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REPUBLIC OF GHANA

GHANA: SUSTAINABILITY FOR THE EARLY WARNING SYSTEM

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Ghana: Sustainability for the Early Warning System

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Abstract

In January 2013, an assessment of the Early Warning System (EWS) in Ghana was conducted in preparation for scale-up and eventual operational handover to the Ghana Health Service (GHS). The exercise evaluated the system's usability and robustness. This report, presented to the Ministry of Health (MOH) and GHS, includes the findings of the assessment, as well as the short- and long-term recommendations to ensure the sustainability of the EWS in Ghana.

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Contents

Acronyms v
Acknowledgments vii
Executive Summary ix
Introduction 1
Overview 3
Use 3
Scale-Up 3
Handover 4
Methodology 5
Workshop and User Interviews 5
Discussions with Dimagi, Inc. 5
Code Review 5
Testing 6
Vendor Interviews 6
Findings 7
System Use 7
System Robustness 8
Recommendations 17
Reporting Frequency 17
Supervision 17
Products 18
Information Use 18
New Features 20
Cost/Benefits of CommTrack 2.0 versus Locally Supported EWS 20
Conclusion 25
Next Steps 25
Appendices
A. EWS New Feature Mockups 27
Figures
1. Load Time for EWS Login Page 10
2. Load Time for EWS Aggregate Stock Report Page 11
3. Load Time for EWS Aggregated Stock Report Page after Caching 12
4. EWS Response Time As Users Increase 13

5. Recommended Supervision Structure 18
6. Information Use at Different Levels 19
7. Dashboard Page 27
8. National-Level Stock Status Page: Product Availability (initial load) 29
9. National-Level Stock Status Page: Stockouts 30
10. National–Level Stock Status Page: All Stock Information 31
11. Regional-Level Stock Status Page: All Stock Information 32
12. District-Level Stock Status Page: All Stock Information 33
13. Facility Page 35
14. RMS/Teaching Hospital Page 36
15. National-Level Reporting Page 38
16. Regional-Level Reporting Page 39
17. District-Level Reporting Page 40

Tables

1. Costs of Options B and C 24

Acronyms

ART	antiretroviral therapy
CHPS	community-based health planning and services
CMS	Central Medical Stores
DHIO	District Health Information Officer
EPI	Expanded Programme on Immunization
ERP	Enterprise Resource Planning
EWS	Early Warning System
FRHP	Focus Region Health Project
GHS	Ghana Health Service
HIV	human immunodeficiency virus
LMIS	logistics management information system
MOH	Ministry of Health
MOS	months of supply
NHIA	National Health Insurance Authority
PPME	Policy, Planning, Monitoring, and Evaluation
P&S	Procurement and Supply Directorate
RFP	Request for Proposal
RHIO	Regional Health Information Officers
RMS	Regional Medical Store
SCMU	Supply Chain Management Unit
SMS	short message service (text messaging)
SOP	standard operating procedure
SSDM	Stores, Supplies, and Drug Management
SSNIT	Social Security and National Insurance Trust
SVN	Subversion
TB	tuberculosis
TWT	tolerable wait time
USAID	U.S. Agency for International Development
USSD	Unstructured Supplementary Service Data

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Executive Summary

The EWS has been in operation in Ghana since July 2011, when it was implemented in 201 facilities throughout the country. After an assessment of the pilot in January 2012 showed positive utilization of the system, a scale-up effort to approximately 400 facilities is currently under way. The GHS has expressed interest in additional scale-up to more facilities and in including commodities from the Expanded Programme on Immunization (EPI) and tuberculosis (TB) health programs, as well as more commodities from the currently included malaria, human immunodeficiency virus (HIV), and family planning programs on the reporting list. In preparation for this scale-up, and for the eventual handover of the system to the Ghana MOH and the GHS, an evaluation of the EWS was conducted in January 2013 with the aim of assessing its usability and robustness and of coming up with a plan for the sustainability of the system.

The EWS was found to be used more by staff reporting from lower levels of the supply chain than by managers at higher levels who are supposed to be using it to make decisions. Some recommendations were made to improve the usability of the system, including revising the reporting schedule for facilities at higher levels of the supply chain (regional medical stores [RMS] and the Central Medical Stores [CMS]), revising the product list for reporting, implementing some new reports and workflows on the web interface, educating decisionmakers on how they can and should use the information made available by the system, and adopting a uniform chain of supervision in all the regions where the system is implemented.

Load and stress testing of the system found it to be ill prepared to handle the increased levels of web traffic and the amounts of data likely to be brought on by scale-up. Recommendations were made to pre-emptively handle these issues by deciding on a maintenance and support plan for the EWS, either by modifying the code base to handle larger amounts of data and finding a local vendor to support the system or by migrating to a cloud-hosted, turnkey, open source solution that is maintained by a United States–based vendor.

Introduction

The EWS is a short message service (SMS)-based stock reporting system that has been operating in Ghana since July 2011. The system was developed through a collaboration between the USAID Focus Region Health Project (FRHP), the USAID | DELIVER PROJECT, and the GHS with the aim of improving visibility into logistics information for health commodities throughout the public health supply chain. The system operates by having staff at health facilities send weekly text messages from their mobile phones to report the stock levels of a subset of their managed commodities. Staff at larger facilities, such as hospitals and medical stores, have the option of reporting via a web interface instead of via text message if they have the appropriate resources (i.e., computer and Internet connection). The information reported is displayed on a web-based dashboard that provides several simple reports related to stock availability and reporting rates, allowing decisionmakers at the higher levels of the supply chain to see the information in real time and in an easily understandable format. The two projects implementing the system (FRHP and the USAID | DELIVER PROJECT) operate in different regions in the country—the USAID | DELIVER PROJECT operates in seven regions, whereas FRHP operates in the remaining three regions. The original pilot for the EWS was conducted in 201 facilities across all 10 regions in Ghana, with 88 FRHP-supported sites and 113 USAID | DELIVER PROJECT-supported sites. Users were asked to report on 43 tracer commodities within the malaria, HIV, and family planning commodity classes.

In January 2012, an extensive assessment of the pilot was conducted by FRHP and the USAID | DELIVER PROJECT. This assessment found that the EWS was improving logistics data visibility as intended, but that there were some issues with the use of the information for decision making, in that not many higher-level decisionmakers were accessing and using the system. Given the generally positive results of the pilot assessment, a recommendation was made to expand the system to cover additional facilities to include all antiretroviral therapy (ART) sites in Ghana and additional facilities in districts supported by FRHP. This would bring the number of facilities using the system to approximately 400, which is about 10 percent of the number of facilities nationwide. The GHS has expressed interest in scaling up to include even more health facilities and to include more products for reporting.

In January 2013, in preparation for this scale-up and the eventual handover to the Government of Ghana, a team was requested to perform an evaluation of the usability of the EWS as well as its robustness and its ability to handle the large amounts of data expected to come from many facilities as the expansion plan continues to roll out. Similar systems implemented in Tanzania and Malawi had seen significant slowdowns in processing speed when large numbers of facilities began to report to them, resulting in some concern that the EWS may also start to see the same kind of slowdown eventually as a result of the scale-up. In addition, with the recognition that the purpose of the system is to ultimately increase stock availability at the facilities, another concern is the extent to which the system is being used by its target audience (the decisionmakers) for its intended purposes.

The objective of the evaluation discussed in this report was to come up with recommendations to ensure the sustainability of the EWS in Ghana and to lay out the kind of investments (financial and

otherwise) that would be required to keep the system running. This report is the outcome of this evaluation.

Overview

The sustainability of the EWS can be considered along three aspects:

Use

Users of the EWS fall into two categories: reporters and decisionmakers. Staff members at health facilities are supposed to conduct a stock count at the end of every week and transmit that information every Friday, with a grace period until Monday. Any report received after Monday is considered late. A report that does not include all the commodities on the reporting list that are managed by a given facility is considered incomplete. For this evaluation, there was a need to determine whether reports are being submitted completely, regularly, and on time by staff at the health facilities.

Once the information is received, it is displayed as reports and graphs on the web interface, which managers at higher levels of the supply chain are expected to use to monitor reporting and to identify problems with stock availability at the health facilities. There was some question about whether managers at the higher levels of the supply chain are accessing the system and using the information provided to make decisions that would ultimately lead to increased commodity availability at health facilities.

Scale-Up

FRHP and the USAID | DELIVER PROJECT are both scaling up the EWS to include more facilities in their respective regions. In USAID | DELIVER PROJECT regions, the system is being expanded to include all ART sites, which total 160 throughout the country. FRHP is scaling up to include additional sites in their regions, some of which are ART sites and so overlap with the USAID | DELIVER PROJECT's goals. All in all, the number of facilities reporting to the EWS is expected to grow from 201 to approximately 400. In addition, in conversations with the GHS, the agency has expressed interest in expanding the system further to include more facilities and eventually to cover all facilities in the country, which number approximately 4,000. Similar stock-reporting systems implemented in Tanzania and Malawi on the same base technology experienced problems with slowdowns in processing speed of the web-based dashboard reports once more data were introduced to the system. Consequently, it was necessary to determine if the EWS would develop similar problems of slowdown as a result of scaling up, so as to plan to mitigate said issues before they occur.

The GHS has also expressed interest in increasing the number of commodities that are reported on using the EWS. Historically, commodities have been included in the EWS reporting list based on GHS health programs. Currently, EWS commodities are limited to malaria, HIV, and family planning products. The EPI and the TB Program are interested in including some of their program commodities. In addition, in the absence of a functional logistics management information system (LMIS) in the country, the GHS would like to have more visibility into stock levels of a larger set of commodities and so are considering adding more commodities to the reporting list. This raises the question of how much is too much when working with such a system. The use of mobile phones is

not optimal for sending large amounts of data—SMS messages have a 160-character limit, meaning that the optimal number of products that can be reported in one message is about 20. Commodity list expansion would therefore bring challenges related to transcribing and transmitting the data from the user facilities. Asking staff at facilities and medical stores to report on a larger set of commodities may also overburden them, leading to mistakes and missing data.

Handover

The EWS was developed by Dimagi, Inc., a software development firm based in the United States. Now that the system is in operation and only requires maintenance support, Dimagi has recommended that support for the system be provided locally, where vendor fees are likely to be lower and access to developers would be quicker and cheaper. The local vendors should be able to complete simple feature requests and tweaks on the web interface, such as changing or adding reports, and to perform some troubleshooting when necessary. There has been some concern about the capacity of local vendors to take on this support, as few vendors in Ghana specialize in Python, the programming language used to develop the system. Another option that has been raised is moving the EWS to Dimagi's CommTrack 2.0 platform, which is a cloud-hosted system that came out of lessons learned from developing the EWS and similar systems in Tanzania and Malawi. The EWS could run on the CommTrack 2.0 platform for a monthly subscription fee that would cover server hosting fees and any maintenance and support needs that arise. However, CommTrack 2.0 would be a more generic platform than the EWS, and moving may result in losing some of the unique reports and features of the EWS if they have not been included in CommTrack 2.0. There would be a need to fill this feature gap, at some financial cost. In addition, the move itself would probably incur some costs related to data migration.

Another factor to consider is the eventual handover of the EWS to the Ghana Ministry of Health. To prepare for that, it is necessary to determine which agency would have ownership of the system and how other agencies and units would interact with it and contribute to it. In addition, making sure that the MOH information technology (IT) department becomes involved in the maintenance of the system sooner rather than later would contribute to its sustainability.

Methodology

Recommendations for the sustainability of the EWS along the three aspects outlined above were gathered though a user workshop, individual user interviews, discussions with Dimagi, code review and testing, and interviews with local vendors.

Workshop and User Interviews

Interviews were conducted with users at the various levels of the public health supply chain. In Ga West District, interviews were held with a user at a community-based health planning and services (CHPS) facility, one at a community clinic, two at Ga West Municipal Hospital, and the District Health Information Officer (DHIO). In addition to these one-on-one interviews, a workshop was held for reporting and decision-making users to discuss their use of the system. The workshop participants included reporting users from a CHPS facility, two hospitals and several RMS, and decision-making users from the district level, various MOH and GHS agencies and units, and the different health programs. During the interviews and the workshop, users were asked about their interactions with and use of the system, and if they experience any challenges interacting with the system. The one-day workshop also spent some time discussing recommendations for how the system should operate in the public health supply chain ecosystem.

Discussions with Dimagi, Inc.

As mentioned in the Overview, Dimagi, Inc., the software vendor that was originally contracted to develop the EWS, has developed a generic cloud-hosted product based on lessons learned from the EWS and similar systems developed by them in Tanzania and Malawi. CommTrack 2.0, as this product is called, is a customizable SMS-based logistics system that can be used in any country and is maintained and hosted by Dimagi for a monthly subscription fee. Although an early version of the system is currently in use in India, the system has not yet been released for wider use. Discussions were held with Dimagi to determine when the system would be ready, what features it will include, and how much the monthly fee would be for a country to use the system.

Code Review

The code base for the EWS was originally the same as the code base for the ILSGateway, a similar system that was built and has been in use in Tanzania since 2011. In 2012, the ILSGateway began planning for scale-up and found that, to support scaling up, data warehousing modifications to the code base were necessary. There was some question about whether these modifications were ported to the EWS. Consequently, the code for the EWS was reviewed to make sure that data warehousing modifications were not applied to it. The code base for the ILSGateway and EWS were compared to determine which modules were different and if any modules were missing.

Testing

Two things are guaranteed to happen when the EWS is scaled up. The first is that there will be an increase in the number of users of the website (an increase in website traffic). The second is that there will be more reporting data in the database.

To determine whether the EWS would be able to handle the added traffic and data load during and after scale-up, testing was performed on a parallel instance of the EWS deployed on an Amazon Web Services test server. The type of testing performed was stress/load testing, and two approaches were followed: one to test the system when there were many concurrent users, and the other to test the system when there was an overload of data.

For the first approach of testing many concurrent users, *Selenium and Neustar Web Performance Management* was used. Selenium is one of the most well-known open source testing automation frameworks used to test websites. *Neustar Web Performance* is a service that runs Selenium scripts in parallel on a large number of virtual browsers.

The second approach (data load testing) was conducted by modifying Dimagi's Smart Data Generator System (a collection of Python scripts and Django applications) that had been previously created to test the ILSGateway. The smart data generator creates fake facilities and fake reporting data to simulate performance as the site scales. It was modified to be used for testing the EWS.

Vendor Interviews

To determine local capability in implementing future changes to the EWS, possible software development vendors were identified and interviewed. The interviews were held with technical staff of vendors as well as management. Vendors who had responded to the original Request for Proposal (RFP) for the development of the EWS were contacted, as were other vendors in country. The list of vendors interviewed is included in the Findings section below.

Findings

System Use

Reporting

Reporting users at the lower levels of the supply chain (CHPS facilities and health clinics) reported that they report to the system regularly and according to the set schedule. Users at larger facilities, such as hospitals and RMS, admitted to reporting less regularly. All reporting users reported seeing benefits from interacting with the EWS, among them:

- Improved stock management habits, due to the need to keep stock cards updated for reporting
- Improved supervision from higher levels of the supply chain

At the CHPS level, increased drug availability and quicker resupply of drugs were also cited as benefits of reporting to the EWS, although these benefits were not reported at higher levels of the supply chain.

Reporting users reported the following as challenges to their ability to report regularly and on time:

- Attrition at facilities and lack of backup for reporting duties, meaning that if the designated reporter is away from the facility, the report will not be submitted until he/she returns
- Poor mobile reception, resulting in the need to attempt several times before a text message is sent successfully
- Poor Internet connectivity for those reporting via the web interface (larger hospitals and RMS)
- High workload, especially at RMS, whose staff reported getting overwhelmed with serving facilities
- Forgetfulness due to lack of reminders
- Depending on when new commodities are received at the facility, updating stock records to send the report before the deadline can be challenging, especially at larger facilities
- Unavailability of a short code for every mobile network provider, meaning that some reporters sometimes have to use their own funds (they are provided with credit but sometimes use it for other purposes and then have to buy extra credit to send the report).

Decisionmaking

Decisionmaking users reported very low usage levels of the EWS. The reasons given for this were as follows:

- Users are very busy and so need reminders to log in to the website. In addition, some users receive summary reports via email and feel that this is enough information so do not need to log in to the website

- Users are limited in what they can do with the information they see on the website. Several decisionmakers mentioned that they are not the direct supervisors of those who are supposed to report, so they cannot follow up with reporters when they see that they are not reporting. In addition, some of the decisionmakers expressed that they are not able to make decisions about procurement, so they cannot do anything even if they see that products are not available
- Inconsistent reporting in the first few months of the pilot led decision-making users to feel that the system was not useful, as it did not have the information it was supposed to have.

Only decisionmakers at the district level (DHIO) in FRHP regions reported seeing benefits from the system, as regular use helps them with their supervision of facilities.

New Features

Discussions with web users also elicited the facts that some of the reports on the dashboard are not as useful as they could be if presented differently and that some additional reports would be desirable to users. Mockups of desired new layouts and features have been prepared based on user interviews and vetted by the USAID | DELIVER PROJECT and FRHP teams.

System Robustness

Code Review: ILSGateway versus EWS Code Comparison Results

The main goal of the code review and code comparison between the ILSGateway and the EWS was to determine whether any of the data warehousing features implemented in the ILSGateway were implemented in the EWS. As a result, the code review centered on modules responsible for and related to the data warehousing.

The approach that Dimagi used to deal with scale-up problems in the ILSGateway was to implement a data warehouse. This means that the procedures responsible for slowing down the website were identified, and then the code was rewritten so that these procedures would be run on a schedule and their results stored in the database instead of waiting until a web user asked for them. As a result, the server performs complex calculations before users click on the links so that pre-calculated results are displayed, eliminating the need to perform calculations on the fly when a user asks for a report.

The building of the data warehouse was accomplished in the ILSGateway by developing a Django application called "*Reporting*." This application handles the generation of the reports and stores the calculated results so that they are readily available when users request them. The following modules exist in the application:

- Organization Summary
- Group Summary
- Product Availability Data
- Product Availability Dashboard Chart
- Alert
- Organization Tree

A module known as "Run_reports" has functions that run the algorithms to populate the warehouse tables with data. This is the preprocessing of the data before any website user asks for it so that it can be stored in anticipation of a request.

A module known as "Runner" runs the functions inside Run_reports. This module has two functions: one for generation of the tables and another for clearing out the reports.

The code review of the EWS code base found that the above Django application has not been implemented in the EWS.

Testing Results

1. Data overload: an increased number of facilities sending reports

The first testing approach focused on testing how the system would behave when there is a lot of reporting data from a large number of facilities. To do this, Python scripts and Django applications written for the ILSGateway were modified to work for the EWS.

The data generator scripts generate fake facilities and fake SMS reporting data for the facilities based on an adjustable probability of the facilities reporting. These scripts were originally developed by Dimagi for testing the ILSGateway. To make them suitable for use in the EWS, the scripts were modified, and missing modules were added.

After these Python scripts were modified, fake facilities were generated and fake text messages containing stock on hand reports were simulated to have come from these fake facilities. In total, the system was stress tested with about 1,400 facilities and 3 months of reporting data from these facilities (January 2013 to March 2013). A reporting rate of 90 percent (a probability of reporting equal to 0.9) was assumed in order to generate the reporting data.

This approach to testing in effect meant that the scale-up of the EWS was simulated on a parallel server. The results of the testing, in turn, can be used to infer how the system is going to react when scaled up.

Tolerable Wait Time (TWT)

Tolerable wait time is a term used to describe how long web users can be expected to tolerate delay from a website. If a site delays loading beyond a certain point, users are likely to close the page and are not likely to come back. According to a 2004 study by Fiona Nah *(Nah, F., "A study on tolerable waiting time: how long are Web users willing to wait?" Behaviour & Information Technology 23, no. 3 (2004): 153-163.)* the tolerable wait time (TWT) on pages without any feedback is between 5 to 8 seconds. Adding feedback (a progress bar, for example) improved the TWT to 38 seconds.

In the case of the EWS, after the 1,400 fake facilities sent reporting data through simulated text messages, the site performance showed major degradation. Figure 2 shows a sample list of pages and the time taken for loading.

Figure 1. Load Time for EWS Login Page

Login Page: 6 seconds and 789 milliseconds

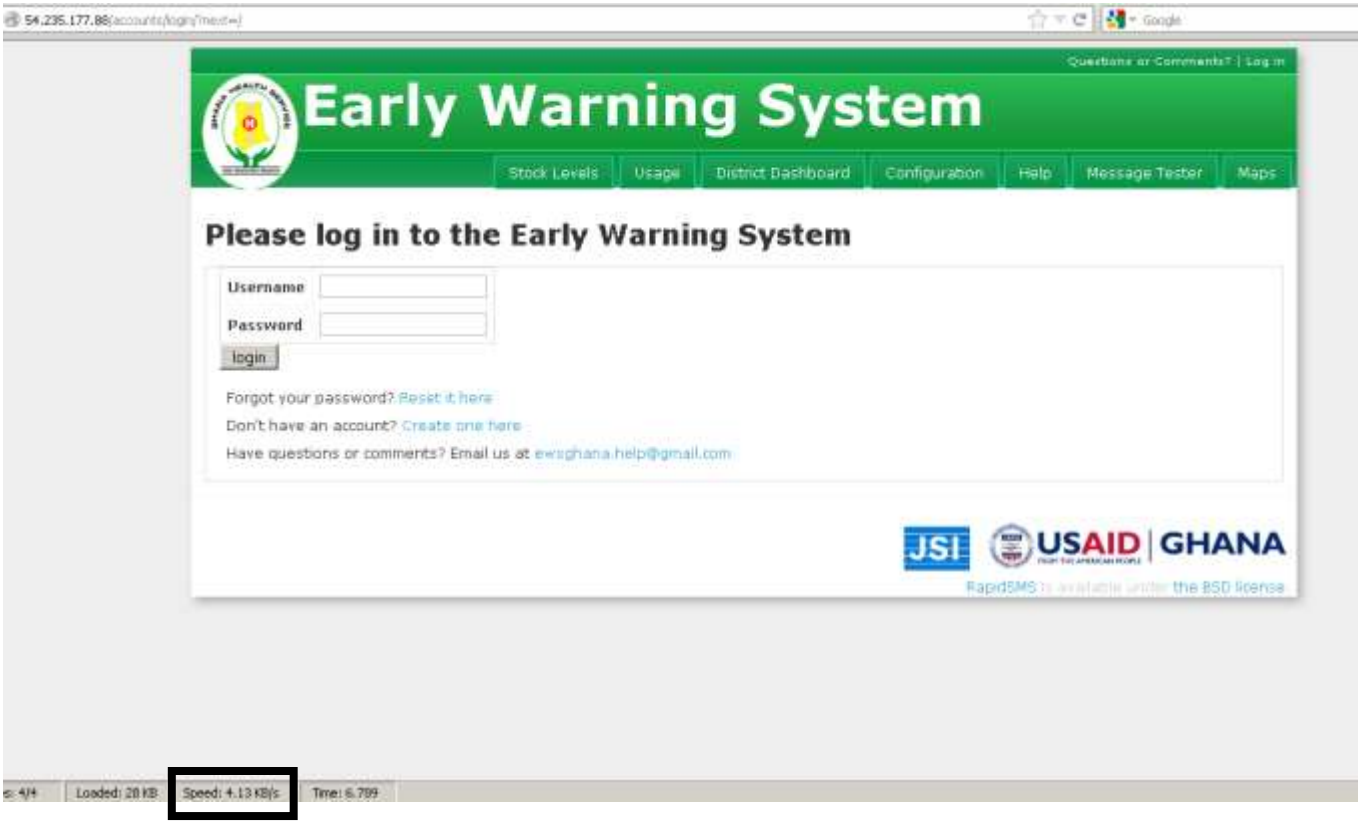


Figure 2. Load Time for EWS Aggregate Stock Report Page

Show Aggregated Stock Report: 8 minutes 54 seconds and 259 milliseconds

After caching was enabled, the load time improved but was still longer than 5 minutes as shown in figure 3. (5 minutes, 23 seconds, and 723 milliseconds)

Figure 3. Load Time for EWS Aggregated Stock Report Page after Caching

These kinds of loading times far exceed what any user can be reasonably expected to tolerate.

2. Concurrent Website Users Generating Huge Traffic

The second approach to testing focused on how the system would behave when there were many concurrent users. This testing was performed using a service provided by the vendor Neustar (formerly known as BrowserMob), a website that simulated multiple browsers connecting to the parallel EWS site and going through basic operations like logging in, opening the dashboard, and drilling down into facility data.

The Selenium script scenario that was prepared had the following steps:

- Step 1: Show login page
- Step 2: Open the landing page
- Step 3: Drill down to a region

Neustar recorded the results and the website response times as the number of users kept increasing.

Figure 4 shows the response time:

Figure 4. EWS Response Time As Users Increase

The average response time for each of the steps in the Selenium script has been plotted in the graph above. The entire transaction has also been shown.

The response time graph shows how long it would take for a response from the website to get to the client as the number of concurrent users keeps increasing. When looking at the above graph, it is readily visible that while there are little variations, the site would take longer than 2.5 minutes to load. This exceeds the tolerable waiting time.

Local Capacity/Vendor Impressions

Local software vendors in Ghana were interviewed with the view of assessing their capabilities in the technology used to develop the EWS and their ability to take on the maintenance of the system once the existing contract with Dimagi expires. The EWS was developed using the Python programming language on a PostgreSQL database with a Django and RapidSMS framework, so vendors were asked about their familiarity with these products. In addition, vendors were assessed on the basis of whether or not they seemed to follow good software development practices in their work.

Seven local software vendors were contacted in Accra. One vendor declined an interview after hearing the details of the project. Out of the six interviewed, Hutspace, a vendor also recommended by Dimagi, was found to have the most related experience in the technology used in the EWS. Next was MobileContent.com (MC.com), which has built various mobile-based systems, although not directly in Python. Other software vendors interviewed are also listed below, ordered based on impressions of their capabilities.

1. Hutspace

Hutspace has worked with Axon Information Systems, which was Dimagi's local partner during the initial implementation of the EWS, for some time and refer to themselves as a Python shop. They have worked on RapidSMS and Django and have modified the EWS codebase itself for another project. Consequently, they are familiar with the EWS and the technology it runs on. They have worked on projects with international companies such as Family Health International and the Every Child Project.

Hutspace evidenced good software development practices by using Git for source control and showing familiarity with the concept of unit testing. They have experience in the unit-testing framework "Nose" that was used in the EWS and have used database management systems including PostgreSQL, MySQL, and the Google AppEngine.

2. MC.com

MC.com worked with Abt Associates and USAID earlier this year on mobile-based systems employing SMS and Unstructured Supplementary Service Data (USSD). They have also developed systems for the Ghana police (for license plate tracking), the World Bank, the Ghana Social Security and National Insurance Trust (SSNIT), and the Ghana National Health Insurance Authority (NHIA). They work mainly in PHP and use a SMS gateway known as SMS Studio. The company showed good software development practices by using Subversion (SVN) for source control. They have used mostly MySQL as their database management system, and they have some limited PostgreSQL experience. Python has not been used so far in the company for development, although they do have a software developer who can write Python code. All in all, MC.com seemed like a well-organized company, capable of taking on maintenance of the EWS after some learning to get up to speed with the technology behind it.

3. URC Systems Ltd

URC Systems Ltd is mainly invested in building products that are outsourced from the United States. They have worked on web- and mobile (Android)-based banking systems. The company mainly uses C and PHP as programming languages. The database management system in use is MySQL, and the source-control system used is SVN. Although some programmers in the company might be familiar with Python, it has not been used as a development language for any of their products.

4. Duku Consulting

This company mainly works on financial software. They have built a web-based, closed user group stock exchange software. The main programming languages in use for projects are Visual Basic.NET (VB.NET) and Java. The database management systems in use include Oracle, SQL Server, and MySQL. The source-control system used is Git and, so far, Python has not been used for any of their projects. The company grew from being a support company to being a development company only recently.

5. Crysol and Code Soft

Crysol and Code Soft are two companies that work together on Enterprise Resource Planning (ERP) implementations. Languages primarily used are VB.NET, Java, and PHP. Database management systems used are MySQL, SQL Server, and Oracle. The companies have not used Python in any of the projects they have built. Even though they had 12 to 13 consultants and six

permanent staff, the companies seemed to be only vaguely familiar with, and not heavy users of, source-control systems.

6. Sawtel

Other than saying that they worked on their own website and providing a brochure, this company could not provide significant technical information, and the only technical person they had was not available for the meeting. In general, the company did not seem to have much experience in software development.

Recommendations

Reporting Frequency

Currently, facilities at all levels submit their reports weekly, between Friday and Monday. As mentioned in Findings, users at the RMS reported feeling overwhelmed due to high workloads and having to report on many products. Although the CMS has not yet begun reporting to the EWS, similar issues are foreseen for when they do begin to report, as they would have the largest number of products to report on. Consequently, it is recommended that the frequency of reporting be adjusted so that different levels of the supply chain report at different intervals. The recommended reporting schedule is as follows:

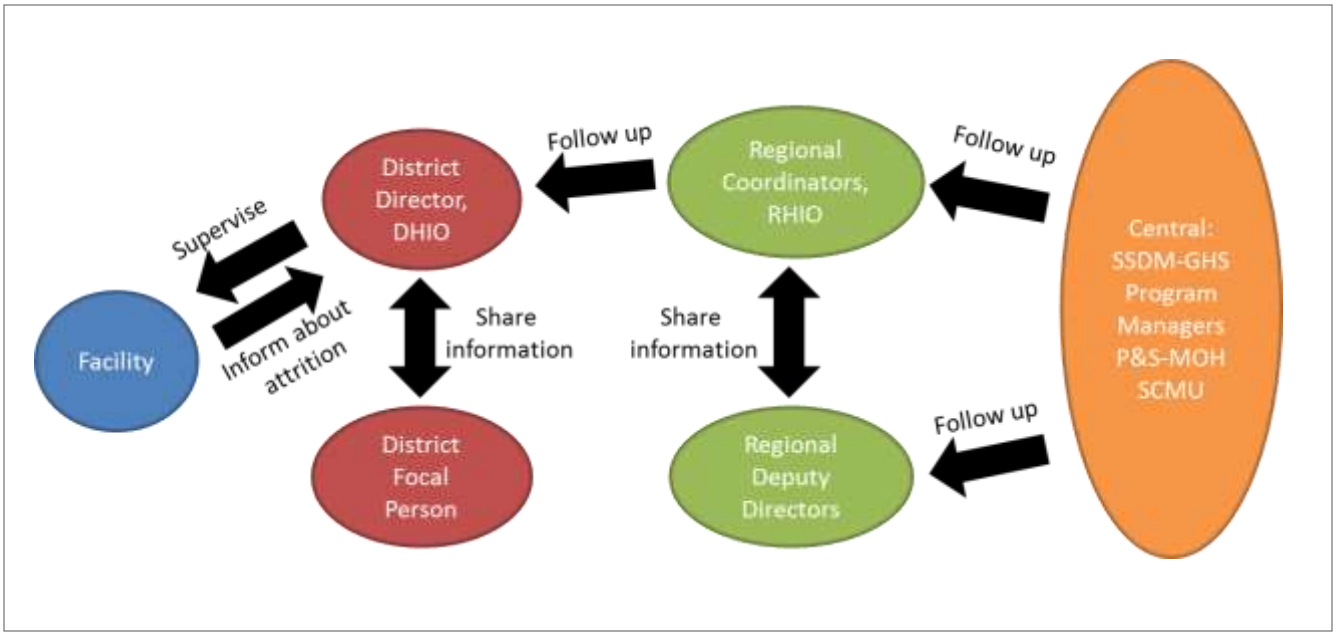
- Health facilities (CHPS facilities, health clinics, hospitals): weekly (reporting period: Friday–Monday)
- RMS: every two weeks (reporting period: Friday–Monday), except in the case of stockout, which should trigger immediate reporting
- CMS: monthly (reporting period: Friday–Monday), except in the case of stockout, which should trigger immediate reporting

Supervision

Currently, supervision of reporting users is implemented differently in FRHP and USAID | DELIVER PROJECT regions. In FRHP-supported regions, the implementation is carried out from the district level, so DHIOs are trained on using the system and are expected to follow up with facility users when there are problems with their reporting. In USAID | DELIVER PROJECT-supported regions, the districts are not involved in the EWS, so it falls on the region to follow up with users on reporting. The July 2012 assessment found that reporting rates tended to be higher in FRHP regions, and this seems to correlate with the involvement of the district for supervision. For consistency across the country, it is recommended that one supervision model be implemented in all 10 regions, regardless of whether it is an FRHP- or a USAID | DELIVER PROJECT–supported region. Given that involving the district has proved to have better results, it is recommended that this harmonized supervision model include the district in the supervision chain.

Figure 5 illustrates the recommended supervision model. The District Directorate would supervise reporting from facilities, and in turn facilities would inform the directorate about attrition of staff so that new staff can be hired and trained. This would hopefully address the issue where only one person at the facility can report to the EWS, and where that person's absence means no report. The District Directorate would also share information with health program focal persons at the district. At the region, if a problem with reporting is noticed, the Regional Health Administration would follow up with the District Directorate. It would also share information with Regional Deputy Directors of health programs. In turn, central-level users would follow up with the region about any noticed reporting issues.

Figure 5. Recommended Supervision Structure



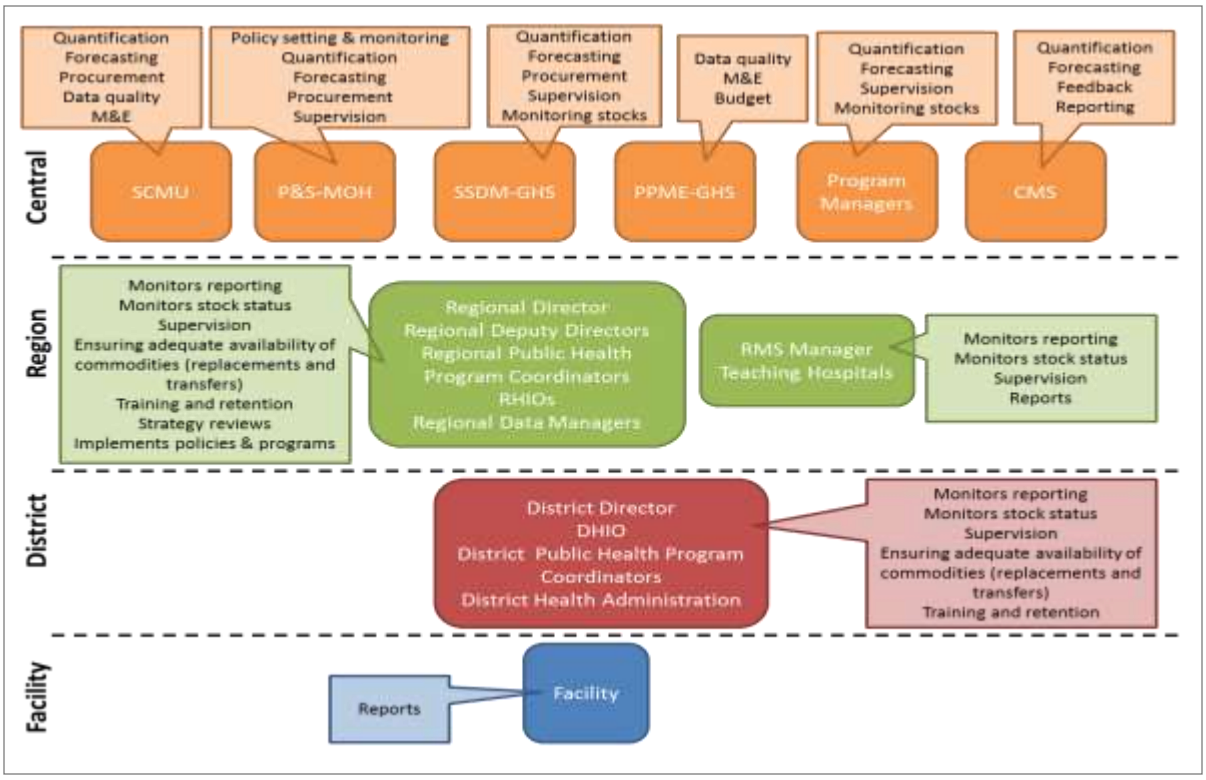
Products

The current list of products to be reported on, at 43, is quite bloated and includes some duplication. Although most health facilities manage on average 10 to 12 of the products, the reporting burden is high at the RMS, where they report on all (or most) of the products. As commodities from more health programs such as EPI and TB are added to the list, it is likely to become longer and more burdensome even for those at the facility level. It is therefore recommended that the list of products be revisited and that inclusion of commodities on the list be rationalized so that the system can fulfill its intended purpose as a snapshot of the larger picture of what is going on with commodity availability in the public health supply chain. It should be kept in mind that, due to the limitations of using mobile phones, not every product managed at health facilities can be reported on via the EWS, and that tracer commodities are intended to provide an abbreviated view of their stock availability and of products like them.

Information Use

Decision-making users expressed confusion at how they are supposed to interact with the EWS and how they should be using the information provided by the system. This confusion led to frustration on some users' part, as they felt that they were not empowered to follow up with reporters who were not reporting or to make procurement decisions where they saw stockouts. The result of this frustration was that these users stopped using the EWS. It is recommended that, to avoid these kinds of frustrations, all potential decision-making users be educated on how the information provided by the EWS can be useful to them, what decisions they can make with it, and how they should interact with the system. Figure 6 shows how users at different levels of the supply chain should use the EWS:

Figure 6. Information Use at Different Levels



Health facility:

- Health facilities (*CHPS facilities*, *health clinics,* and *hospitals*) report to the EWS according to the agreed-upon reporting schedule.

District:

- At the district level, the District Director, DHIO, District Public Health Program Coordinators, and District Health Administration can all use the information on the EWS to monitor reporting and stock status, ensure adequate availability of commodities through arranging for replacements and transfers between facilities where able, supervise facilities, organize trainings, and address attrition of staff where necessary.

Region:

- At the regional level, there are two sets of users: those who only make decisions with the information and those who both report and make decisions. The *Regional Health Information Officers (RHIOs*), *Regional Data Managers,* and *Regional Public Health Program Coordinators* can use the information provided by the EWS to monitor reporting and stock status and to promote adequate availability of commodities by providing relevant information to the *Regional Director* and *Deputy Directors* to effect redistribution of commodities as needed. They can also use the system to monitor reporting and stock status, supervise facilities, organize trainings, address attrition of staff where necessary, perform strategy reviews, and implement policies and programs. The *Regional Medical Store managers* and *users at teaching hospitals* should report to the EWS, and they can also use the information reported by lower-level facilities to monitor reporting and stock status at—and supervise—those facilities.

Central:

- At the central level, there are users at several agencies and units. The *Supply Chain Management Unit (SCMU)* of the MOH can use the information available on the EWS for quantification, forecasting, and procurement decisions, as well as for assessing data quality and for monitoring and evaluation. The *Procurement and Supply Directorate (P&S)* of the MOH uses the information for policy setting and monitoring, for decisions about quantification, forecasting and procurement, and for supervising the CMS. The *Stores, Supplies, and Drug Management (SSDM)* unit of the GHS can use the system for quantification, forecasting, and procurement decisions, as well as for supervising and monitoring stock levels at RMS and health facilities. The *Policy, Planning, Monitoring, and Evaluation (PPME*) unit of the GHS can use the information in the EWS for data quality assessments, monitoring and evaluation, and to feed into budget decisions. *GHS Health Program Managers* can use the system for quantification and forecasting, as well as for supervision and monitoring stock levels of RMS and health facilities. Lastly, the *CMS* will report to the system and use the information for quantification and forecasting and to provide feedback to the RMS.

New Features

As mentioned above, users expressed frustration with some of the reports on the EWS dashboard, as well as the desire to see some new reports and workflows that would present the information in more useful ways. It is recommended that the web interface of the system be revised in order to accommodate these user requests. Mockups reflecting the recommended changes are attached in appendix A.

Cost/Benefits of CommTrack 2.0 versus Locally Supported EWS

Dimagi named the open source code that the EWS is presently built on CommTrack. Having taken many lessons learned from the EWS and its other sister applications deployed in Malawi and Tanzania, the CommTrack code has been significantly modified to create CommTrack 2.0. CommTrack 2.0 is envisioned as a turnkey, cloud-hosted solution that countries can sign up for and use "out of the box" with minor modifications for their specific context. Lessons learned from deployments in various countries have been incorporated, thereby making the system more scalable and compliant to standards. Dimagi has expressed that they will not be supporting the EWS beyond the expiration of the current contract, and that they are planning to focus their efforts on CommTrack 2.0. This would make the EWS an orphan application with no supported code base, and any future EWS modifications would be pure customizations with little, if any, applicability in the open source arena, which was one of the original selling points of using Dimagi and its open source code.

The fact that CommTrack 2.0 is a turnkey solution means that though there are possibilities for customizations, the system is quite generic. In considering migration to CommTrack 2.0, it is worth noting that there will likely be feature gaps between what is currently on the EWS and what is offered by CommTrack 2.0, and these gaps will have to be filled. Since the implementation of CommTrack 2.0 has been mostly generic, customizations that were built specifically for Ghana in the EWS are missing. To bridge these feature gaps, Dimagi estimates that it would take approximately U.S.$30,000-worth of level of effort. In addition, there would be a cost associated with migrating all the data that is currently in the EWS database into CommTrack 2.0, amounting to

approximately U.S.$20,000. In total, migrating to CommTrack 2.0 would involve a one-time cost of approximately U.S.$50,000. Once the system is in use, there will be a running cost of monthly subscription fees which would go towards hosting, technical support, and upgrades.

The alternative to migrating to CommTrack 2.0 would be to locally support the EWS by contracting with a local software development vendor (see Findings above for vendor impressions). Given the performance issues found during the load testing (discussed in Findings), data warehousing modifications similar to that implemented in the ILSGateway would have to be applied to the EWS to support future scale-up of the system. Given that local vendors are not considered to have the necessary technical capabilities to implement the data warehouse, this would have to be done by Dimagi. The estimated one-time cost for this implementation is approximately U.S.$50,000. There will also be running costs of web hosting and contracting a local vendor to support the system. Costs for contracting a local vendor are unknown and can only be gathered via an RFP.

Five options were identified with regards to how to proceed with CommTrack 2.0 versus the EWS:

A. Status quo: Continue using EWS the way it is now and scale up and see what scalability issues will befall the system in the future

B. Locally support the EWS: Scale up using EWS with data warehousing implemented and contract a local vendor for maintenance and support

C. Discontinue the EWS and transition to CommTrack 2.0 before scale-up: This would involve running parallel instances of both systems for a few months while training users on CommTrack 2.0 and allowing them to get used to it. After a few months, the EWS would be discontinued and users would continue with using CommTrack 2.0

D. Scale up using the EWS with data warehousing implemented while migrating to CommTrack 2.0 step by step

E. Scale up using the EWS without implementing data warehousing while migrating to CommTrack 2.0 step-by-step.

The advantages and disadvantages of going through with each option are discussed below.

A. Status quo: Continue using the EWS the way it is now and scale up without data warehousing optimizations and see what scalability issues befall us in the future (not recommended)

- Advantages
  - No immediate cost.
- Disadvantages
  - Slowdown and reduced utilization. Without data warehousing modifications applied to it, the EWS as it currently stands will not be able to handle the added volume of data when many facilities are added to it. Testing results confirm that significant slowdown will occur, and this will almost certainly result in the loss of users.
  - Orphan code. Dimagi has taken the lessons they learned from building the systems in Tanzania, Malawi, and Ghana and has created CommTrack 2.0. As a result, the EWS application will not be the main point of focus and ongoing support with Dimagi. CommTrack 2.0 is the cloud-hosted solution that is and will be the project that Dimagi will be investing in and working on in the future. Although it is possible to contract

Dimagi as well as local vendors to maintain and update the current EWS code, the code base will not be as lively as the one for CommTrack 2.0, where change requests, tests and feature upgrades will be coming from various parties and being implemented without Ghana specifically asking for them. In short, there will not be active open source community involvement for the software. This runs the risk of the code becoming outdated and the system falling into disrepair.

A. Scale up using the EWS with data warehousing implemented and contract a local vendor for maintenance and support

- Advantages
  - No slowdown during scale-up.
  - Feeling of ownership by Government of Ghana/MOH officials because the system will be locally maintained.
- Disadvantages
  - Orphan code, as discussed above.
  - Local vendor capabilities will limit future directions and feature requests that will come from users as they become avid users of the system.
  - Data warehousing costs

B. Discontinue the EWS and migrate to CommTrack 2.0 before scale-up

- Advantages
  - No data warehousing costs for the EWS.
  - All the advantages of using CommTrack 2.0 code base that is updated and maintained by Dimagi.
- Disadvantages
  - Training costs. Web users will be completely new to the system and will have to be retrained.
  - Feature gaps. Some features found in the present EWS have not yet been developed for CommTrack 2.0. These are features that were built as a result of the Ghana users requesting them. Losing these features even temporarily would mean more dissatisfied users and will decrease the utilization of the website. Filling these gaps will incur a cost.
  - Data migration costs. It will be necessary to migrate historical data from the EWS to CommTrack to make it available for analysis and report generation.
  - Monthly subscriptions costs for using the system will be incurred.

C. Scale up using the EWS with data warehousing implemented while migrating to CommTrack 2.0 step by step (not recommended)

- Advantages
  - No abrupt transition to a new system.
  - No slowdowns during scale-up.
  - There is time for data migration.
  - There is time to bridge the feature gaps.
  - CommTrack 2.0 code maintained and kept up to date by the original vendor, Dimagi.
- Disadvantages
  - Data migration costs, as discussed above.
  - Costs to bridge the feature gaps, as discussed above.
  - Training costs, as discussed above.
  - Because Commtrack 2.0 is generic, users will have to adapt to certain types of reports, and customization might not be possible to the same level as with EWS.
  - Data warehousing costs incurred in EWS even if it is going to be slowly moved out of the picture. This will result in double costs.
  - Eventually, monthly subscription costs for using CommTrack 2.0.

D. Scale up using the EWS without implementing data warehousing while migrating to Commtrack 2.0 step by step (not recommended)

- Advantages
  - No data warehousing costs incurred.
- Disadvantages
  - Scale-up would see significant delays in the performance of the website, resulting in decreased user engagement and utilization, as discussed above.
  - Eventual costs for data migration, bridging feature gaps, training and monthly subscription, as discussed above.

Given the advantages and disadvantages laid out above, we recommend that options B and C be considered seriously. Option A would result in eventual disuse of the system, whereas options D and E simply put off the migration to CommTrack 2.0, incurring extra costs in the meantime. The financial implications of options B and C are laid out in the table below. It should be noted that SMS costs would apply in all scenarios and would work out to be about equal, so they have not been included in table 1.

Table 1. Costs of Options B and C

Option B: Locally support EWS with data warehouse	Option C: Migrate to CommTrack 2.0
New features: U.S.$20,000	New features: U.S.$25,000
Data Warehousing: U.S.$20,000–50,000*	Feature parity with EWS: U.S.$30,000
Monthly hosting fees: U.S.$100 per month	Data migration: U.S.$20,000
Local vendor support: currently unknown	Training: currently unknown
	Monthly subscription fees: U.S.$1 per facility per month (for 500 facilities, this means U.S.$500 per month)

*Data warehousing costs can be as low as U.S.$20,000 if it is implemented for only the slowest one or two reports. Warehousing the entire site will cost U.S.$50,000.

Conclusion

The EWS has shown value for its users and seems to have strong support in the Ghana Ministry of Health and the GHS. To ensure the system's sustainability, it is necessary to have a plan for its future and eventual handover to the MOH. This includes ensuring that the system is actively used and that it is well maintained and supported. The following next steps are recommended for accomplishing this:

Next Steps

Revisit Standard Operating Procedures (SOPs) for the EWS

Institute harmonized procedures for reporting and supervision in all regions, regardless of whether they are supported by FRHP or the USAID | DELIVER PROJECT. Health facilities, RMS, and the CMS should report at different intervals due to the difference in reporting load. The district should be involved in the supervision of reporting to the EWS and be able to provide information to the region as needed. The reporting list should be revisited to ensure that tracer products from each health program area are included so as to provide a widespread picture without overburdening those who are reporting.

Educate Decisionmakers on How to Use the System

Decision-making users at higher levels of the public health supply chain should be educated on how to use the system and how to interact with it. This includes educating them on how the information available on the web interface can be useful to them and what decisions they can make with it.

Implement Requested New Features

Reports currently on the EWS web interface have been found to be lacking in their ability to provide easily understandable logistics information. This may frustrate potential users and negatively affect their use of the system. More user-friendly reports and workflows should be implemented to avoid this scenario. Mockups of new features have been developed and vetted by both the FRHP and the USAID | DELIVER PROJECT teams to guide this implementation (See appendix A).

Determine Costs for Local Support

To determine the full costs of locally supporting the EWS, it is necessary to understand whether a software development vendor based locally in Ghana would be capable of maintaining the system and how much they would charge for this service. This information can be gathered by floating an RFP to which vendors respond with details of their proposed technical approach and their costs, allowing for evaluation on both fronts.

Decide on Future Maintenance and Support

Once the costs of contracting a local vendor are known, it will be possible to make a decision about whether to migrate to CommTrack 2.0 or to maintain and support the EWS locally. It should be

kept in mind that financial costs should not be the only factor taken into consideration for this decision. Access to a constantly updated and well-maintained open source code base, as well as the ability to benefit from new features requested by other countries, is a strong argument for CommTrack 2.0. However, this must balance with a feeling of ownership on the part of the Ghana Ministry of Health and the GHS, as this is crucial to the success of the system in the country.

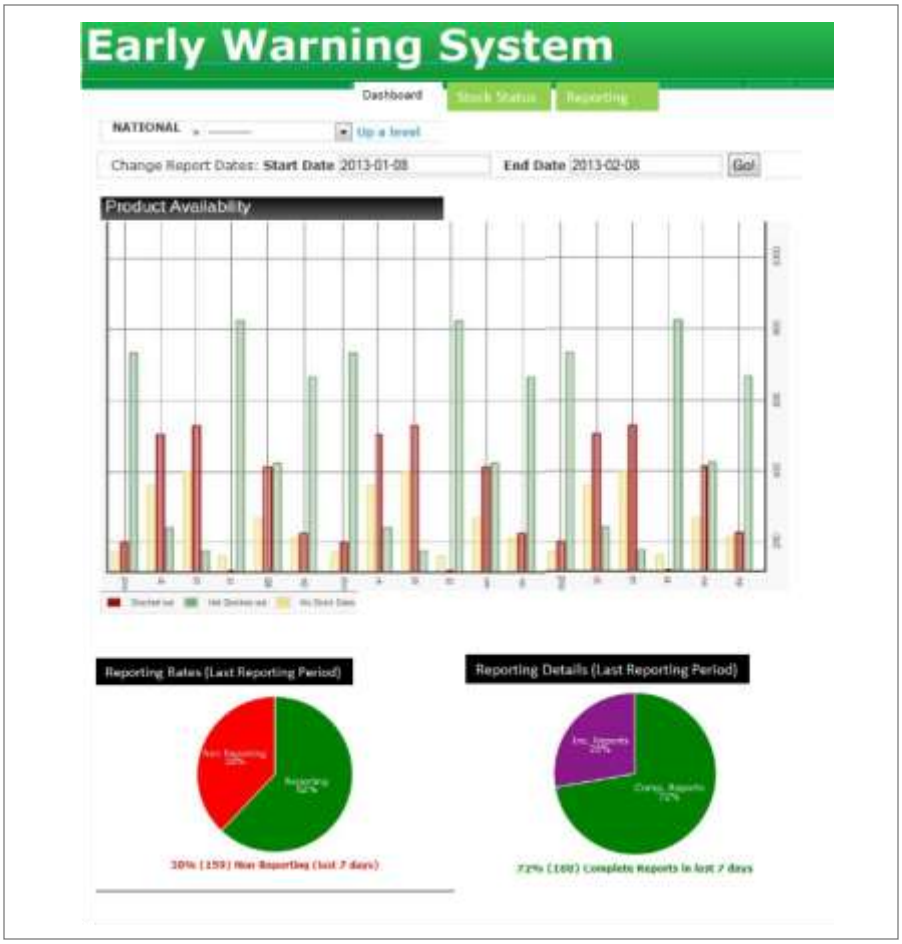
Appendix A

EWS New Feature Mockups

Dashboard (National, Regional, District)

This will be the first page to load and will present a summary of stock status and reporting information. The page will load at the user's access level, so central-level users see national data, regional users see information for their region, and district users see information for their district. The page displays a *product availability graph,* and *reporting rate* and *reporting details pie charts* for the appropriate level. Note that the reporting-related pie charts show data from the **last reporting period** (Friday–Thursday) instead of the last 7 days. It is possible to drill down (or up) to a level other than the one that initially loads, but it is not possible to drill down to the facility level on this page. To see further details related to stock status and reporting/usage, the user will click on the Stock Status or Reporting tabs. See figure 7 for the national-level dashboard (regional and district levels look exactly the same).

Figure 7. Dashboard Page



Stock Status Page (National, Regional, District)

This page displays the stock information for the level the user selects (or has access to). The user will have the ability to drill down (or up) to another level. The following elements are included on this page at the national, regional, and district levels:

Product Availability Graph

The product availability graph shows the current availability of products at the selected level. This graph displays the number of facilities that are stocked out, not stocked out, and have no stock data within the selected administrative area (nation, region, or district).

Months of Supply by Product Table

A table showing the current months of supply (MOS) per product at facilities should be displayed. At the national level, only MOS at all the RMS and teaching hospitals will be displayed. At the regional level, only MOS at that region's RMS and teaching hospital (if there is one) will be displayed. At the district level, the MOS at all the facilities in the district should be displayed. The facilities/RMS/teaching hospitals in the MOS table should be hyperlinked so that a user can click on one to be taken to that individual facility stock status page. This table should be exportable to Excel.

Product Selection Pane

A selection pane on the page allows the user to select one or more products that they would like to see and compare. This selection pane controls the products displayed in the product availability graph, the MOS table, and the stockouts by product graph.

Stockouts Table

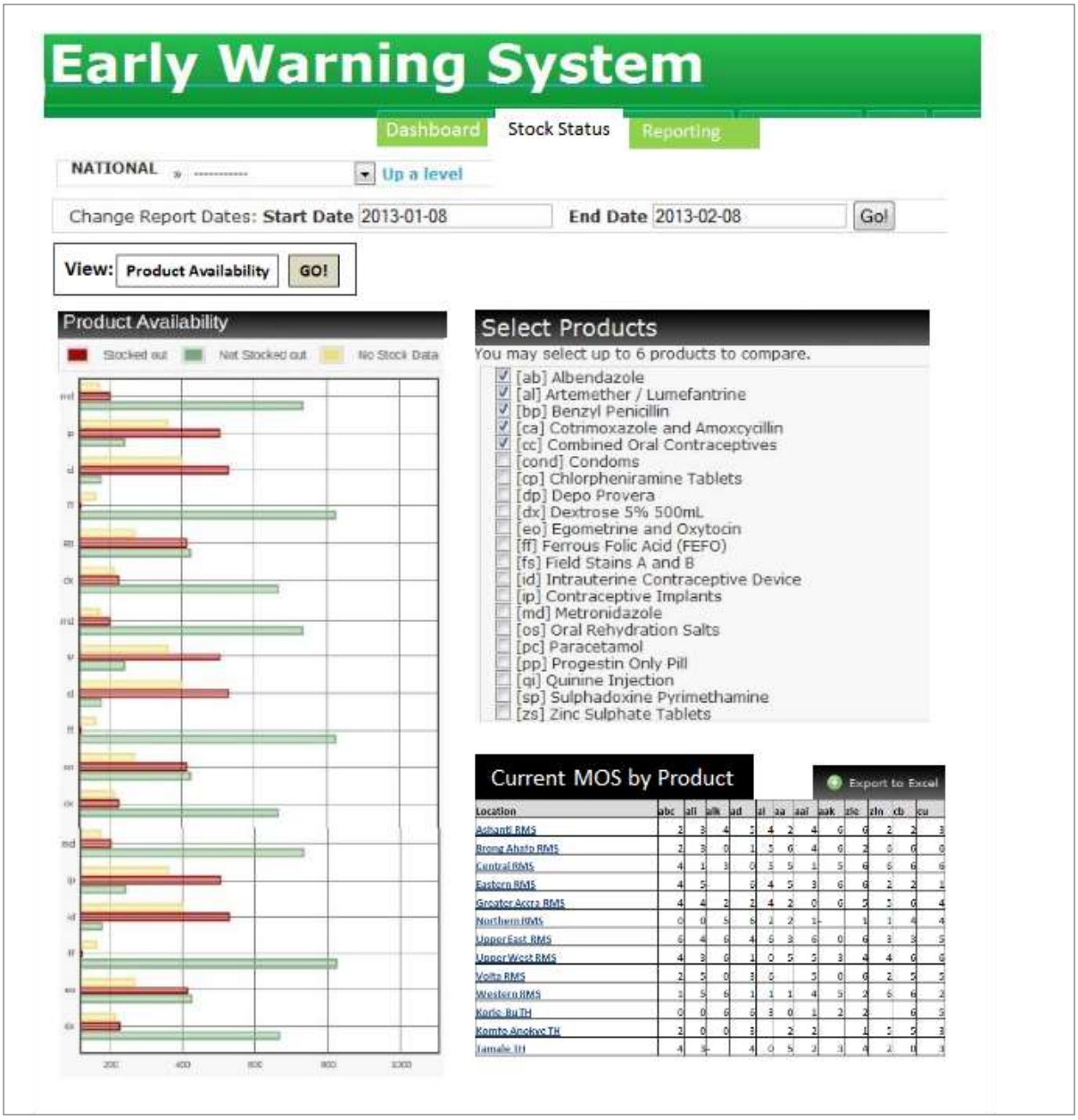
This table lists the products that are currently stocked out at facilities/RMS/teaching hospitals in the selected level. At the national level, stockouts at all RMS and teaching hospitals are displayed. At the regional level, stockouts at that region's RMS and teaching hospital (if there is one in that region) are displayed. At the district level, stockouts at all facilities in the district are displayed. This table is not controlled by the product selection pane, so all products stocked out should be listed regardless of the products selected.

Stockouts by Product Graph

This graph shows the number of facilities within the selected administrative area that are stocked out of products over a period of time. Although the other graphs and tables on this page show current information, this graph has a time period selector that allows a user to view information from different periods of time. The information graphed should be from the first week of every month within the selected period (i.e., there should be only one data point per month) instead of plotting every week's information. The products displayed in the graph are controlled by the product selection pane.

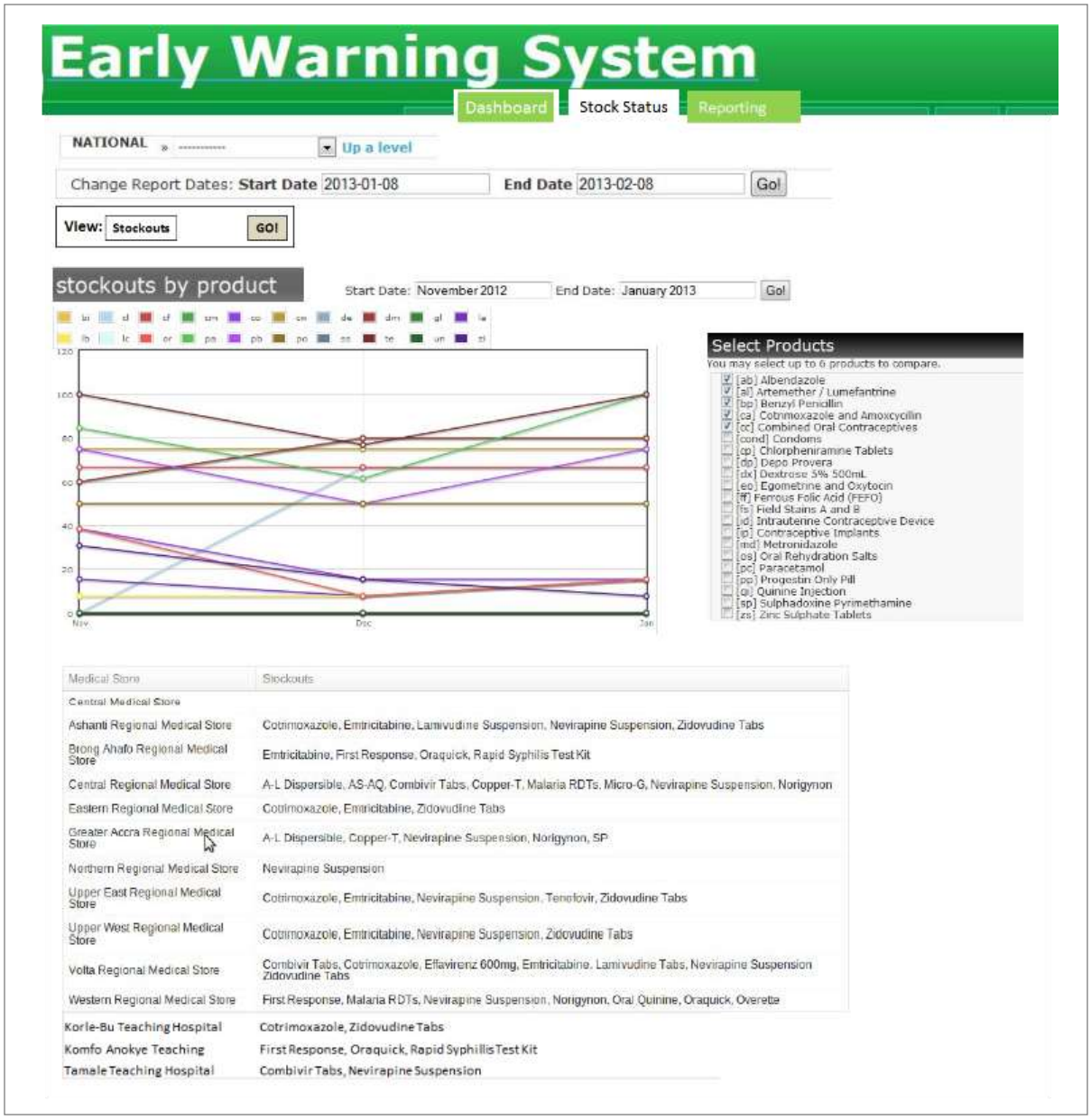
The Stock Status page (see figure 8) will also have a drop-down menu with options for what stock-related information the user wants to see. The options in the menu are: 1) Product Availability, 2) Stockouts, and 3) All Stock Information. On initial load, the page will display product availability information. This will include the product availability graph and the MOS by product table (described above), as well as the product selection pane.

Figure 8. National-Level Stock Status Page: Product Availability (initial load)



The user can then select if they want to see stockout information. This will include the stockouts by product graph and the stockouts table (see figure 9), as well as the product selection pane.

Figure 9. National-Level Stock Status Page: Stockouts



The user can also select the All Stock Information option from the drop-down menu. This will display all the elements on the Stock Status page (see figures 10, 11, and 12).

Figure 10. National–Level Stock Status Page: All Stock Information

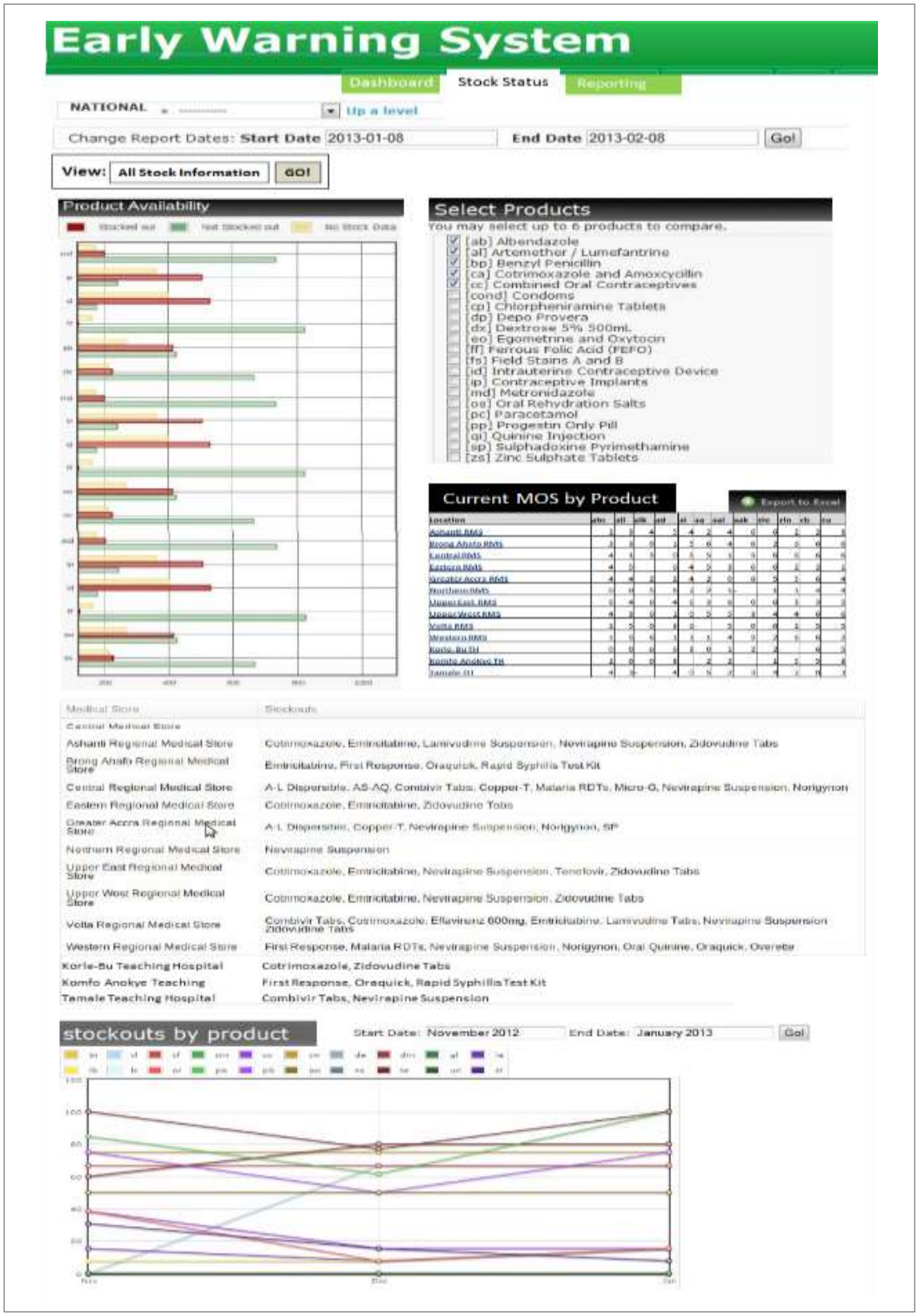


Figure 11. Regional-Level Stock Status Page: All Stock Information

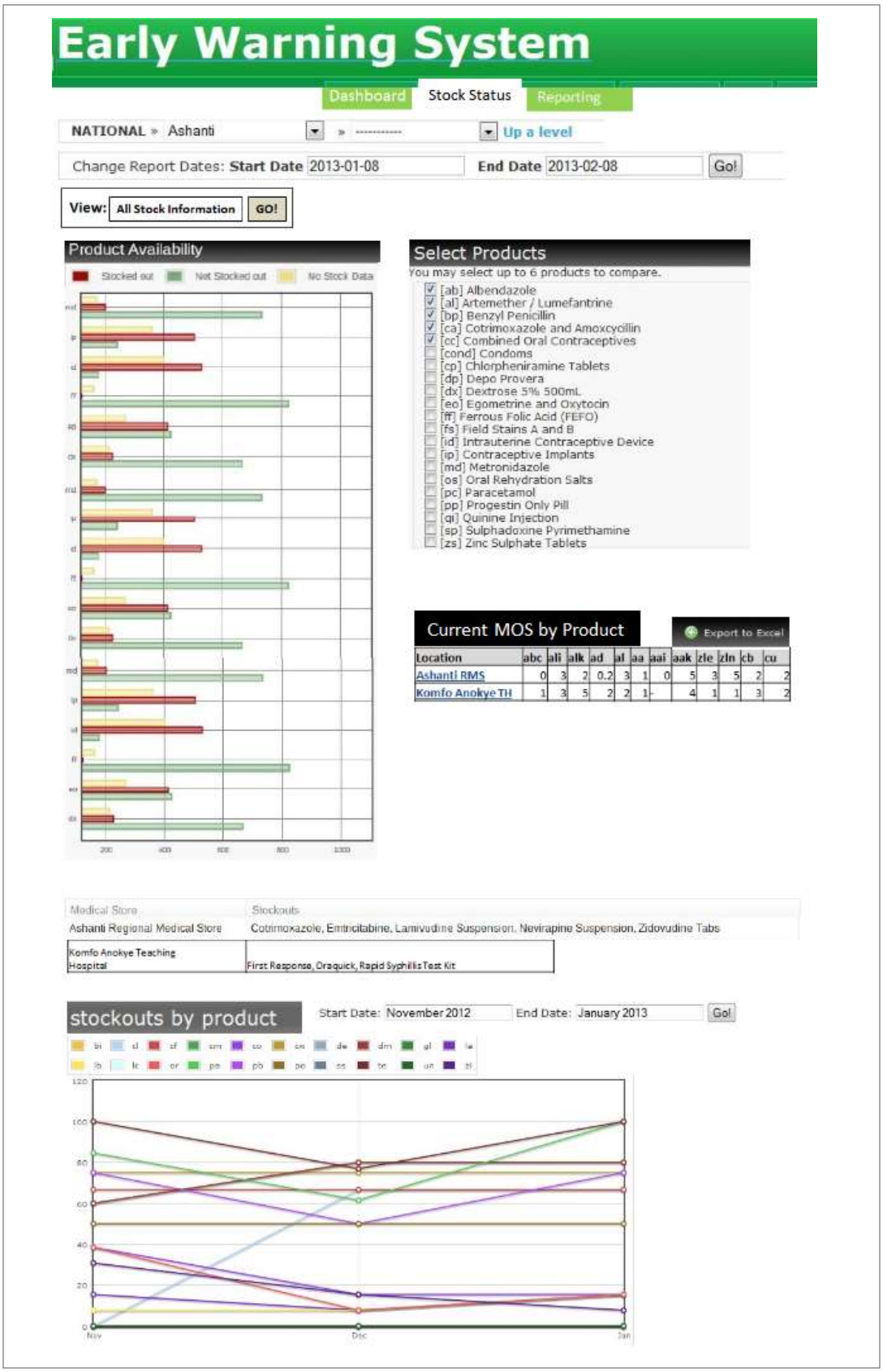
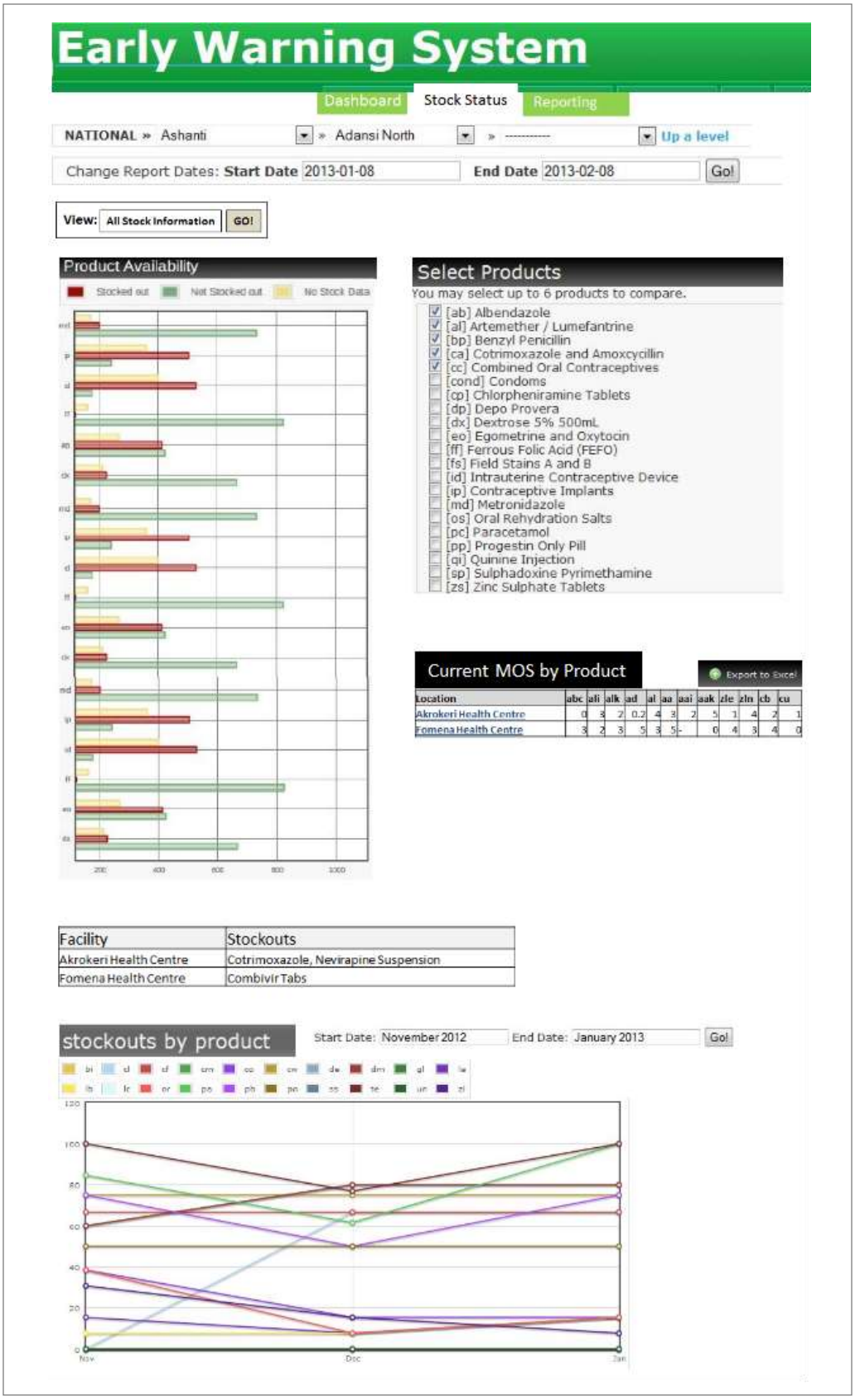


Figure 12. District-Level Stock Status Page: All Stock Information



Facility/RMS/Teaching Hospital Page

This page displays information for a given facility, RMS, or teaching hospital, including stock status information, date of last reports, inventory management trends, and reporting users. A user can navigate to this page either by drilling down using the pull-down menu at the top of the Stock Status and Reporting pages or by clicking on the hyperlinked name of the facility/RMS/teaching hospital in the MOS by Product table (Stock Status page), the Non-Reporting table, and Incomplete Reports table (Reporting page). See figures 13 and 14). The following elements are displayed on the page:

Stock Table

This table displays the current stock information for all products managed at the facility/RMS/teaching hospital. The table should be exportable to Excel.

Inventory Management Trends Graph

This graph displays the MOS of products available at the facility/RMS/teaching hospital over a selected period of time. The products displayed in the graph are controlled by the product selection pane. The max and min levels for the facility/RMS/teaching hospital are superimposed on the graph to show appropriate stock levels. Unlike the Stock table, which shows current information, this graph should allow the user to select any period of time to view.

Product Selection Pane

The selection pane allows the user to select one or more products that they would like to see and compare. This selection pane controls the products displayed in the inventory management trends graph.

SMS User Information

The page should also include information on the SMS users at the facility/RMS/teaching hospital, including names and phone numbers, as well as information on the person in charge.

Stock Input

For web users, the page should include a capability to input stock information for the facility/RMS/teaching hospital.

Figure 13. Facility Page

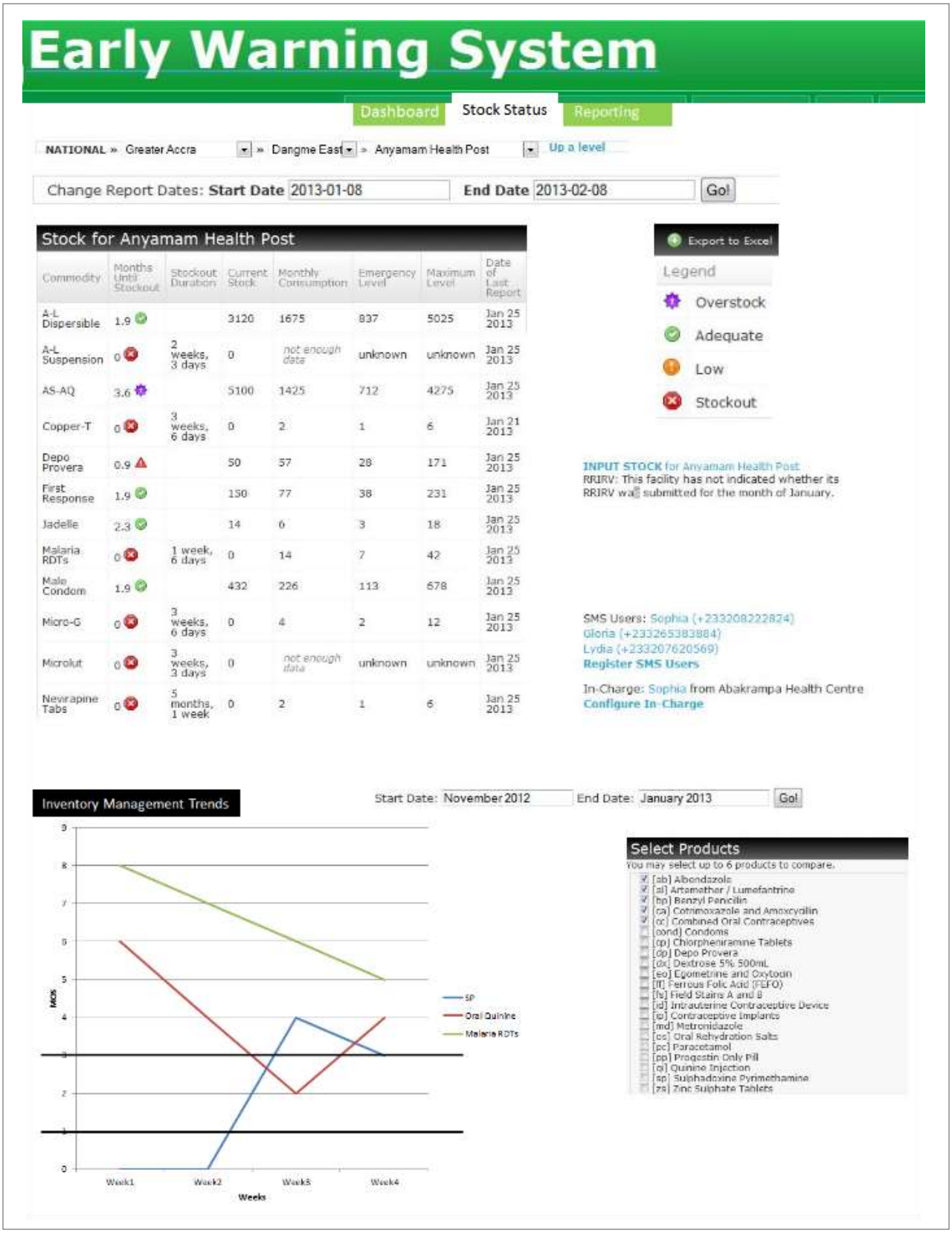
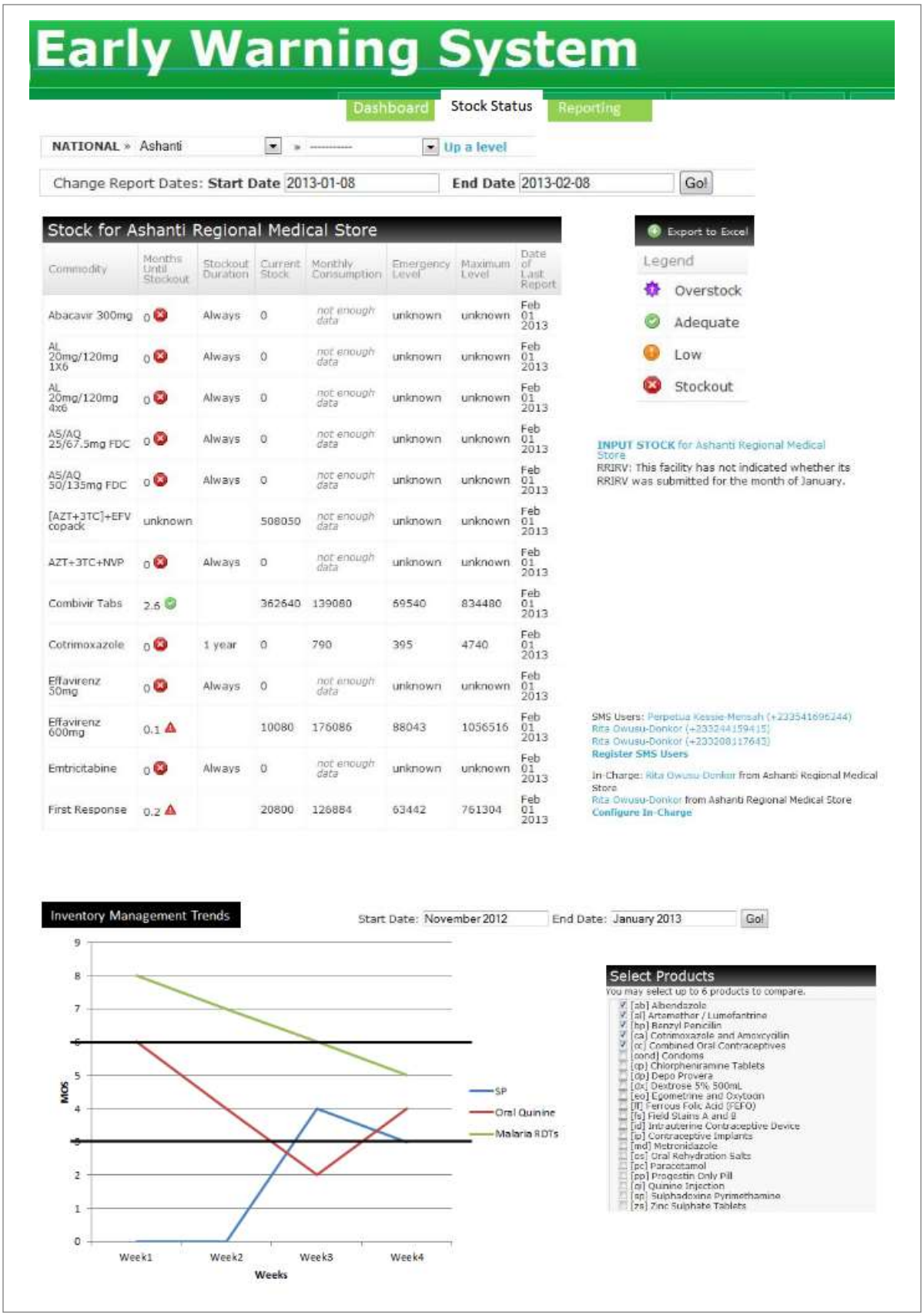


Figure 14. RMS/Teaching Hospital Page



Commodity	Months Until Stockout	Stockout Duration	Current Stock	Monthly Consumption	Emergency Level	Maximum Level	Date of Last Report
Abacavir 300mg	0	Always	0	not enough data	unknown	unknown	Feb 01 2013
AL 20mg/120mg 1X6	0	Always	0	not enough data	unknown	unknown	Feb 01 2013
AL 20mg/120mg 4x6	0	Always	0	not enough data	unknown	unknown	Feb 01 2013
AS/AQ 25/67.5mg FDC	0	Always	0	not enough data	unknown	unknown	Feb 01 2013
AS/AQ 50/135mg FDC	0	Always	0	not enough data	unknown	unknown	Feb 01 2013
[AZT+3TC]+EFV copack	unknown		508050	not enough data	unknown	unknown	Feb 01 2013
AZT+3TC+NVP	0	Always	0	not enough data	unknown	unknown	Feb 01 2013
Combivir Tabs	2.6		362640	139080	69540	834480	Feb 01 2013
Cotrimoxazole	0	1 year	0	790	395	4740	Feb 01 2013
Effavirenz 50mg	0	Always	0	not enough data	unknown	unknown	Feb 01 2013
Effavirenz 600mg	0.1		10080	176086	88043	1056516	Feb 01 2013
Emtricitabine	0	Always	0	not enough data	unknown	unknown	Feb 01 2013
First Response	0.2		20800	126884	63442	761304	Feb 01 2013

Reporting Page (National, Regional, District)

This page includes information on reporting aggregated across the selected level. The user should have the ability to drill down (or up) to another level. See figures 15, 16, and 17). The following elements are displayed on the page:

Alerts

Alerts regarding reporting at facilities/RMS/teaching hospitals are displayed at the top of the page. This may include non-reporting facilities, lack of registered reporters, lack of registered in-charge, etc. At the national-level view, only alerts referring to RMS and teaching hospitals are displayed. At the regional level, alerts referring to that region's RMS, teaching hospital (if one exists), and facilities within that region are displayed. At the district level, alerts referring to facilities within that district are displayed.

Reporting Pie Charts

The reporting pie charts display rates for reporting versus non-reporting and complete reports versus incomplete reports in the **last reporting period**. This means that instead of displaying the rates over the past 7 days, the period should remain static as Friday–Thursday of every week.

Reporting Tables

The reporting tables should list the facilities/RMS/teaching hospitals that have not reported or have submitted incomplete reports, with the date of the last report received. These tables should ONLY list the delinquent facilities/RMS/teaching hospitals, and there should be no tables listing those that have reported and/or have submitted complete reports. At the national level, only delinquent RMS and teaching hospitals should be listed. At the regional level, delinquent facilities/RMS/teaching hospitals in that region should be listed. At the district level, delinquent facilities in that district should be listed. The names of the facilities/RMS/teaching hospitals in the tables should be hyperlinked for access to a given facility/RMS/teaching hospital page.

Figure 15. National-Level Reporting Page

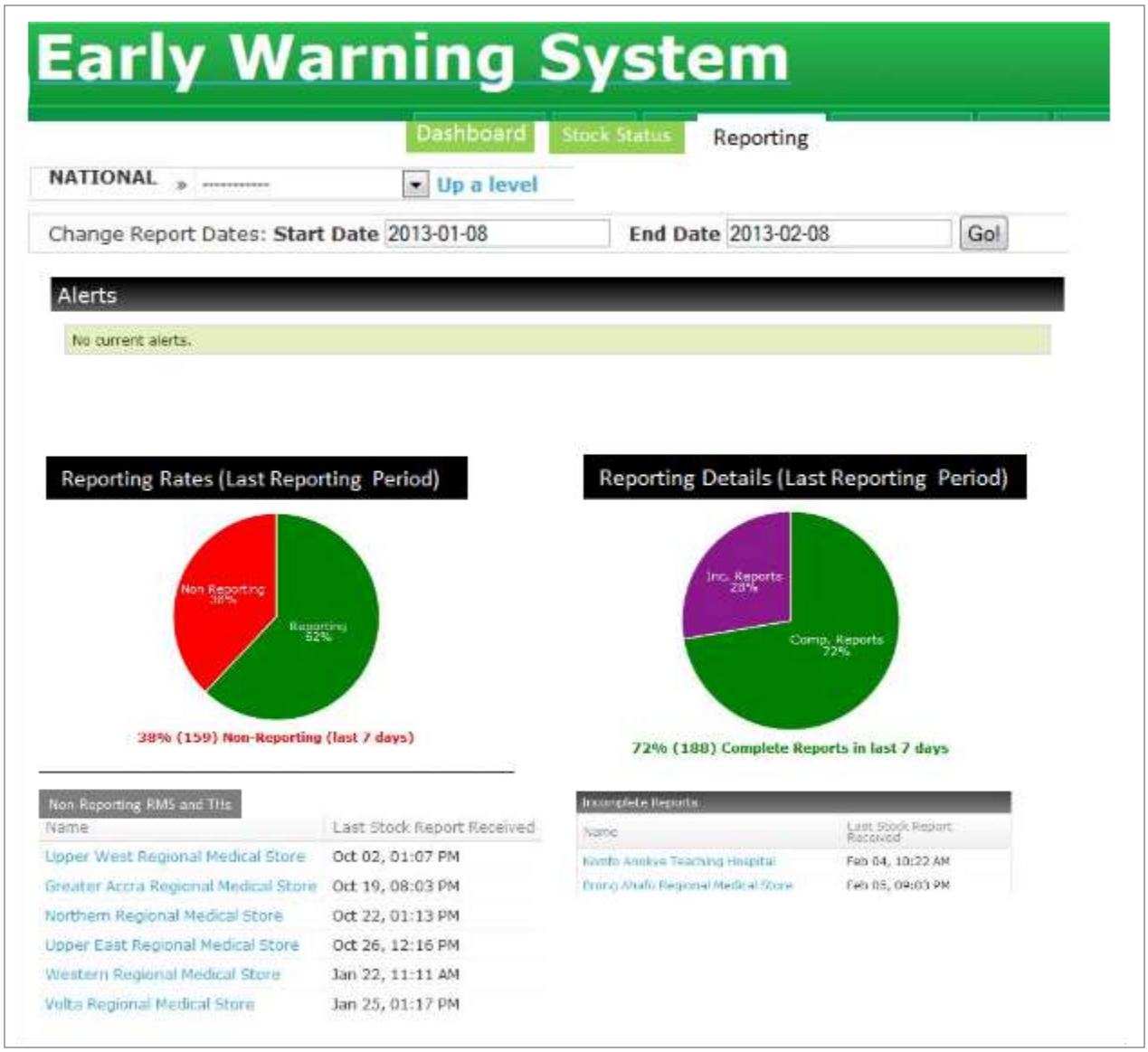


Figure 16. Regional-Level Reporting Page

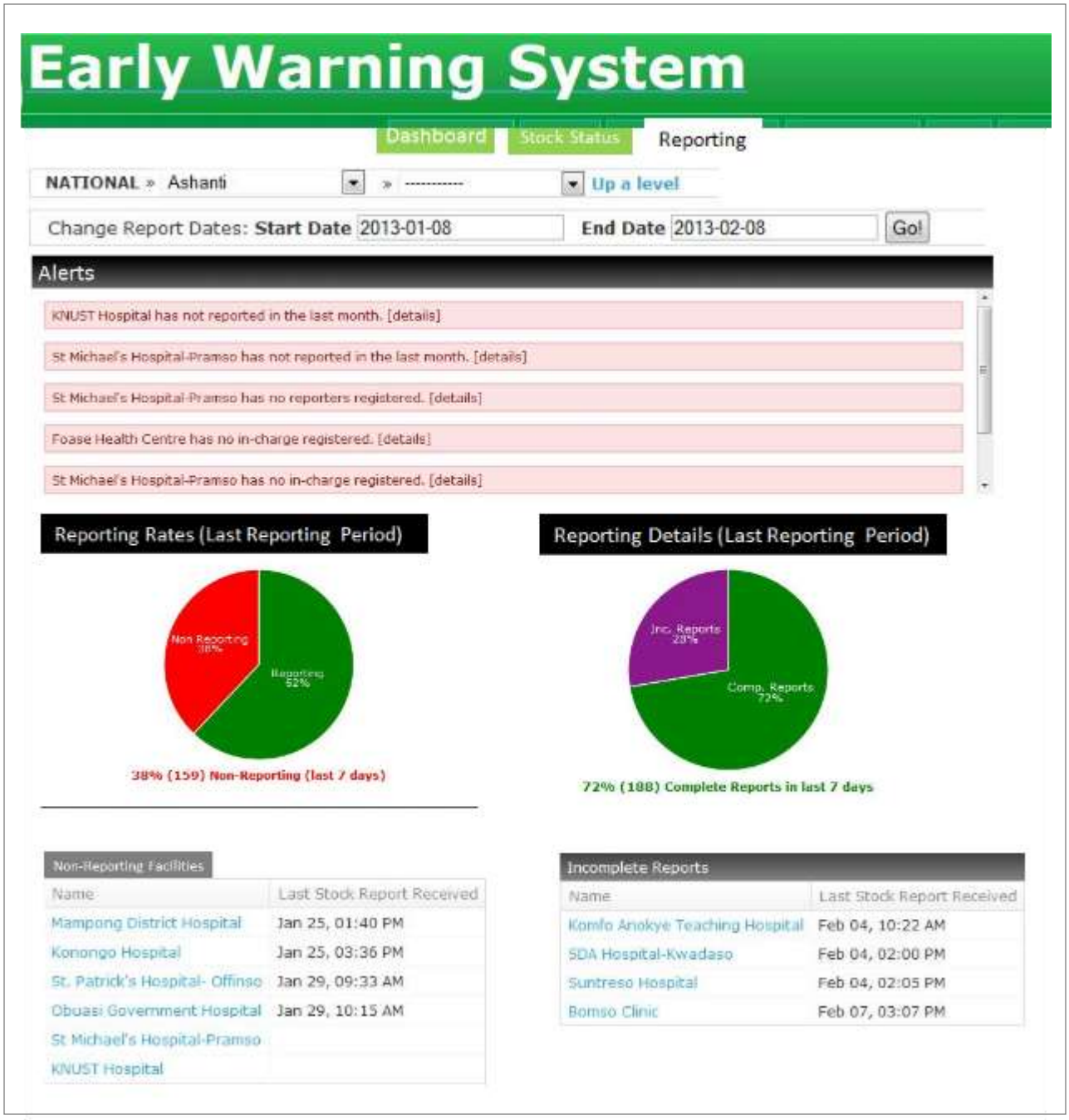
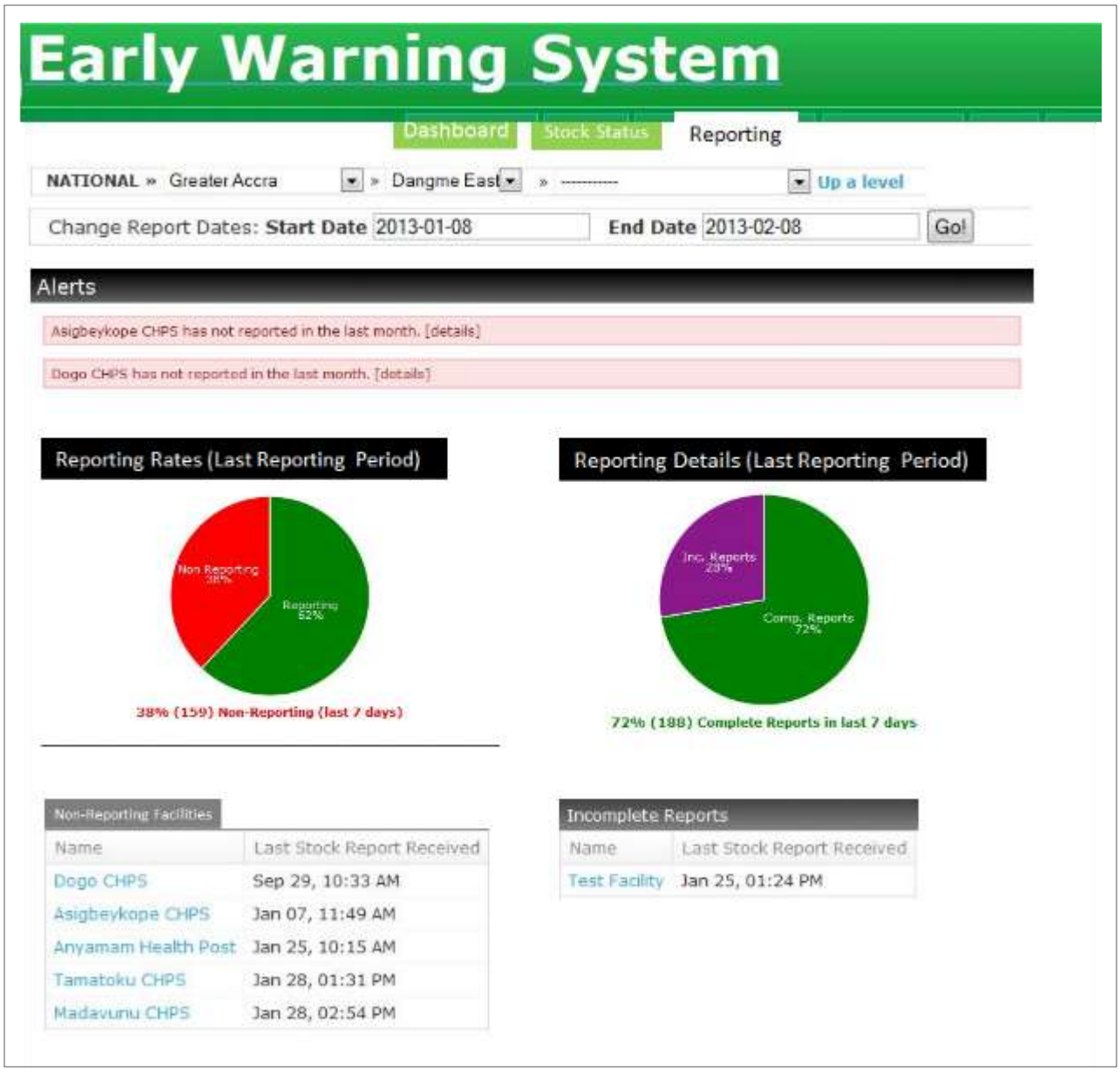


Figure 17. District-Level Reporting Page



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