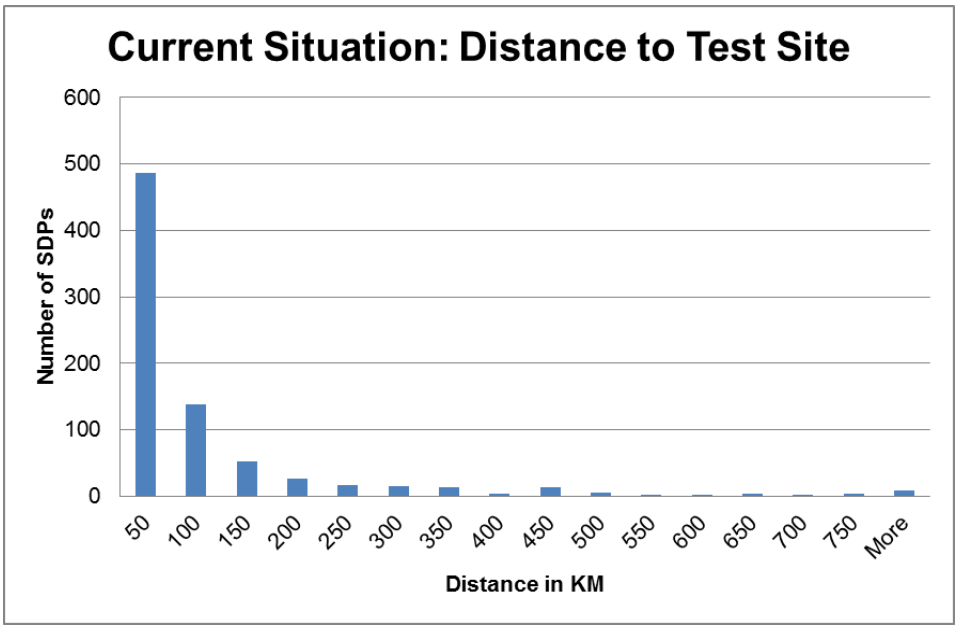


Figure 6: Histogram of Distance to CD4 test site from SDP , Current Situation

Volume of CD4 tests per annum

In order to get a better understanding of the geographical distribution of the tests, the following map was generated. As can be seen in red, there are many sites around the country which perform less than 2500 tests per annum. The annual capacity the FACS Count and Calibur machines were estimated to be 18,200 and 44,200, respectively. Thus, assuming a FACS Count machine, these sites have a best-case utilization rate of 13.7%. It can also be seen from the map (especially in and around the Addis Ababa area) that several of the red dots, or the testing sites with very low volume, are located very close to a site with much higher volumes. This points to an imbalance in work load across testing sites located in close proximity to one another.

One additional point to be made on the few sites that show very high volumes – most of them are the regional labs. These are the EHNRI/Regionally managed lab testing sites that usually have additional capacity and resources. In terms of machine capacity, these are the sites that tend to have the higher capacity FACS caliber machines. These sites are used as back-up resources for the region in which they reside, and thus have much higher volumes than a typical ART site.

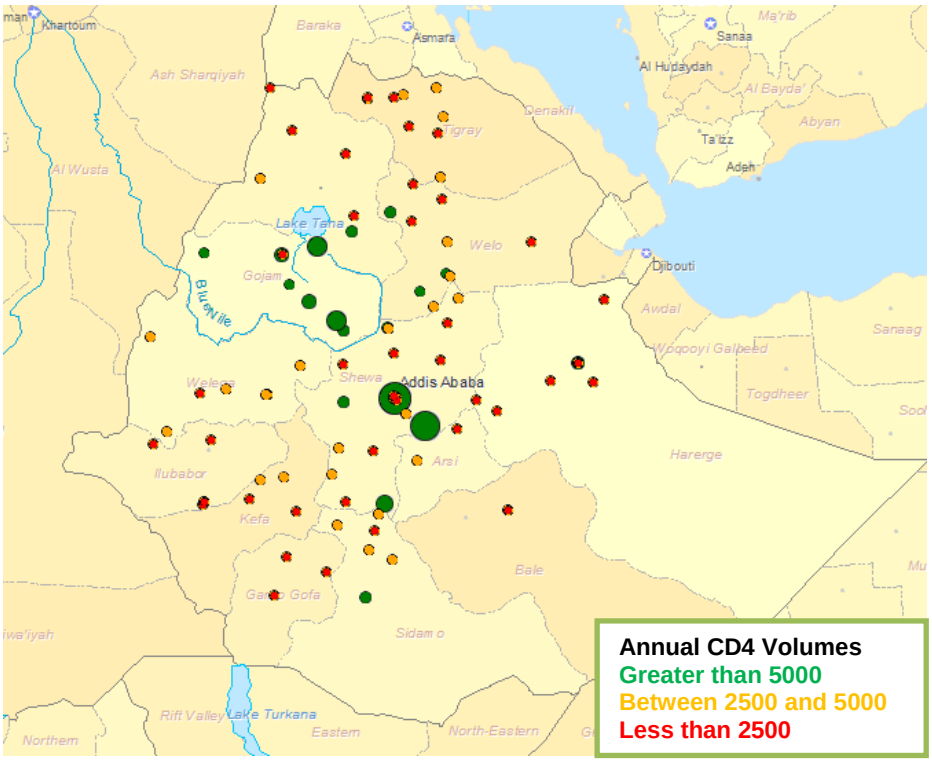


Figure 7: Annual CD4 volumes at testing sites

Utilization of Machines

The utilization of machines, across the various tests, was addressed based on the information provided about the number of machines, along with some assumptions about the number of working days and the effective capacities of the machines. Assumptions included:

- Annual Capacity: calculated based on 260 working days, 6 hrs/ day
  - We know that this is not true for most labs, since there are some that work overtime and on weekends to meet demand, and there are others that are only used once a week. However, this was the number used as an average estimate.
- The capacities of the CD4 machines were assumed to be 70 tests per day for the FACS Count and 170/day for the FACS Calibur. The capacities of the machines for the remaining tests can be found in Appendix B

Given the above assumptions, the list of available machines, and the volume of tests reported as performed, the following was calculated. Thus, we can see that the current CD4 machine utilization rate is estimated nationally at 19%.

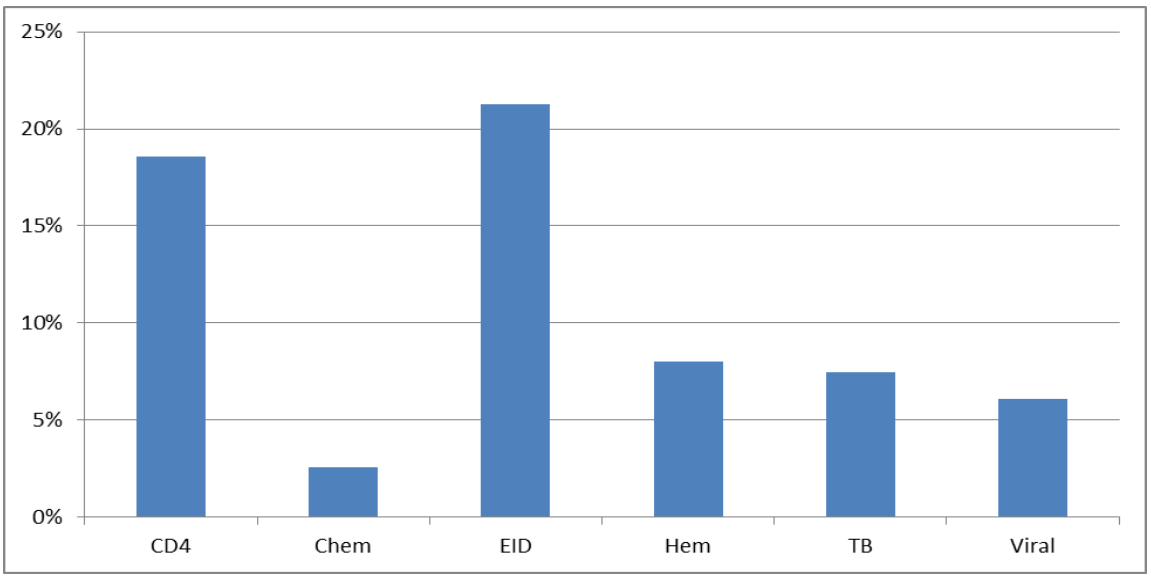


Figure 8: Machine Utilization by Test Type

With utilization being low and a sub-optimal distribution of the machines across the regions, the question about where to add additional capacity (and if that's the best way to improve access) becomes a very important one to answer. Thus, in order to shed some light on this issue, we conducted an analysis of how best to optimize the current network (to reduce overall costs) and also identified candidate locations for the introduction of additional capacity.

Current (Baseline Flows)

As was seen from the distance histogram, there are several collection sites in the country whose samples currently have to travel a significant distance to get to their assigned testing site. The figure below is a map view of all of the current assignments. Each line between a collection site (red triangle) and testing site (green site) is denoted as an assignment between those two sites. As a reminder, this data was gathered from the most recent LDLRN document.

What is immediately apparent from the graphic is that there are several collection sites that have testing facilities nearby, but are traveling much further away to their assigned testing site. This translates to 20% of collection sites traveling over 100 km to their testing site. The average transport distance was calculated to be 82 km, one way.

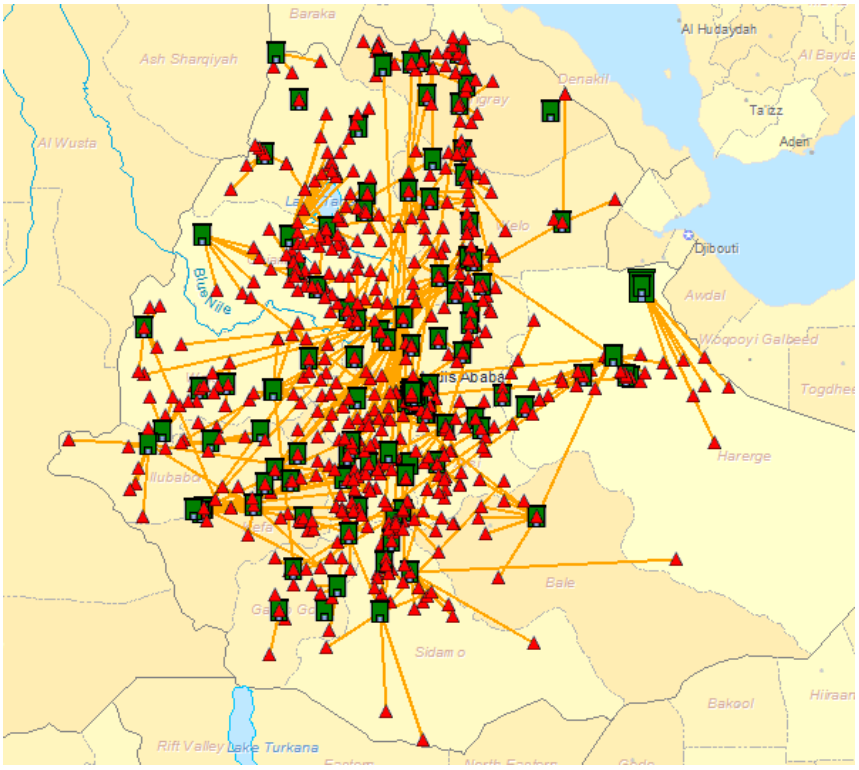


Figure 9: Collection Site-to-Testing Facility Current Assignments

The total transport cost for the baseline is estimated at $1.7 million.[7] Of this, the vehicle and fuel costs[8] account for a strong majority, at $1.55 million. The remainder of the cost was from the opportunity cost for the lab technician transporting samples.[9] It should be noted that for these calculations, and the ones that follow, the total cost is reported as the total cost of the network, regardless of which entity is paying for it. For instance, we know that the regions allocate certain budgets, and each region is responsible for managing its own costs. The costs (especially vehicle and fuel costs) are those incurred either through private or public vehicles in the course of transporting the samples and results. Thus, this number is used as a representative cost and specific public transport fees are not taken into account in cases where that may be the primary mode of transport. This allows us to have a more consistent cost, in light of missing or sparse data on transportation modes.

These numbers, along with some of other data points discussed above serve as baseline values, against which we can compare any potential changes to the network.

[7] This and all following currency numbers are provided in USD and are annual costs, unless specified otherwise
[8] Vehicle cost includes: Postal costs for current postal lanes, an assumed cost of .025 per shipment per KM, and the return leg on transport for non-postal service
9 Lab tech cost based on daily wage of $10.71 and time spend traveling for those sites that reported a manual drop-off and pick-up in the LDLRN

Scenario Analysis Results

The multi-stakeholder meetings that took place during the second in-country trip resulted in a prioritized list of optimization considerations. These meetings included discussions at the US Embassy in Addis Ababa, attended by PEPFAR-Ethiopia, USAID Mission, and CDC representatives, as well as a meeting at EHNRI. Based on feedback on the most pressing needs, practical considerations, and on-going capacity plans, the following were used to guide the scenario analysis:

Optimization Considerations

- Current instrument utilization
- Planned programmatic scale-up
- Incoming POC instruments (CHAI/CDC/ICAP deployment approach)
- Incoming CD4 instruments (quantities and final destinations)
- Existing end of life instruments and age of instruments
- Developing further redundancy/back-up capacity
- Referral distances
- Postal service use for sample referral

A follow-up workshop was held to focus on the core optimization considerations mentioned above, and to provide an opportunity to discuss unknowns, various costing components, approaches, potential assumptions and the way-forward.

Unknowns included:

- Arrival dates of newly procured instruments
- Final destinations proposed for newly procured instruments
- Validated numbers of incoming new instruments
- Vendor capacity to install incoming instruments (deployment duration)
- Future Care and Treatment Program updates and overall laboratory vision for the next 3-5 years
- PEPFAR/EHNRI/MOH immediate and long terms plans for laboratory development

- A general approach, approval, and estimated timeline to implement any laboratory network developments

After much discussion about several considerations and their perceived relevance and importance, a consensus was reached in order to pursue the following scenario options during this phase of the project:

- Developing optimal referral assignments (cross-regional, all test types)
- Investigating costs to implement the Postal Service across the entire country
- Rationalizing POC integration at SDP (referral sites) and compare with the CDC/EHNRI/CHAI POC deployment strategy
- Analyze the impact of POC deployment on the current referral network, magnitude of the cannibalization effect (reduced instrument utilization and cost implications)
- Assessing the need for and use of additional FACS Count and Calibur machines for CD4 testing

Optimal Referral Assignments

As seen from the analysis of the current situation, the existing referral assignments in place are not ideal and account for a significant portion of the current inefficiencies. Using the network optimization functionality in SCG, the optimal assignments (based on distance and transport cost) were determined. In terms of improving the lab referral network, this is seen as the low-hanging fruit, since it does not involve capital investments and an overhaul to the current processes.

The figure below shows the modeled optimized network. It is apparent from the shortened and fewer orange lines on the map, that there were significant changes to the assignments. The transportation costs inputs used in this scenario (i.e. fuel costs, etc.) were the same as those in the baseline analysis. The average distance traveled went down by 50 km, from 82km to 32km.

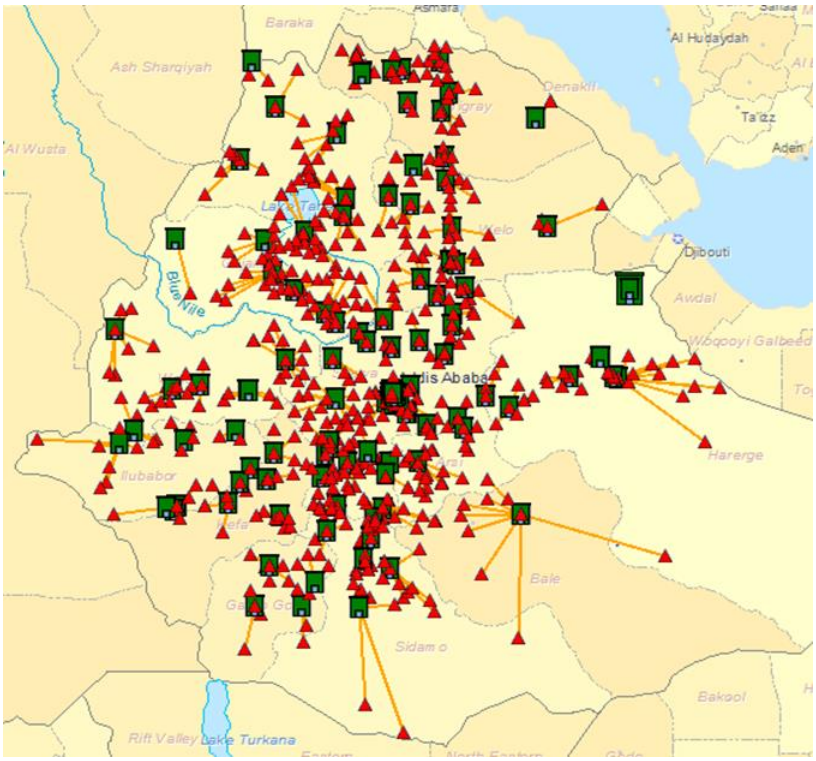


Figure 10: Collection Site-to-Testing Facility Optimal Assignments

The total transport costs under this scenario are $677,000, with $585,000 going towards vehicle and fuel costs and $92,000 towards the laboratory technician's opportunity cost. Thus, the modeled optimized assignments result in a 60% reduction in transport costs with very minimal capital investments. It should be noted here that this reduction in transport cost (i.e. distances) ultimately relies on the accuracy of the geodata. Multiple rounds of validation were put in place to have as accurate a picture of the geolocations of the collection sites as possible. However, this cost reduction may be affected if geolocations are found to be inaccurate.

Another comparison to the baseline comes in the form of the distance to testing site analysis. The figure below shows that under the optimal assignments, 78% of the collection sites are now within 50 km of their assigned testing site and 94% are within 100 km. There are also no sites that have to travel farther than 400km.

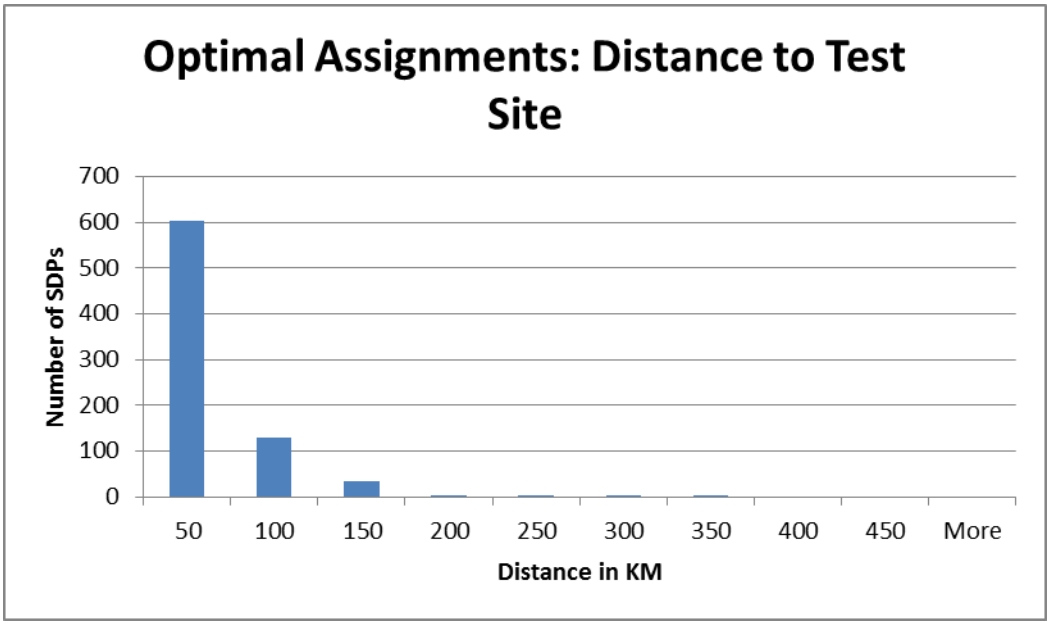


Figure 11: Histogram of Distance to CD4 test site from SDP, Optimal Assignments

A visual analysis of the road network overlaid on this map suggests that the solution is feasible, based on existing road network coverage. There are some instances in the optimal solution where a collection site from a one region is assigned to a testing site in a different region. This may prove to be a problem since the lab referral network is managed at the regional level. In these situations, either the regions can work together, or chose to reduce administrative burdens and keep the original assignments. Even if all of the optimal assignments do not prove to be very practicable, there are still significant savings to be realized from some simple changes.

A detailed list of the primary assignments, along with the next closest (or backup) assignment is provided in Appendix D. Formally establishing backup assignments is a way to ensure machine failure does not impact patient testing when a primary referral instrument is down.

Country-wide roll-out of Post System

One of the major changes proposed by EHNRI is to enlist the services of the national postal system for sample collection and result delivery for all laboratory sample and testing needs. As noted in the current state analysis, there are several areas of the country that are currently using the postal service. So far, the main area with operation postal service collection and delivery is Addis Ababa. From early reports, this system seems to be functioning well in this region. However, data surrounding the postal services' operational capabilities in other regions of the country, especially the remote regions, was not available. At this time, it is unclear whether or not this capability exists.

Based on the information provided, current postal rates ranged from $0.09 - $0.18 per sample. Even if we assume an average postal shipping cost of $0.20 per sample to account for more expensive shipping in remote regions and a $0.05 cost for the return of the paper results, it is estimated that the total cost of transportation for the current volume of annual CD4 tests (approx.. 800,000) would reach approximately $200,000. This translates to nearly a 70% reduction in transport costs even compared to the optimal assignment scenario. This savings is due to the shared transportation cost of delivering existing mail and packages, whereas the previously mentioned transportation cost are for strictly dedicated sample transport routes.

If the capability exists within the system, and it can be proven to be reliable and scalable, there may be significant cost savings in moving to the postal system. Further analysis in to the true capabilities of the system, and several pilot programs are recommended. Factors such as sample turn-around-time, adequate storage during transportation (cold box transport), and adherence to defined assignment system by the postal service should be measured in detail during the pilot process. An additional point to note here is that there is little information on the penalty the postal system will incur for a lost or late sample or result. Without an enforceable penalty system in place, there is a misalignment of incentives which may lead to this system failing.

CD4 Point-of-Care Machine Integration Analysis

A relatively new technology being deployed in the developing world to increase access to CD4 testing are Point-of-Care (POC) machines. These are machines that have much lower annual capacities (approximately 5000 tests per annum), and are much smaller in size, less technically demanding to operate, and can be considered portable. Additionally, they require a single reagent cartridge for each test, over the more conventional CD4 instrument which requires multiple commodity types.

From previous sections we've seen that there are several collection sites that are currently performing less than 2500 tests per annum. A simple analysis would assume that these testing facilities could benefit from a smaller machine than the FACS Count and Calibur machines that are currently in place. However, since the primary purpose of the introduction of these machines is to increase access for the patients who may be seeking a CD4 test, the focus of this analysis was placed on identifying additional sites that would serve as ideal locations for a POC machine to enhance service access. Ideally, POC deployments should greatly reduce the sample to result turn-around-time, and would help retain more patients that may need to be put on life-saving medication.

During the time that this analysis was being conducted, it was realized that CDC and CHAI were performing a similar analysis in the country to determine where to deploy incoming POC machines. The following section describes our process, as well as the CDC/CHAI process and the preliminary

results from both analyses are compared. The following sections will illustrate how complex this problem can be, and that a plan that seems logical and reasonable at first glance can have some hidden side effects.

SCMS POC Analysis

The collection sites were considered the master data for this analysis and were subject to the following criteria:

- Daily volume of tests must be less than 20 (Note that this analysis is using historical service statistics data, an actual measure of existing service delivery, not targets).
- Distance traveled to the testing site must be greater than 50km.

Using these criteria, 54 candidate sites were identified. The figure below shows the location of these candidate sites. A detailed list of these sites can be found in Appendix E.

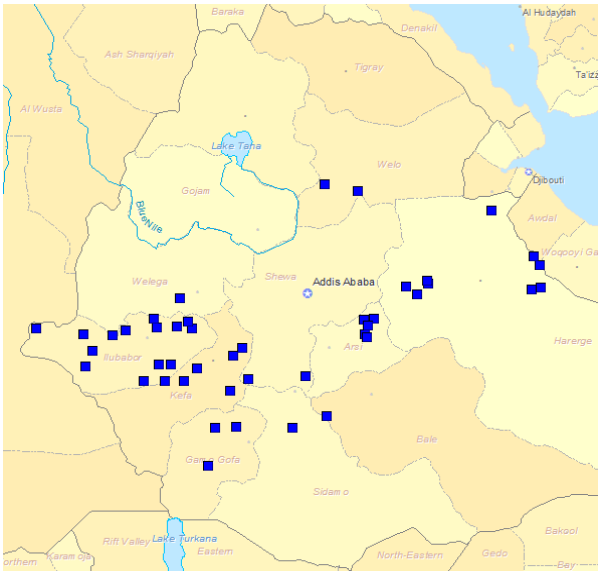


Figure 12: CD4 POC Candidate Sites

Although this seems like a very reasonable approach, there are several other factors to consider. For instance, once we put these sites on a map, we realized that there are several sites chosen as candidate sites for POC that are very close to one another. Presumably, if the combined daily volume of the sites is less than 20 tests, they can share the single POC machine.

Another very important consideration is the effect that the introduction of the POC machines will have on the existing referral network. As the data shows, there are many machines in the network that are severely underutilized. The introduction of the POC machines at these sites will result in reducing further the utilization of the labs to which these sites were referring their samples. For this initial exercise of 54 candidate sites, the effect on the current system is shown in the following table.

Referral Site	Volume removed with introduction of POC
Chiro	50%
Gambella	35%
Ambomsa	33%
Karamara	32%
Metu Karel	31%
Bisidimo Hospital	20%
Jimma	17%
Hawassa Regional Lab	17%
Sawla	9%

Table 4: Effect on POC introduction on current referral network

By introducing the POC machines, the current referral network is cannibalized, with several sites losing over 30% of their annual volume. Therefore, a thorough analysis of the cannibalization effect must be done to understand the trade-offs that are being made.

CHAI CD4 POC Analysis

The CDC and CHAI group were conducting their own analysis to identify ideal locations for POC machine deployments. The group shared with us their preliminary analysis that they conducted for a few regions. The primary difference between the two analyses is that the CHAI process is based on target test numbers, and the SCMS analysis was based off historical data. SCMS Washington based laboratory technical advisors consistently see actuals vs. targets being typically at or about 60% in most countries as part of national commodity quantification exercises with CD4. Using targets as a predictor of need for CD4 overestimates demand. This is due to those patients in care being less predictable in returning for CD4 services, with those currently on treatment returning in a more predictable fashion due to frequent visits for treatment pick-up. This is further demonstrated in Ethiopia with SCMS quantification data collected in the past, with an uptake estimated at 50% from December 2012 and in previous years.

The criteria used by the CHAI study was similar in that there were targeting collection sites only, and those with targeted daily test numbers between 6 and 20. While distance was a consideration, it was not a strict criterion. The initial draft put together data for four regions: Amhara, Oromia, Tigray, and SNNPR. Within these four regions, 42 sites were identified as candidate sites. The map below shows the location of 35 of the 42 sites (due to unavailable geocodes for the remaining sites). Figures 11 and 12 show that there is little overlap between the initial studies done by SCMS and CHAI. In fact, only two sites (Masha and Sawla) appear in both lists.

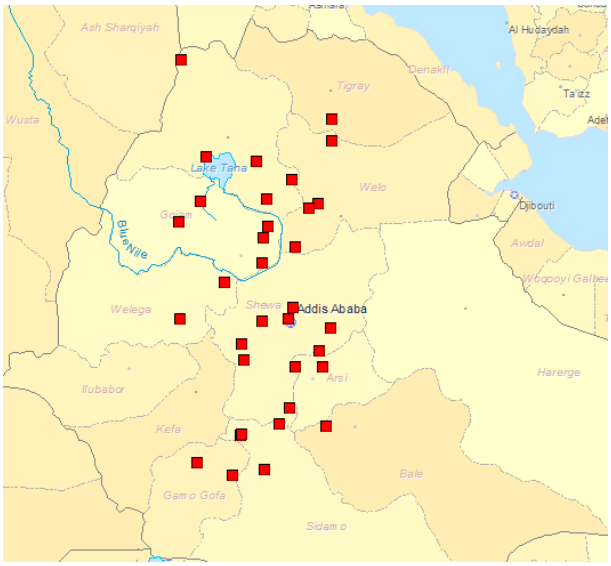


Figure 13: CHAI proposed locations for CD4 POC Deployment

At the time of this report, the CHAI study had not taken into account the effect that this deployment plan would have on the current referral network. One of the major benefits of having a model of the current referral network is the ability to analyze the effects of various changes. Based on the 35 sites were matched to sites in our master list of collection sites, the introduction of these POC sites would result in a loss of test volume at current lab sites anywhere from 2 – 22%. Due to the significant variance between the SCMS and CHAI proposed location sites, it is recommended that further data sharing and analysis be conducted to produce an optimal solution that will not only increase access, but ensure an acceptable level of referral sample reductions at conventional CD4 testing sites.

Addition of FACS Count and Calibur machines

In the midst of the additional capacity in the form of POC machines, there are currently on-going discussions about additional FACS Count and Calibur machines that are to be deployed within the country. One of the scenarios we were asked to develop was the determination of the ideal placement of the new machines. However, under the objective of optimizing the service levels and costs of the network, this scenario resulted in a recommendation to add no new FACS Calibur and Count machines.

Other than the mathematical approach, there are several reasons in support of this. As was shown with the addition of the POC sites, addition of new high-capacity machines within a network with very low overall machine utilization will have significant cost implications due to further reduced utilization (increased consumption in-efficiencies), site level buffer stock increase, additional equipment maintenance costs, EQA enrollment, and training demands. If the budget was unlimited, this might be a feasible option given the objective of increasing access. However, budgets are stagnating, and the introduction of additional machines will result in additional overhead costs, Additional commodities (reagents) will now need to be shipped to additional locations, further increasing commodity distribution costs.. With the increase in the number of machines, the buffer stock of reagents needed at the central level will also increase at a more dramatic rate and add to service delivery costs.

In light of these factors, one recommendation for additional machines would be to replace some of the older machines that are handling high volumes. The figure below shows the 65 machines of the existing CD4 instruments (61 Count in red and 4 Calibur in green) that have been in operation for over 5 years. There are some that have been in operation for more than 8 years. Apart from just the age of these machines, it is also important to note that Becton Dickinson is currently developing replacement instruments for the FACSCount, with the Canto serving as the overall replacement for the FACSCalibur. These existing CD4 machines should be considered end-of-life machines, with a strategic instrument replacement strategy to be developed in close coordination with Becton Dickinson. With repair and maintenance of the machines being a significant issue, replacing the older machines would be the best course of action, especially if the new machines have already been purchased. Additionally, Ethiopia is currently in a state of transition between the older double tube FACSCount CD4 method and the newer, cheaper, single tube approach. Rollout of the single tube approach could be further enhanced by replacing the older instruments with updated machines capable of conducting the single tube method, instead of upgrading aged instruments.

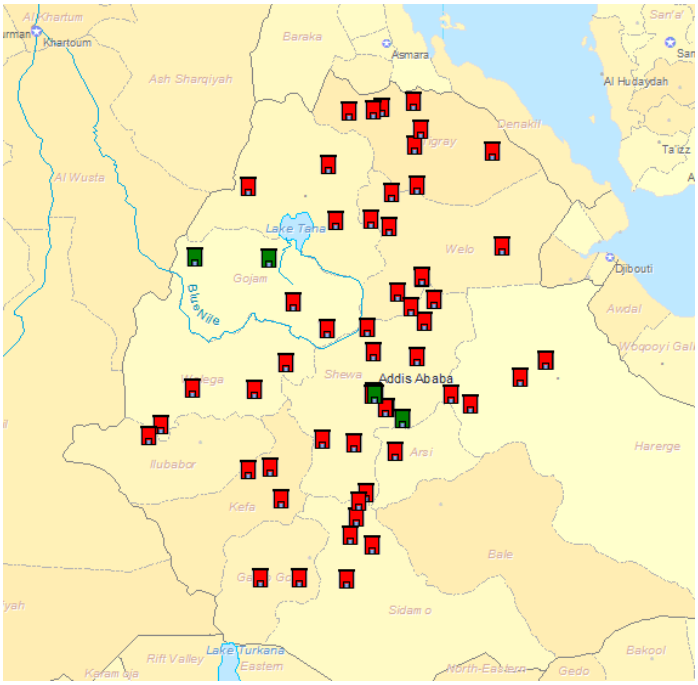


Figure 14: Locations of CD4 Machines greater than 5 years

Limitations

As with any analysis rooted in several key data elements, there are limitations to the study related to data quality and availability. Most of the data used for this study was obtained via surveys at a certain point in time. This raises questions about the accuracy of the data since it relies on accurate self-reporting. Also, it is unclear as to whether the snapshot data used is sufficiently representative of the annual operations of the network. And finally, without a central validated data source, it is very difficult to keep the analysis up to date. As mentioned, the data is historical. Several aspects of this study might have already changed, but are not reflected in this analysis. Additionally, we acknowledge that information for some areas and some collection sites (specifically, the Somali region) were not available due to security concerns of the data collectors. A final area for limitations within the data collection and analysis lies in the significant amount of manual work that was done to match various datasets in the absence of a master data source.

Additionally, there is a lack of information on the necessary laboratory reagents needed to sustain the existing network, the modeled optimized network, and the proposed POC deployment approach. During several of our site visits, the lack of reagents when needed was cited as a reason for why a machine wouldn't be used (stock outs). This information is not documented adequately. Thus, the system shows that more machines are needed since there is a demand for the tests. However, demand is not necessarily for machines, but for timely access to reagents so that the existing machines can operate as expected. The effects of untimely delivery of reagents, stocking-out, and expiry of reagents at the central level were not factored into this analysis. This is especially important when discussion adding traditional CD4 capacity, since that will increase the actual stock and buffer stock of reagents required. Not only is this cost important, but this calls for tightened central oversight and coordination between PFSA (for reagent delivery) and EHNRI.

A limitation of the study when evaluating access, especially in the case of the POC machine integration, is the concept of patient access. With limited data about where the population needing the tests resides, we are missing a key input into the study – distance traveled by a single patient to access a testing site. This information would offer greater insight into further informing optimal locations for POC machines.

Recommendations

Efforts should be made to maintain momentum around this particular activity and its outputs. There was a significant level of engagement during the workshops and general meetings between EHNRI, USAID, CDC, as well as CHAI. There seems to be considerable interest in using this approach to advance access to improved laboratory services, and ensuring a cost effective and responsive laboratory network.

Short-term recommendations following this analysis are:

- Review and validate all data inputs and outputs. Assignments, distances, as well as machine status and locations must be validated to gain the most benefit from this process
- EHNRI to work with the regional administrations to re-structure their referral networks to reduce cost and redundancy in the system. Where necessary, encourage regions to work across boundaries to improve overall efficiencies
- Initiate dialogue and prioritize future STTA needs around laboratory optimization activities, to include a second line referral network to address instrument failures, a strategic response to equipment maintenance challenges and instrument replacement (considering age, operational status, double tube to single tube)
- Investigate various transport modalities (postal service, dedicated sample deliver resources, etc.) in more detail, and to identify specific regional optimization approaches.
- Analyze the effects of reagent shortages, identifying the root cause of the current issue and proposing operational changes to ensure adequate supply of reagents.
- Work closely with all partners around POC testing and workflow integration, and impact analysis on the existing laboratory network.
- Use the illustrative CD4+ optimization exercise to guide CD4+ optimization efforts in the short term, possibly to inform a longer term POC CD4 and possible viral load integration strategy in response to the recent revised WHO guidelines
- Engage Becton Dickinson via their PPP initiative with CDC and EHNRI to further advance GIS related activities around laboratory optimization.

The first three requirements are related to validating results with input from all stakeholders, and closer collaboration amongst these stakeholders. Some of the recommendations listed, including the ones pertaining to identifying optimal transport modalities, planning for EOL machines, and incorporation of POC machines require additional analyses.

Longer-term recommendations are:

- Develop a comprehensive and collaborative approach to data collection. This must be done across multiple stakeholder to ensure validity of master data, and remove redundancies in data collection and analysis
- Develop a repair and maintenance plan to serve country-side needs for existing and incoming machines
- Work towards reducing machine diversity within a test type, thereby reducing the burden placed on additional reagents and also repair and maintenance.

Conclusion

This analysis shed a lot of light on Ethiopia's current laboratory referral network and ways to improve it. During the process of collecting information and gathering strategic consensus from the various stakeholders, it was evident that many of the stakeholders were facing similar issues that would be alleviated greatly from increased collaboration. In light of the imminent funding reductions or stagnation, particularly within PEPFAR, it is very important for these organizations to work together closely to increase patient access to testing facilities.

While there are several areas where additional analysis needs to be done, it is evident from this study that there is some 'low-hanging fruit' within the network that can increase efficiencies. This relates to the referral assignments, both primary and secondary. Changing the assignments of collection sites to referral sites does not require any significant infrastructure changes or capital investment, yet it will yield significant cost savings.

In relation to the addition of capacity, whether that is additional FACS machines or POC machines, it is evident that integrated approaches amongst the stakeholders that take into account a more holistic view of the network are necessary. Comprehensive data collection and management will help address this issue greatly. With the help of software and analysis tools, such as the ones used in this analysis, the effects of various changes to the network can be assessed very quickly to facilitate cross-organizational discussions.

Appendix A. LLamasoft Trip 1 Report

SCMS Trip Report

Country: Ethiopia

Consultants:
Neelima Ramaraju
Sidharth Rupani

March 4th – 15th

1. Background

The Pharmaceuticals Fund and Supply Agency (PFSA) is going through a period of enormous change with 17 new warehouses under construction, imminent delivery of 75 new distribution trucks and rapid growth in turnover, from around $20m per annum in 2007 to an estimated $300m per annum in 2011. USAID, SCMS and other partners are supporting these changes. Expansion of the delivery fleet requires a new level of distribution planning, as well as optimization of the options for distribution modalities to be adopted at the strategic planning level. To ensure that PFSA understands the options for operating an efficient network, scenarios for distribution optimization as well as the lab referral network are to be developed.

2. Purpose

- To undertake a comparative analysis of agreed upon scenarios to determine the most effective options to distribute product from PFSA's network of distribution centers to health facilities including identifying circumstances where distribution to district level would be more appropriate
- To develop proposals for logistically designed laboratory referral networks intended to meet the national diagnostics service targets whilst optimizing the number of lab reference sites and maximizing the utilization of lab equipment
- To introduce Ethiopian stakeholders to the concepts of optimization and the potential beneficial impact on operating costs of national systems

3. Activities

ID	Task	LOE	Deliverables
IN COUNTRY			
C1	**Conduct an in brief with the Resident Advisor and with the USG if requested.**	.25	None
Summary: Conducted in-briefs with the SCMS team to describe the project objective			
C2	**Finalise data availability, data assumptions and sensitivity analysis requirements for both studies**	1	Data tracking Sheet (on-going process)
Summary: On-going process to assess the data availability and data quality. Worked with the team to create a data tracking sheet (submitted with this report). Discussed general assumptions and estimation methods with the team.			
C3	**Field assessments to test data and assumptions validity, identify constraints and compare with model limitations**	7	No direct deliverables. Several Data Analysis sheets are interim deliverables that are currently being processed.
Summary: Visited a regional branch warehouse, the regional labs, and a district hospital in Hawassa. Conducted interviews with several stakeholders during the 10 days and was able to gather significant information about the current and planned operations, included the constraints and requirements of the model.			
C4	**Confirmation of work to be carried out at home base**	1.5	None
Summary: Worked with the SCMS team in country to discuss and agree-upon the follow-up activities, including the list of scenarios to focus on and the responsibilities of the various parties over the remaining duration of the project.			
C5	**Out-brief with CD, Clients, and USAID if requested**	.25	PowerPoint for Out-brief (submitted with this report)
Summary: Out-brief was conducted at the USAID mission office and was received well. The presentation that was shared with them is attached here.			
POST-TRIP			
P1	**Submit a two-page trip report within one week of the end of the trip.**	.25	Trip Report
Summary:			
P2	**Continued modeling activities at home-base**	37	
Summary: This trip marked the beginning of the project and was very useful in understanding the current operations, plans, stakeholders, and data availability. There are other items in place (see follow-up actions and full SOW) to ensure the completion of a usable and complete analysis. This will be the bulk of the work and will be conducted over the next couple of months, prior to the second in-country trip at the end of May.			

4. Follow-up Actions

Most follow-up items are related to data collection and analysis, and have been discussed

in detail. The team will continue to have weekly check-in meetings and track all progress and milestones on a weekly basis.

Action	*Person (s) Responsible*	*Estimated Completion Date*	*Location of Work*
Weekly check-in meeting for full team	TEAM (already set-up by Bob)	On-going	Respective home offices
Continue Data Collection	Team	3/29/2013	SCMS Office Ethiopia
Data Analysis	LLamasoft Team (validation by SCMS team)	4/15/2013	LLamasoft offices
Baseline Modeling and Validation	LLamasoft Team	5/13/2013	LLamasoft offices
Scenario Analysis	LLamasoft Team	6/10/2013	LLamasoft offices
In-country scenario review	Full Team	5/31/2013	SCMS Ethiopia Office
Final Results and Recommendations	LLamasoft Team	6/24/2013	LLamasoft offices

5. Team Matrix & Key Contacts

Name	Position/Title	Organization	Email & Phone Number	Significance/Notes:
Neelima Ramaraju	Director of Public Health Applications	LLamasoft, Inc.	neelima@llamasoft.com +1 404-808-1804	STTA Provider: Engagement Lead
Sid Rupani	Supply Chain Solutions Manager	LLamasoft, Inc.	Sid.rupani@llamasoft.com +27 (0)79 837 7829	STTA Provider: Project Manager / Lead Analyst
Allison Griffin	Supply Chain Solutions Consultant	LLamasoft, Inc	Allison.griffin@llamasoft.com +1 214-315-9751	STTA Provider: Analyst
Marvin Couldwell	Country Director	SCMS	mcouldwell@et.pfscm.org	
Bob Steele	Technical Lead	SCMS	bob_steele.t21@btinternet.com	Primary Point of contact from SCMS
Jason Williams	Principal Laboratory Advisor	SCMS	jwilliams@pfscm.org	Advisor on Lab Study
Daniel Taddesse		SCMS	dtaddesse@et.pfscm.org	SCMS Ethiopia: Primary Contact
Abyu Faris	Warehouse and Distribution Manager	SCMS	AFaris@et.pfscm.org	Technical Point of Contact for Distribution network
Tesfaye Seifu	Manager	SCMS	tseifu@et.pfscm.org	Technical Point of Contact for Lab Referral network
Yemaneberhan Tadesse	Deputy Director General	PFSA		Project executive sponsor from PFSA

6. List of Annexes

- Data Tracking Sheet
- USAID out-brief

Appendix B. Summary of Site Inputs

This Appendix contains detailed information about the site inputs that were used in the model, and can be found in the attached excel sheet of Appendices under the name "Site Information – Appendix B". The table headers that can be found in this appendix include:

SiteName
SiteType
SiteLatitude
SiteLongitude
Hub
Region
Zone
Woreda
Count_Functional_Machines
Count_NonFunctional_Machines
Calibur_Functional_Machines
Calibur_NonFunctional_Machines
Hem_Machine
Chem_Machine
Hem_Machine_NF
Chem_Machine_NF
Split_Sourcing
Count_Years
Calibur_Years
LLama_POC_Site
CHAI_POC_Site

Appendix C. Test Capacities by Machine Type

Test Type	Machine	Capacity
CD4	FACS Count	70/day
	FACS Calibur	170/day
EID	GeneAmp PCR 9700	21/day
Viral Load	Abbott m2000rt	24/day
Chemistry	Humastar 80	80/hour
	Humastar 180	180/hour
	AutoLab	200/hour
	Saba	200/hour
	5010 Photometer	10/hour
Hematology	Cell Dyn 1800	60/hour
	Cell Dyn 3700	90/hour
	Sysmex 1800i	80/hour
	Sysmex KX 21N	60/hour

Appendix D. Optimal Assignments

This appendix contains a list of all of the primary and secondary assignments for each collection site. Due to the large size of this data set, it is included in the excel appendices supplement and can be identified by the title.

Appendix E. SCMS POC Candidate Sites

The following is a list of the 54 sites identified as potential candidate sites for POC deployment

Collection Site	Daily CD4 Test Volume	Distance to Test Site (in KM)	Test Site
Collection_Abajema HC	2	20.52	Referral_Ambomsa HL
Collection_Ambomsa HC	10	0	Referral_Ambomsa HL
Collection_Angada HC	2	151.8	Referral_Ambomsa HL
Collection_Aseko HC	5	29.55	Referral_Ambomsa HL
Collection_Chole HC	10	52.58	Referral_Ambomsa HL
Collection_Gologota HC	1	2.6	Referral_Ambomsa HL
Collection_Moye HC	1	41.6	Referral_Ambomsa HL
Collection_Kombolcha HC	4	440.73	Referral_Bisidimo Hospital
Collection_Kombolcha HC	8	440.73	Referral_Bisidimo Hospital
Collection_Asebot Health Center	4	194.01	Referral_Chiro Hospital
Collection_Doba Health Center	3	130	Referral_Chiro Hospital
Collection_Hirna Health Center	16	130.61	Referral_Chiro Hospital
Collection_Kuni Health Center	1	175.52	Referral_Chiro Hospital
Collection_Abobo Cato Hc	1	60.68	Referral_Gambella Hospital
Collection_Bonga health cenetr	1	285.4	Referral_Gambella Hospital
Collection_Gog Dipach	1	96.7	Referral_Gambella Hospital
Collection_Itang Health cente	5	47.29	Referral_Gambella Hospital
Collection_lare Health center	1	489.26	Referral_Gambella Hospital
Collection_Matar Health center	1	184.57	Referral_Gambella Hospital
Collection_Pugnedo Gov hc	3	111.85	Referral_Gambella Hospital
Collection_Pugnedo Ref hc	4	167.63	Referral_Gambella Hospital
Collection_Bonga hospital	4	114.6	Referral_Hawassa Regional Laboratory
Collection_Chire hc	1	68.73	Referral_Hawassa Regional Laboratory
Collection_daka hc	2	82.86	Referral_Hawassa Regional Laboratory
Collection_Gecha hc	3	310.62	Referral_Hawassa Regional Laboratory
Collection_Keyafer Health center	13	22.2	Referral_Hawassa Regional Laboratory
Collection_konda hc	3	55.67	Referral_Hawassa Regional Laboratory
Collection_masha hc	3	58.94	Referral_Hawassa Regional Laboratory
Collection_masha hc	8	58.94	Referral_Hawassa Regional Laboratory
Collection_sheshinda Hc	1	61.99	Referral_Hawassa Regional Laboratory
Collection_Shishenda	5	67.42	Referral_Hawassa Regional Laboratory
Collection_Tummi Hc	1	475.42	Referral_Hawassa Regional Laboratory
Collection_wacha hc	3	303.88	Referral_Hawassa Regional Laboratory
Collection_wacha hc	5	303.88	Referral_Hawassa Regional

			Laboratory
Collection_Waka Health center	6	20.02	Referral_Hawassa Regional Laboratory
Collection_Waka Health center	5	20.02	Referral_Hawassa Regional Laboratory
Collection_Asendabo hc	10	60.15	Referral_Jimma University
Collection_Shabea	5	52.74	Referral_Jimma University
Collection_Sokoru hc	8	95.03	Referral_Jimma University
Collection_Awbere HC	2	193.73	Referral_Karamara HP
Collection_Deghabur HC	4	396.07	Referral_Karamara HP
Collection_Harshin HC	2	304.68	Referral_Karamara HP
Collection_Hartishek HC	2	269.39	Referral_Karamara HP
Collection_Kebribeyah HC	4	274.23	Referral_Karamara HP
Collection_Togochale HC	1	214.8	Referral_Karamara HP
Collection_Bedele hc	5	114.66	Referral_Metu Karel Hospital
Collection_Bure hc	3	70.78	Referral_Metu Karel Hospital
Collection_chewaka hc	1	127.17	Referral_Metu Karel Hospital
Collection_Chora hc	5	78.91	Referral_Metu Karel Hospital
Collection_Dembi hc	5	108.72	Referral_Metu Karel Hospital
Collection_Gech hc	3	123.93	Referral_Metu Karel Hospital
Collection_Suphe hc	4	34.29	Referral_Metu Karel Hospital
Collection_yayo hc	5	20.29	Referral_Metu Karel Hospital
Collection_Sawla Health center	12	0	Referral_Sawla Hospital