Vaccine Supply Chain in Ethiopia

HST 184: Health Information Systems to Improve Quality of Care in Resource Poor Settings

Final Paper

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Introduction

The Clinton Health Access Initiative operates in many countries including Ethiopia with an aim to save lives from preventable and treatable diseases. In Ethiopia the organization is working to advise the ministry of health in Ethiopia on an efficient logistics supply chain management system for vaccines. Currently the vaccine distribution capacity is five vaccines and will rise to seven with the introduction of a number of vaccines like the Pneumococcal vaccine (PCV10) and Rota next year. The introduction of these vaccines will inevitably affect the organization’s stock Management and logistics in Ethiopia since the rate of hospital visits per health center will remain constant.

Problem Statement (initial)

The task is to specify a logistics and stock management information system to optimize the vaccine supply chain in Ethiopia. As for all national vaccine supply chains, the vaccine’s sensitivity to heat poses a risk of waste, especially for the health facilities. The current system is paper based and includes the use of stock cards which is predominant in most health centers, about 80% practice. This system is very inefficient and prone to errors (including transcription errors), is not granular enough to be useful, and cannot forecast demand of inventory and makes it tedious to extract useful information for decision making at any level of the supply chain.

Ethiopia has switched to a number of vaccines like the single dose pentavalent vaccine (a few years ago), the pneumococcal and plans to introduce the Rota vaccine. These vaccines are bulky and more expensive both to purchase and store. Thus, it is essential that an improved and efficient logistics system is put in place to reduce waste, stock outs, overstocking, and expired stock, and to improve on decision and information flow between the national cold storage, the regional health facilities, and every level of the vaccine supply chain.

The current system is highly decentralized for a country with 80 million people with great regional differences, which also affects the distribution of the vaccine. The vaccine is meant to be given to every child under one year with an average of 4 to 5 visits to the health care facility.
The need for better logistics, transportation innovations, and the increase in the distribution costs will have to be taken into account.

**Background**

**Main Issues**

**Organizational**

Trying to reduce the number of layers and channels that the vaccine passes through before it is used and would eliminate waste as well as cut down on stock shortages. The supply chain starts from the initial quarterly dispatch of the vaccine from the central vaccine storage to the regional stores and goes down to the zone stores and finally to Wereda and Kebel headquarters, where it is picked up monthly by the health posts.

**National level**

The existing capacity at national level (67%) is not adequate for storage of vaccine, and is compensated for by increasing the frequency of the supply period, delaying shipment, pushing the stock to regional cold rooms. The main advantage at the national level is the availability of computerized temperature monitoring system.

**Subnational level**

At this level, some cold stores have electronic systems used for stock management as well as electronic records of temperature logs that varies across regions. We would like to get more information on what kind of system they use. Other subnational stores, for example in Oromia, lack storage capacity as well and this affects the frequency of their shipments from the national facilities.
Local facilities

At the service delivery level, challenges include lack of knowledge on how to calculate the vaccine wastage rates. In addition, most stores only use the EFFO method for the vaccines and not for the diluents. Most health facilities have the capacity to accommodate their vaccine needs, even during campaign times, and can rent temporary facilities to store vaccines during peak stock levels. However, there are many facilities maintenance problems.

Educational Goals

We intend to learn more about how to organize and monitor a computerized supply chain system while taking in to account country specific characteristics. Specifically, we would like to understand best practices in industry and current areas of innovation.

Approach/ Resources

Literature sources

- www.who.int/vaccines-documents.
- Richard Heeks (2002), ‘Failure, Success and Improvisation of Information Systems Projects in Developing Countries.’
- [www.lggi.org](http://www.lggi.org) Mobile phone-based supply chain system
Related works

Similar work has been carried out for vaccine chain supply in the following countries and affiliate organizations:

- Hib/ Hep B vaccine in Chile by the Global Alliance for Vaccines and Immunisation (GAVI) and Sanofi Pasteur
- Hib vaccine in Ghana by GAVI and the Ministry of Health.

Proposal

After reading through the literature and acquiring more information about the supply chain system in Ethiopia, we came up with this proposal:

Use of mobile technology in supply chain management

Logistimo offers a simple and scalable solution without the need for expensive hardware. It allows low-end mobile phones to capture transactional data, track inventory, place orders, forecast demand, optimize inventory, and generate demand analytics. Configuration and management of supply chain entities, relationships, materials, users and authorizations are performed through a web browser-based dashboard. Meanwhile, the mobile app can be pushed to users via SMS, and auto-installed in a matter of seconds. Users can then begin entering transactions, such as orders, receipts, issues, and periodic physical inventory counts. All this information is recorded in an online data store, which can be accessed by authorized members in the supply chain via a mobile phone or web browser. This system is currently used in rural India and could be used in the remote isolated areas of Ethiopia.

Findings

Our initial task was to identify a logistics and stock management information system that would make the vaccine supply chain in Ethiopia more efficient. As we have discussed in our problem statement, we found the current paper-based system to be highly inefficient and decentralized,
thus hampering record-keeping and communication; resulting in inefficient management of the supply chain. A centralized system will be ideal in order to condense stock-outs and vaccine wastages. There were a few important considerations for any system chosen to facilitate vaccine delivery in Ethiopia. They include:

- The lack of national databases in Ethiopia: Stock-outs are particularly common at lower levels such as the health center, and according to several surveys these smaller health centers do not really have any type of database.
- Financial considerations: we need an inexpensive system that is easy to implement and financially sustainable by the Ministry of Health or whatever organization takes charge of the vaccine delivery project.
- Shortage and/or absence of skilled workers in supply chain management: Software requiring a lot of skilled resources for maintenance would not be ideal because supply chain management capacity and IT skills are generally low; with very little formal training reported.
- Visibility of program: supply and demand exists but Central level do not provide information on stock status at the health post level and health facility level.
- Routine quantification for procurement is done however Health post requirements are not forecasted separately from the other levels.
- Language barriers when using the software at local health community levels: Since the official language in Ethiopia is Amharic, Arabic as well as other ethnic languages at decentralized levels, it would be hard to transcribe software information even if English is taught in school as the language of instruction.

Though we did not find any large-scale vaccine-delivery systems existing in other resource poor settings, we identified several drug delivery systems such as the pharmacy supply system used in Haiti and India. These systems made use of some of the considerations we needed to take into account such as the availability human and financial resources, and provided models that we could build on.

It was difficult for us to get in touch with people on the field, and we were unable to conduct any interviews. We therefore highly relied on published literature about the supply chain system in...
Ethiopia as well as a baseline assessment of the situation done by the John Snow Inc in 2010. Therefore our assessment of the problem may not be as accurate as it could have been.

**Significant Findings**

We identified two software systems that could be used with our chosen mobile technology system, Logistimo, for stock management and vaccine delivery. These include Rx-Solution and M-supply. Our suggestion was to use one of the proposed software at the Ministry of health and district levels (M-supply & RxSolution) and the mobile technology in the rural health posts in Ethiopia (Logistimo).

**Mobile technology**

Logistimo offers a simple and scalable solution without the need for expensive hardware. It allows low-end mobile phones to capture transactional data, track inventory, place orders, forecast demand, optimize inventory, and generate demand analytics. Phones with JAVA Script and GPRS including Smart phones can be used with this software. The system also uses GPRS data channel for transfer of information. In low resource settings like the health facilities in rural Ethiopia this technology addresses critical challenges in enabling inventory control, and improvements in forecasting. The system uses a web browser and mobile app which users can download and automatically install in just seconds, enter transactions such as orders, receipts and perform periodic physical inventory counts. All this information is recorded in an online data store, which can be accessed by authorized members in the supply chain via a mobile phone or web browser.

**Support Software**

**Rx-Solution** is primarily described as a pharmacy dispensary system. It has drug management, dispensing, inventory control, and consumption-based ordering abilities, making it suitable for stock management. It is built in SQL and can run stand-alone or networked, making it a suitable option for vaccine delivery in with or without web access. However, the fact that it is a closed software source that needs a lot of resources for maintenance, and our unsuccessful attempt to
get in touch with the owners of this software disqualified it as a potential candidate for stock management.

**M-supply** is an inventory control system which records each receipt and issue of stock for an item. For products with batch numbers and expiry dates, m-Supply tracks each batch of an item separately so the quantity of each batch is known and recorded. This software allows one to easily issue goods in a FEFO (First expiry, first out) manner which would be crucial for vaccines that have a short shelf life. For less experienced and poorly trained personnel the software has a graphical interface that is easy for people not experienced with computers to learn. M-Supply has proven methods that calculate how much you need to order on the basis of actual usage and stock levels—personnel don't have to set minimum and maximum stock levels manually.

The system also has the advantage of handling unlimited foreign currencies for incoming invoices which would be helpful since Ethiopia gets its vaccines donated from a number of different agencies which may use varying currencies. In addition the system is easily customized for particular needs. It has the capability to be queried by other applications supporting the open Data base Connectivity /Structured Query Language or web services models. It also permits interaction between remote copies of m-Supply using web services which may come in handy for easy monitoring of health facility stock levels by the ministry of health in Ethiopia.

**Implications of Findings**

The implications of our findings are that, if implemented, Logistimo combined with M-supply can revolutionize vaccine supply chain management in Ethiopia with little or no change to existing infrastructure at minimum costs and maximum cost-effectiveness; and without immediate need for significant capacity building in IT. For any health related use of technology to quickly diffuse, especially in low and middle income countries, it must gain acceptance by the leadership of the public health sector: and to achieve this, it should have recorded significant success in other settings, or have the potential for early success with low start-up costs. With proper application, there will be a near immediate fall in stock-out rates, inequitable distribution of stock, and expiration of stock.
Our proposed combined use of technology in vaccine chain management promises much immediately and in the long term with ‘little’ initial capital investment (cost of computers/mobile devices, internet service provision, constant electricity supply, manpower training/new IT man-power salaries).

Furthermore, this proposed vaccine chain management system could serve as the beginnings of a National database for vaccination coverage statistics, which could in turn be the basis for monitoring and evaluating diverse health interventions and the deciding direction of future interventions. For example, if it is determined that more vaccines are used in an area where fewer birth certificates are issued, compared to one with a higher population or birth rate; it can be postulated that there is a lower vaccine coverage in that area, and studies could be carried out to understand the root causes for that and their remedy.

Also, being mostly open source and low cost, our program is highly sustainable. Even after the initial round of funding for initiating the program has wound up, unlike many novel ideas which became unsustainable in LMICs, this supply chain management platform is most likely to remain and thrive, because the financial burden on the government for running it will far outweigh the losses (economic, social, and otherwise) of letting it go under. And being open source (MSupply) means that the benefits of updated versions can be applied to enhance the system at little cost overall.

Other implications of our findings will prove to be potential roll-out challenges with which the proposed plan may have to grapple:

- The cell phones required to run the down-stream parts of this operation will become a lot more valuable than their economic value. And with the current upsurge of cell phone utilization in Ethiopia and cell theft being on the rise, lose of a couple of the phones used in the supply chain management, especially from the same district, could set the operations back a bit.
- Constant electricity for powering the hardware for providing this service is a must, and should be taken into consideration in implementing at any level as prolonged power outages could result in operational chaos.
Benefits of Findings

The importance of vaccination as a tool to reduce mortality in children less than five years old in resource-poor settings cannot be ignored. For those governments and organizations seeking to rollout extensive vaccination programs in their countries, costs are an important consideration. A sustainable vaccine-delivery system that will prevent stock-outs and eliminate wastage will be a step forward in improving health care delivery in resource-poor settings.

Our findings can improve health care quality and delivery in resource-poor settings in so many different ways:

Direct Implications:

- Near elimination of stock-outs, wastages, and supply-point shortages.
- Better prediction of future demand and having the capacity to accommodate such needs.
- Significant enhancement of vaccine coverage rates.
- Marked reduction in morbidity and mortality from vaccine-preventable diseases in children.
- Reduced access costs of vaccination and other health services, in the form of waiting times (with loss of potential income while waiting), transportation costs (especially if they have to return another day due to current stock-out), and any other inconveniences.

Indirect Implications:

- Improved health status of the whole population, beginning with children
- Provision of a basis for capacity building in aspects of Healthcare management and health information systems
- Facilitate data base creation, being electronic records which are more easily transmissible and statistically manipulated.
- Provision / management of data for Monitoring and evaluating vaccination campaigns, but also other public health interventions

Potentially this improvement of service can also significantly make changes in the following areas:
1. **Promotion of Provincial/National inter-sectoral collaborations**: Because of ease of scaling to involve other sectors (transportation / storage/ food supply, etc), a couple of other health programs can be added-on to the vaccine supply chain management; e.g. nutritional supplementation for under-fives, provision of formula feeds for HIV negative babies of positive mothers; or provision of cash and non-cash incentives to mothers to incentivize utilization of the health services.

2. **International collaborations in the health sector**: Given the open-source nature of most of the technology, health sector collaborations can be done more easily and regional data bases can be instituted and managed for the betterment of the region, especially among countries that share boundaries. A case in point is the attempt to eradicate Polio in the West African sub-region: if the right technological framework – like this one – had been up and running in each country, collaborating as a region to eliminate the disease would have been much less challenging.

3. **Ease of conducting research in health systems / services**: This will enhance the quality and cost-effectiveness of interventions while improving efficiency.

**Problem Reformulation**

Initially when we were told to define a logistics and stock management information system the group quickly thought of transportation and storage of the vaccine. According to the literature most of the waste in Ethiopia of the vaccine arises from storage and transport problems and this was the basis of the group’s idea that fixing the storage and transport problems would reduce waste and cost less especially with the introduction of new child vaccines in Ethiopia like the Rota which are highly sensitive to heat. After meeting with our advisors, the task was clearly spelled out- we were advised to concentrate on the information system and ignore the transport and storage issues pertaining to the vaccine.

So basically our job was to address issues to do with communication and stock management between the ministry of health and the local facilities. The current system in Ethiopia has a lot of loop holes since stock cards are used and shortages often arise especially at the local facilities.
because the communication with the national storage facility is poor. For this reason an MIS system that can connect the national cold store in Addis Ababa storage with the local health facilities would help reduce stock outs, forecast demand and reduce costs associated with transportation and storage.

**Problem Statement (Reformulated)**

For this project the assignment is to specify a logistics management information system to optimize the vaccine supply chain in Ethiopia. With the current system in place a lot of inefficiencies have arisen leading to huge losses for the Ministry of Health. Since the system is paper based with the use of stock cards which is predominant in most health centers, it has been prone to errors especially transcription errors, cannot forecast demand of inventory and has made it tedious to extract useful information for decision making at any level of the supply chain. A system that can address such inefficiencies is highly demanded so as to reduce costs.

The logistics MIS would also have to take in to account that the country’s supply system is highly decentralized with great regional differences, which also affects the distribution of the vaccine. In addition the system will also have to address the fact that some of the health facilities do not have access to internet, computers and are comprised of staff as with low literacy levels. The need for better logistics, transportation innovations, and the increase in the distribution costs will have to be taken into account but will not be directly addressed in this paper.

**Process Improvement**

All attempts will be made to conduct interviews with stakeholders on the ground who include practitioners in the field, end-users, and bureaucrats in the health ministry, cell phone dealers, and mobile/internet service providers. This will broaden the scope of our intervention and deepen our perspectives with regards to on-the-ground realities: e.g. to what extent is technology currently being used in the health sector, how fast did previous health IT diffuse; were they sustainable, so on.
Other less crucial but still significant conversations will include: which make of phones lasts longest on a single charge; which phone brand and models are more likely to be stolen and as such best avoided; which service providers have the best tariffs, and are most widely spread, and so on.

**Recommendations (Next Steps)**

Based on our findings, the next step in this project would be to follow-up on the viability of these finding through a practical pilot project/ experiment in Ethiopia considering that all communication on-ground have been done and approved of as well as project approval from the Ministry of Health and Government of Republic of Ethiopia. Based on the literature, there are no limitations in the access of most of the software and can be obtained at no cost.

The pilot can be carried out in a randomized trial in a number of selected decentralized locations with in Ethiopia. The project can be evaluated by measuring the outcomes of before and after the intervention of the mobile and software technology. Outcome measures can be based on the number of children under five that have been immunized, the quantity of consignment dispatched that has been utilized and the quality of service of a health center through prompt transfer of information.

A lot more research has to be done on the compatibility of the two software models proposed with Logistimo. There is need to study the database transcription, whether the software have the same configurations in software language.

While our emphasis is on the use of this technology combination for vaccine chains, its ripple effect will be far-reaching. We would recommend that vaccine transport and storage operations should not be ignored. It is known that cold chain management affects life-span of vaccines. Therefore, more technology and best practices should be put in place to improve that area which can also be applied to other medicines. One best practice that can be further studies for cold chain management is the use of **microchips from RFID**, used in India in cold chain...
refrigerators, which is designed to monitor key environmental parameters, such as temperature and time, for thermally sensitive goods as they move through a supply chain.

We recommend further insight into other best practices like CoolComply, a solar-powered wireless detection system, can be used or incorporated with our proposed findings. This system monitors the doses and the temperature of the medication, relaying readings via wireless to the local healthcare workers to track temperature and intervene when necessary. It is currently employed for drug treatment for Multiple Drug Resistant Tuberculosis (MDR-TB).
Designing a Public Health Software Framework: Porting OpenMRS data to i2b2

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Introduction

Over the past several years the role of technology in resource poor settings has seen a rapid increase in innovation and development. These innovations have been spawned in part by the availability of open source software, cheaper hardware including laptop “servers” and cell phone technology, and a renewed interest in alleviating the suffering of those living in poverty. Three of the eight Millennium Development Goals (World Health Organization, 2010) directly address the importance of health care in eliminating poverty. Computing technology can play an important role in increasing the availability and improving the quality of health care in resource poor settings. While the use of such technology holds real promise, it also exposes weaknesses and challenges. One of these weaknesses is the difficulty in disseminating medical data from disparate systems for use in discovery research and analysis.

Accurate information is critical in improving the quality and sustainability of any system, whether the system is manufacturing, retail, education, or health care. Without accurate data it is difficult to measure how an organization or system is doing and where to make improvements (Fraser, 2011). For this reason, it is vital that the best analytical discovery tools are available to those striving to understand the strengths and weaknesses of systems in the hope of making improvements.

For our class project we developed a framework to simplify the adoption of one such analytical tool, i2b2. Typically the implementation of i2b2 is a complex and time consuming process, requiring significant time and resource commitment and an intimate technical knowledge of the underlying structure of the system. This makes the costs of implementation of i2b2 too steep for many organizations. The goal of our framework is to simplify the implementation of
i2b2 to allow this tool to be more accessible to those working in resource-poor settings for the improvement of health care. We used OpenMRS, an open-source electronic medical record (EMR), as a reference system to develop our framework.

**Background**

Of course, in order to take advantage of any electronic data analysis tool, the data must be entered accurately into an electronic database. There are unique challenges to supporting electronic medical data entry in resource-poor settings, such as the lack of a stable infrastructure to support computing equipment and technical staff (Blaya, 2010), resistance to change, and political forces. Analysis of these barriers to the adoption of electronic medical records, while critical, are out of the scope of this paper.

Electronic medical record systems are used primarily to maintain patient information as related to medical encounters, observations, and diagnoses. EMRs excel at supporting the day-to-day operations required to run a clinic, hospital, or health care system. EMRs are designed to be patient-centric systems and are not optimized to support ad-hoc data discovery of potentially multi-source data from across an enterprise. A data discovery tool, such as i2b2, can enhance the reporting capabilities of an organization by providing optimized, de-identified, aggregate analysis of a population.

i2b2 is used heavily in research for quickly identifying cohorts of patients. While the reporting functionality of an EMR might be capable of identifying a given population, system administrators could be concerned and reluctant to grant researchers access to confidential patient data stored in an EMR. This kind of analysis can be off-loaded to an i2b2 instance without needing to grant researchers direct access to an EMR. The confidentiality of patient data is accomplished by “de-identifying” the patient medical information as it is imported into
i2b2. Once in i2b2 researchers from the local clinic, to the ministry of health, to researchers
in an academic institution on the other side of the globe can query the i2b2 database without
compromising patient confidentiality.

OpenMRS

OpenMRS is a popular open source electronic medical record used in over 50 countries
around the world (OpenMRS Atlas, 2011). OpenMRS has been an attractive choice for clinics
and research institutions due, in part, to its open nature, low deployment costs, and ease of
extending the system through modules. In 2004 the Regenstrief Institute and Partners In
Health established OpenMRS with the goal of creating an open source, community supported
electronic medical record system.

OpenMRS consists of a Java web application, an API, and a database. The Java web application
draws heavily on the third party libraries Spring and Hibernate. The Spring Framework was
designed to simplify the development of Java programming by addressing the complexities
introduced by the J2EE architecture. Spring relies on dependency injection and annotations
to greatly simplify and speed up the development of Java applications. Spring web applications
follow the Model-View-Controller (MVC) design pattern for web development. Hibernate is an
object-relational mapping tool used to map database records to Java objects (“Object-relational
mapping,” 2011). The OpenMRS API is designed to sit between the web application and the
database and simplify access to the data model. OpenMRS can run on any platform that
supports Java technology, such as Linux, Windows, and Mac OS X. While OpenMRS is typically
installed on top of a MySQL database, the application is considered database agnostic and can
run with any standard relational database management system.
OpenMRS is built around a robust concept dictionary (Ball, 2011). The concept dictionary maintains all the possible questions and answers, or facts, that can be assigned to a patient. Concepts are divided into different classes, such as symptoms, diagnosis, lab tests and results, drugs, and procedures. OpenMRS concepts are also broken down by data type. Some data types include numeric, coded, text, and Boolean. The question/answer combination is considered an observation in OpenMRS and would be stored in the obs table. The obs table maintains the crosswalk between the questions and the answers. For any given patient visit, or “encounter,” recorded in OpenMRS, many observations will be collected about the patient.

Observations can be simple questions and answers represented by concepts. Consider the question: “Are you experiencing night sweats?,” and the answer: “No”. The question would be stored in OpenMRS as a concept. The answer, “No,” is also a concept and would be considered a “coded” data type. Not all answers are concepts. For example, with the question “CD4 Count” there are hundreds of possible answers. For this kind of question a numeric data type, such as “350,” would be appropriate.

Because all facts about a patient, excluding basic demographic information, are built upon concepts and are mapped to patients through observations allows OpenMRS to be flexible and support internationalization. Issues such as the localization of the application is possible because the concept dictionary abstracts the text of questions and coded answers. For example, the concept representing “cough” might have the concept id of 452 in OpenMRS. The French word for cough, “toux,” or the Cameroon Metta dialect word for cough, “kwe,” would all share the same concept id, 452. (Ball, 2011)

While the concept dictionary in each OpenMRS instance is autonomous, it is possible to
map local concepts to standard medical vocabularies, such as SNOMED-CT, LOINC, ICD-9, and RxNORM. These vocabularies would be considered “concept sources” in OpenMRS. The mapping of concepts to external vocabularies improves the compatibility of OpenMRS data with other medical systems and makes it easier to generate an ontology, or hierarchical representation, of the data. This is valuable in creating a fully functional i2b2 instance.

**i2b2**

i2b2 (Informatics for Integrating Biology and the Bedside) is a scalable informatics framework that enables usage of existing clinical data for discovery research. It is an open source Java-based project with an i2b2 web client and a Rich Client Platform (RCP) workbench application. i2b2 is built as a modular system or "hive", with many “cells,” some of which are core cells. There are optional cells, clients, and plug-ins that are used to extend the core functionality.

i2b2 allows you to build patient cohorts through a graphical user interface; the client is tree-based, referencing an hierarchical ontology, which enables the user to build a dynamic query, drilling down through layers and applying filters. The ontology is mapped to a vocabulary in the underlying dataset from the source electronic medical records.

Typical use cases for this type of analytical software include "driving biology projects" such as identifying asthma, rheumatoid arthritis, IBD (Inflammatory Bowel Disease), MS (Multiple Sclerosis), and diabetes, as exemplified by our interview with two i2b2 team members from Partners HealthCare (Gainer, 2011). This team uses an in-house tool known as the "data mart builder" that creates the data mart in the i2b2 star schema, which is a series of pre-built custom SQL statements used to retrieve, arrange and upload the source system data to an i2b2 data mart.
An interview with Recombinant, a company that assists in implementing i2b2 solutions, makes the distinction between data warehouse and data mart, with a data mart being a smaller database with one specific purpose. Their implemented solutions typically consist of a data warehouse, with clinical systems (EMRs), departmental systems, billing systems, pharmacy systems, and scheduling systems feeding the warehouse, and building several purpose-built data marts from the warehouse data. Tools such as Kettle are used to load data. (Palchuk, 2011)

Recombiant reiterates the former use case already identified, that i2b2 has a narrow use case which is to find out if you have a population or a cohort that you can include in a study. i2b2 excels at answering the question, "How many patients are there?" Being able to answer such a question on-the-fly can lead to new research opportunities and funding sources. This kind of question, when drawing from multiple data sources, is often too time consuming to tabulate manually.

Another use case noted is that of hypotheses testing, most notably being able to compare a site's patient population with a suspected hypothesis, where decisions can be made concerning populations on the basis of sample information. i2b2 has also lent itself to essentially being in EMR in some implementations, used as a registry, and used for quality improvement purposes.

An interview with Cincinnati Children's Hospital (Marsolo, 2011) reiterated the typical i2b2 use cases; using i2b2 to identify cohorts of patients where users query a de-identified data mart to produce a matching list of records. In addition, Cincinnati Children's Hospital uses i2b2 to analyze outcome measures with their clinical effectiveness group and medical records operations. Cincinnati Children's Hospital also references a patient registry use case which is useful in consolidating patient data from multiple systems, including legacy systems (Marsolo,
Interoperability between i2b2 instances is possible, however the i2b2 instances must be based on the same ontology. SHRINE is an i2b2 plug-in, or “cell,” that is used to run “federated queries.” Federated queries can run across multiple instances of i2b2 hosted at different locations across the Internet. SHRINE is useful only when aggregate data is needed across the instances.

i2b2 officially supports two database types, Oracle and Microsoft SQL Server. However it might be possible to run on an open-source database, like MySQL. There may be one instance of i2b2 running on an open-source database, and some have endeavored to achieve this, however in most cases here in the United States, the institutions implementing i2b2 already have available Oracle and/or Microsoft SQL Server licenses. More research needs to be done to determine if i2b2 can be deployed on an open-source database, such as MySQL. This would be useful for organizations working in resource poor settings where licensing costs could be prohibitive to adoption. i2b2 has been customized to run on the JBoss application server on either Windows or Linux platforms.

As demonstrated from the use cases presented, the core strength of i2b2 is in the ad-hoc identification of patient cohorts. i2b2 forces the organizations to start thinking of the secondary uses of clinical data and that data from point-of-entry clinical software can serve multiple purposes. (Palchuk, 2011)

**Research Questions**

Our research questions for this project are:

- Can we create a framework to make the adoption of i2b2 more accessible for
organizations operating in resource poor settings?

- What best practices, if any, exist for importing data from source systems, such as OpenMRS, into i2b2?
- What standards should we follow to protect patient health information (PHI)?
- How can we create an meaningful ontology from the “flat” OpenMRS concept dictionary?
- What standards and data formats should we consider for transporting data between source systems and i2b2?

**Methods**

To answer the above questions, we explored the current literature on OpenMRS and i2b2 to better understand both systems. Next we conducted personal interviews with developers of OpenMRS and i2b2 to learn more about the structure of each system and the challenges we should anticipate as we set out. We also interviewed users of i2b2 to get a better understanding of the typical use cases for i2b2 and how that might benefit organizations who are actively using OpenMRS.

We had a chance explore both OpenMRS and i2b2 to familiarize ourselves with the user interfaces and the back-end databases. To explore OpenMRS we used de-identified data from the Partners In Health Malawi OpenMRS implementation. To better understand the i2b2 data model we used the default demo data from the i2b2 database. We set a timeline and had regular weekly meetings with our advisers to brainstorm ideas and design the structure of our framework.

**Analysis**

As we considered potential designs for our framework, one of our main objectives was to develop a process that moved i2b2 within reach for organizations operating in resource poor settings. We aimed for as close to a turn-key solution as possible. Whatever framework we
designed needed to adhere to the following stipulations: it must 1) be open source, 2) where possible utilize open standards, 3) be data source agnostic, and 4) be simple to implement without compromising core functionality.

Developing an open source system allows future developers to build on what we have developed, as well as, debug our code. Where possible we followed open standards, to reduce the learning curve for other developers and to allow our programs to be as interoperable as possible. Our solution will be data source agnostic, as well. While we are using OpenMRS as our reference EMR for this project, we want our framework to be able to support data from any electronic medical system, whether it be an EMR, laboratory, inventory, or pharmacy system. Finally, our framework needs to strike a balance between simplicity, where we potentially compromise on functionality, and complexity, where we provide complete control at the expense of losing potential adopters due to a steep learning curve.

Ultimately, we discovered that the best way to develop our framework was to try to implement the framework in experimental, proof-of-concept stages, using an agile development model (“Agile software development,” 2011). This process revealed some weaknesses in our framework. For example, early on in the project we considered leveraging the Continuity of Care Record (CCR) (“Continuity of Care Record,” 2011) standard to move data between source systems and i2b2. As we started to look deeper and attempt to develop the code to generate CCR, we discovered that this standard was not appropriate for representing many of the elements required by i2b2. Working within an agile development model we were able to adapt accordingly and investigate other solutions.

Our reference source system was an OpenMRS instance loaded with de-indentified data from
the Partners In Health Malawi system. We started by developing a standalone Java application which migrated OpenMRS data to i2b2 using a basic SQL-to-SQL process. This step was useful in helping us more deeply understand the table structures of OpenMRS and i2b2. See Appendix A for a diagram which visually maps OpenMRS and i2b2 data structures.

The i2b2 database is comprised of several schemas, several of which can be considered system schemas. The system schemas support the i2b2 application cells but do not contain medical data. The remaining schemas are populated with data from the source systems. The metadata schema is roughly analogous to the OpenMRS concept dictionary and contains the ontologies required to support i2b2. i2b2 can support an arbitrary number of ontologies within one i2b2 instance. i2b2 also supports a schema which stores the patient, concept, encounter, provider, and observation data within a special database design called a star schema ("Star schema," 2011). The i2b2 star schema contains a fact table, called observation_fact, and four dimension tables: concept_dimension, patient_dimension, provider_dimension, and visit_dimension. Data integrity is maintained in the star schema through database constraints. The star schema is optimized for the efficient querying of vast amounts of data. See Appendix B for an illustration of the i2b2 star schema.

Despite the fact that both OpenMRS and i2b2 share many of the same elements, such as concepts, patients, encounters, providers, and observations, the migration is not as straightforward as it might seem. It is necessary to prepare the OpenMRS data prior to export so that it can be imported into the i2b2 star schema. For example, two critical transformations need to be applied to the OpenMRS data on export. These are to de-identify the data to protect patient health information (PHI) and to map OpenMRS concepts to an i2b2 ontology. We use the “safe-harbor” method (National Institutes of Health, 2004) to de-identify personal health
information, by replacing patient and encounter identifiers with new incremental identifiers. For identifying dates, such as birthdate, death date, and encounter dates, we randomly generate the month and day while preserving the year. For patients over 89 years of age we chose a random birthdate within 2 years of the actual age. We map the generated patient and encounter identifiers with the actual identifiers within the OpenMRS database. This identifier mapping, which remains in OpenMRS and is not exported, will allow researchers to track down individual patients, if necessary, provided they receive IRB approval.

The other important transformation that must be made to OpenMRS data on export is the mapping of concepts to an ontology. An ontology, in i2b2 terms, is a hierarchical representation of concepts. The idea of an ontology is one of the core strengths of i2b2. Without an ontology all concepts would exist at the same level and it would be difficult to query for classes of concepts. For example, consider the two diagnoses of “Abdominal aortic aneurysm” and “Atherosclerosis of aorta.” These two diagnoses both fall under the following ontology: Diagnoses -> Circulatory System -> Arterial vascular disease. Within this ontology, the “Abdominal aortic aneurysm” concept falls under the sub-level “Aortic aneurysm and dissection” and the “Atherosclerosis of aorta” concept falls under “Atherosclerosis”. This ontology allows users to easily search either for patients with a specific diagnosis, such as “Abdominal aortic aneurysm,” or for patients with any malady of “Arterial vascular disease.” Users can also step up through the ontology to query any patients with a disease of the circulatory system.

In our proof-of-concept implementation for this class, we mapped OpenMRS concepts to a more basic ontology, organized by: OpenMRS implementation name -> concept classes -> concepts. We took this approach because developing an ontology is a time consuming process involving
input from many areas of an organization. In the future, we hope to use the database behind the Maternal Concept Lab project (“Maternal Concept Lab,” 2011) to help us map local OpenMRS concepts to standard vocabularies such as SNOMED-CT and RxNorm. From there we should be able to generate a meaningful and robust ontology from the OpenMRS data.

We explored several design scenarios in the process of developing our framework which are listed along with companion diagrams in Appendix C. The design we decided on uses a custom XML schema as the medium through which source system data is loaded into i2b2. We have developed an OpenMRS module which simplifies the generation of the XML for organizations using OpenMRS. The module includes several options including the ability to limit data export by patient cohort, only export new patients, encounters, and observations, and to specify whether or not to use an internal ontology or to map concepts to a standard ontology, where possible.

Framework Design Diagram

![Diagagram](image)

We also created a standalone Java application which transforms the XML document into SQL statements and imports the data into the i2b2 database. This i2b2Import application can optionally clear an entire i2b2 instance of stale data. This is useful if you want to periodically
refresh your i2b2 instance with new data.

This framework meets all of our objectives. It strikes a balance between ease of use and unlimited functionality. It is data source agnostic so it can work with any source system so long as the XML schema is followed. All code is open source and we adhered to open standards, where possible.

Conclusion

This project has helped us better appreciate the complexities of creating an open source health care framework for use in resource poor settings. We deepened our understanding of OpenMRS, i2b2, and the different standards and tools involved in porting medical data between systems. In addition, issues such as the confidentiality of patient information, understanding data warehousing technology, and how i2b2 can augment the reporting and discovery capabilities of an organization, have been central to our project.

While we have made considerable progress in the development of this framework, we have more work to do and questions to answer. For example, it would be helpful to solicit more feedback from OpenMRS implementers to gauge their interest and requirements for an i2b2 implementation. In addition, more research into alternative, open source databases, such as MySQL, for i2b2 would be helpful for organizations working in resource poor settings.

As of this writing, we have a robust design for our framework and we have started to develop the tools required to support its implementation. These tools include a new OpenMRS i2b2 Export Module and an i2b2Import application. We also created an XML schema definition (XSD) to support the migration of medical data from any source system into i2b2. We plan to continue to
develop and promote these tools after the conclusion of the course. Once the OpenMRS module is complete, we will host the module at http://modules.openmrs.org and create an OpenMRS wiki page to document the module and the project generally. On June 16, 2011 we will present on our project on the weekly OpenMRS developers conference call.

The framework and tools we have developed hold promise for making i2b2 more accessible for organizations with limited resources. In particular, organizations using OpenMRS might find these new tools especially helpful and could use i2b2 to augment their ability to perform data discovery and clinical research. We hope our project will have an impact on the quality and delivery of health care for those living in resource poor settings.
Acknowledgements

Our interviewees and advisers were particularly generous with their time and expertise and deserve honorable mention in our paper. We would like to thank several members of Partners In Health, including Rita Cuckovich, Ellen Ball, Evan Waters, and Hamish Fraser. Our first project interview was with Rita, and she adeptly introduced us to the OpenMRS Reporting Module and the idea of patient cohorts. Ellen Ball shared her extensive knowledge of the OpenMRS concept dictionary and also helped extract and de-identify the Malawi dataset used in several group projects in the class. Evan Waters also contributed his time and expertise of the PIH Malawi dataset answering several rounds of questions from project teams. Our project, let alone the course, would not have been the same without Hamish's expertise, insight, and guidance.

We would also like to thank Evan Pankey, one of our team advisers, for his diligence, experience, and encouragement throughout the project. His deep knowledge of development projects, project management, and his lecture on conducting “goal directed research” were helpful in thinking of strategies to conduct interviews and develop our framework.

Two i2b2 team members, Vivian Gainer and Nich Wattanasin from Partners Healthcare gave us our first real understanding of i2b2 and best practices for implementation. Their expertise and patience were helpful as we just started to grasp the scope of our project more deeply. Matvey Palchuk of Recombinant Data Corp shared his extensive understanding of i2b2 and medical informatics with our team. His articulate explanations of the strengths and weakness of i2b2 and of possible use cases were helpful as we came to better understand the utility of i2b2. Matvey's wide experience and perspective in the field of medical informatics were refreshing and
enlightening. Finally, we would like to thank Keith Marsolo of Cincinnati Children's Hospital who gave us a most comprehensive overview of i2b2 use cases. Keith’s name and Cincinnati Children's Hospital kept coming up in our earlier interviews as a hands-on i2b2 expert; our expectations were not disappointed.

The contributions of time and expertise from these individuals were invaluable to our project conception and design. Thank you.
References


Palchuk, M. (2011, March 29) of Recombinant Data Corp. Personal interview regarding i2b2 with Tewuh Fomunyam and Stephen Lorenz.

Marsolo, K. (2011, April 11) of Cincinnati Children’s Hospital interview regarding i2b2 with Tewuh Fomunyam and Stephen Lorenz.


Appendix A - OpenMRS to i2b2 Data Mapping:
Appendix B - i2b2 Star Schema:
Appendix C - Design Scenarios:

Scenario 1: OpenMRS Module

Pros:
- Easy for OpenMRS users to implement
- Transfer data to i2b2 in one step

Cons:
- Not really a "framework"
- Specific to OpenMRS
Scenario 2: Continuity of Care Record (CCR) with Standalone Application

**Pros:**
- Built upon a current standard
- Systems might already export CCR formatted data

**Cons:**
- CCR does not support the detail required by i2b2
- Verbose
Scenario 3: Custom XML with Standalone Application

**Pros:**
- An extensible framework
- Source agnostic: should work with any EMR, Lab, Pharmacy system

**Cons:**
- Lots of “moving parts”
- Yet another XML schema to learn
Scenario 4: Custom XML with Custom i2b2 Import Plug-in

**Pros:**
- An extensible framework
- Source agnostic: should work with any EMR, Lab, Pharmacy system

**Cons:**
- Lots of “moving parts”
- Yet another XML schema to learn
- Significant developer learning curve to develop
Scenario 5: CSV with Custom i2b2 Import Plug-in

**Pros:**
- Easy to export CSV even from legacy systems
- Source agnostic: should work with any EMR, Lab, Pharmacy system
- Fairly compact

**Cons:**
- Lots of “moving parts”
- No enforced schema
- Requires manually mapping CSV columns to conversion columns
- Prone to human error
Appendix D - Useful Tools:

**Oxygen XML** ([http://www.oxygenxml.com](http://www.oxygenxml.com)): Useful for manipulating and viewing XML and XSD files.

**Inqscribe** ([http://www.inqscribe.com](http://www.inqscribe.com)): Interview transcription software with the ability to easily pause, slow down, or step back through an audio file while transcribing. We used the 30 day free trial.

**Free Conferencing** ([http://www.freeconferencing.com](http://www.freeconferencing.com)): A free online phone conferencing tool which supports dial-in, Skype, and conference call recording. Useful for our weekly meetings and phone interviews.

**Dropbox** ([http://www.dropbox.com](http://www.dropbox.com)): Cloud based file sharing tool (think FTP for the new millennium) which integrates with your desktop environment and makes file sharing seamless.

**Google Docs** ([http://docs.google.com](http://docs.google.com)): Cloud based word processing tool used to collaboratively write class papers.

**VMware Player** ([http://www.vmware.com/products/player](http://www.vmware.com/products/player)): Free utility which allows you to run VMware virtual machines on your computer. Useful for testing i2b2 demo virtual machine.

**MySQL** ([http://www.mysql.com](http://www.mysql.com)): Free, open-source database used to hold sample OpenMRS database.

**Eclipse** ([http://www.eclipse.org](http://www.eclipse.org)): Open source, community based development platform used in our class for Java programming.
Dhaval Adjodah -
HST.S14 Final Project:
The Malawi Dataset -
May 10, 2012 -
• Unfortunately, I was not able to come up with a statistical prediction model for the diagnostics that lead to somebody having Tuberculosis
  • There was far too little data to reach any such advanced statistical computation
  • However, I found interesting tidbits of information about the structure of the data
A dataset of patients who have a TB diagnosis at some point or the other was pulled, together with their preceding and subsequent other diagnostics.

It was found out that 52 patients got TB sooner or later.

They have in total 2213 diagnostics with the PIH Malawi staff of which 197 were unique (a single encounter can yield many diagnostics).

The idea was to be able to analyze this large set of diagnostics for a trend in diagnostics: perhaps all people who get TB come to the clinic beforehand 2-3 times with a pneumonia diagnostic.
• Upon closer inspection, it was found that a lot of diagnostic rows were duplicated for the same patient id and the same encounter id (and date-time).
• There were many variations of the same ICD-9 diagnostic name: TB had about 6 different names,
  • some of them actually medical variants,
  • some of them different shorthands
• The most extreme example in patient 19027: he shows up on 2009-09-14 at 10:29:34 and receives no less than 63 diagnoses that day.
Data had to be filtered:

- remove duplicated diagnoses for the same patient at the same time,
- to manually find possible variations of the same names that previously appeared to be two different diagnoses (with some help from Evan Waters),
- to remove diagnoses that appear to be blatant errors in the system such as “PRESUMED” and “CLINICAL” and
- to remove all diagnoses that are not respiratory-related (with Dr. Fraser's help)
• A filtered data-set was produced:
  • it still contained 52 unique patients,
  • but contained only 325 diagnostics.
  • Each patient had a mean of 6.25 different diagnostics although in most cases, this occurred on the same day.
- The problem is that for each patient who has more than 1 diagnostic.
- Since we are interested in seeing the progression of diagnostics over time, we need the distinct encounters (on different dates) each patient had.
- The mean number of unique encounters by patients is 2.0.
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</tr>
<tr>
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<tr>
<td>2008-Dec-02</td>
<td>10:11:00</td>
<td>PERIPHERAL NEUROPATHYEURONIA NOS</td>
</tr>
<tr>
<td>2008-Dec-02</td>
<td>10:11:00</td>
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</tr>
<tr>
<td>2009-Mar-24</td>
<td>21:01:00</td>
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</tr>
<tr>
<td>2009-Mar-24</td>
<td>21:01:00</td>
<td>PERIPHERAL NEUROPATHYEURONIA NOS</td>
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<td>Notes</td>
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<td>-------------</td>
</tr>
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<tr>
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<td>ACTIVE TUBERCULOSIS</td>
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<tr>
<td>2009-Mar-31 14:13:00</td>
<td>TUBERCULOSIS NOS</td>
<td></td>
</tr>
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</table>
A similar analysis was done on patients with pneumonia.

- 721 unique patients were found who had a diagnosis of pneumonia sooner or later.
- These 721 patients generated 2,622 encounters, with a mean number of encounters per patient of 3.6.
Plotting only unique encounters, we find that the average unique encounters per patient is 2.3.
• Plotting only unique encounters, we find that the average unique encounters per patient is 2.3.

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<tr>
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<td>(SINUSITIS, OTORRHOEA, TONSILLITIS, OTITIS MEDIA)</td>
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</tbody>
</table>
Questions?
HEALTH INFORMATION SYSTEMS
FOR MATERNAL HEALTH IN
ZIMBABWE

By
Eden G-Sellassie and Tewuh Fomunyam

Supervised by
Freeman T. Changamire, M.D., Sc.D
“The lack of maternal health care violates women’s rights to life, health, equality, and nondiscrimination. MDG 5 can be achieved... but we urgently need to address the shortage of health workers and step up funding for reproductive health programs” Thoraya Ahmed Obaid (Former UNFPA executive director)
Much attention to maternal health - MDG 5

570 of the estimated 1000 women dying every year from pregnancy related causes in 2008 were in sub-Saharan Africa.

The life-time risk of a woman dying from pregnancy related causes is 36 times higher for developing than for developed countries. (WHO 2010)
ANC has been shown to improve maternal health when started early and is adequate and appropriate by reducing maternal mortality (Campbell and Graham, 2006).

WHO recommends at least 4 ANC visits for each pregnancy with the first occurring within 16 weeks of pregnancy.

Only 1 in 3 rural women in developing countries receive the recommended care during pregnancy. (UN 2010)
ZIMBABWE BACKGROUND

- Population 12,523,000
- Life-expectancy at birth 47/50 male & female respectively
- GDP spending on health 9%
- Literacy rate 92%
HEALTH SYSTEM

- Health delivery is decentralized
  - Public sector
  - Private sector
  - Faith based institutions
    - Most of the services are provided by private and faith based hospitals due to the health system collapse following the economic crisis

- Administration is centralized
  - to guide policy, administration and provide coordination for decision making
HEALTH SYSTEM CONT’D

- Health Financing
  - National Health Strategy plan 2009-2013 was developed in response to the financial crisis
Anecdotally, most clinics and hospitals in Zimbabwe are still using paper medical records.

RTI is working with the government of Zimbabwe to strengthen the health information system including instituting the use of electronic medical records.
MATERNAL HEALTH IN ZIMBABWE

- High Maternal mortality ratio of 730/100,000 compared to 624/100,000 in 2008 and 231/100,000 in 1990. (UNFPA)
  - 1 in 42 lifetime risk of a woman dying from a pregnancy related complication
- ANC coverage at least 1 visit 90%
- ANC coverage 4 visits 57%
- Institutional delivery 65%
- Skilled birth attendant coverage 66%
Maternal and Perinatal Mortality carried out in 2007 revealed that the 3 delays accounted for 72% of maternal deaths.

- Delay in identifying problems and deciding to seek medical care
- Delay in reaching health facility after deciding to seek care
- Delay in receiving needed care at the facility

42.8% of the main avoidable factors in the deaths were institutional.
FACILITATORS TO ANC ATTENDANCE

- Most women book for ANC
- Strong desire to deliver at the facility
- Some TBAs refuse high risk women
- Increasing mobile network coverage
- Health worker aware of the challenges
BARRIERS TO ANC ATTENDANCE

- Failure to recognize danger signs
- Denominational doctrines (Apostolic)
- Lack of communication facilities
- Lack of transport
- High user fees at district hospitals
- Lack of drugs and supplies
- Staff shortage
NON-BARRIERS TO ANC ATTENDANCE

- Cultural beliefs
- Rituals
- Taboos
- Women’s ability to decide
<table>
<thead>
<tr>
<th>Kenya</th>
<th>Uganda</th>
<th>Nigeria</th>
<th>Zambia</th>
</tr>
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<tr>
<td>- The use of a PDA/GPS system built on pendragon forms for data collection during home visits in Western Kenya were reported by end users as faster (4.4±0.9), easier (4.5±0.8) and produced high quality data (4.7±0.7) on a 5 point scale.</td>
<td>- Mobile phones are being used to send messages to pregnant women in the Jinja district to increase adherence to appointments and the involvement of men. (Connect4Change, ND)</td>
<td>- Collaboration between the National Primary Health Care Development Agency (NPHCDA) and Duke University aims to implement a robust electronic health record system based on the Open MRS to complement the efforts of the MDG supported Midwifery Services Scheme.</td>
<td>- The installation of an electronic perinatal patient-referral system designed to support health personnel in making referrals laid the groundwork for a larger EMR system. (Darcy et al, 2010)</td>
</tr>
</tbody>
</table>
RECOMMENDATIONS

- Expand use of cell phones to include sending reminders to women especially as it has been reported that most women book for ANC.
- Expand and encourage the use of electronic data collection tools.
- Infrastructure development such as roads through collaboration with key ministries.
- Collaboration between NGOs and the government in the implementation of information technology to improve health care.
CONCLUSION

Before implementation of technology to improve ANC attendance, measures need to be taken to ensure that the health system has the necessary capacity in terms of staff and supplies to handle the increase demand for services. Without the elimination of barriers, no amount of technology will be able to improve access to services.
HST.S14 Health Information Systems to Improve Quality of Care in Resource-Poor Settings
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HST 184 - Health Information Systems to Improve Quality of Care in Resource Poor Settings

Impact of US Federal Funding on Global e-Health Initiatives in Developing Countries

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INTRODUCTION

Improving health in developing countries has been the global battle for decades, when major financial resources in the form of foreign aid have been transferred from wealthy to poor countries. With the active involvement of politicians and civil society foreign aid specifically for health has increased spectacularly in harmony with the worldwide commitment to achieve the Millennium Development Goals.

The total flow of Official Development Assistance (ODA) has increased from $US 59.8bn in 2000 to $US 119.83bn in 2006. (Stevens, 2008) However a meta-analysis performed by Doucouliagos and Paldam in 2005 of 97 studies, showed only a small positive but insignificant impact of aid on growth. (Doucouliagosa & Paldam, 2008) In the field of healthcare, the efficacy of aid is very hard to measure, because of the difficulty of attributing clinical outcomes, such as a reduction in maternal mortality, to a number of dollars of aid. In developing countries, the inability to track resources enhances the fungibility of foreign aid, making it ineffective despite being earmarked. (Bourguignon & Sundberg, 2007) According to a study carried out by the Center for Global Development, poor resource tracking and irrelevant data within health systems of developing countries hamper sound decision making, advocacy efforts and efficiency of donor funds. (Rannan-Eliya, 2009) Lack of information and evidence represent major constraints in the management of Health systems.

PROBLEM SUMMARY

Stanford Medical Informatics defines e-Health as the "scientific field that deals with biomedical information, data, and knowledge - their storage, retrieval, and optimal use for
problem solving and decision making. It accordingly touches on all basic and applied fields in biomedical science and is closely tied to modern information technologies, notably in the areas of computing and communication”. Currently there is little information surrounding the level and impact of US Federal spending on e-Health system interventions in resource poor settings. Our project was formed with the aim of filling this void, by studying and evaluating US federal funding on global e-Health initiatives in developing countries.

With the ongoing economic downturn the government is forced to prioritize spending. The recent budget of the federal government saw significant cuts in funding for foreign aid and international affairs programs by $6.5bn. This slashing of US federal aid affects nearly all program areas covered by the international affairs budget, including those related to health assistance. With a limited budget, it is important to apportion resources to the most efficient programs that produce the best outcomes. By evaluating programs and their outcomes the federal government can ensure the most efficient allocation of its finite resources.

**OUR APPROACH**

In order to begin the process of assessing the impact of US federal funding on e-Health initiatives the following questions were formulated:

1. How much spending has been earmarked for e-Health initiatives in the last five years?
2. How much of that allocated has been disbursed?
3. How much is spent on each activity within the umbrella of e-Health?
4. How many countries have been covered?
5. What systems have been used/ created, for what purposes?
6. What evidence is there that the systems are operational and being used?
7. What software has been created? Are these tools available for others?
8. What were the outcomes of the projects?

To identify federal grant allocations we began by an online search and identified three main sources that listed government grants: CFDA, grants.gov, and RePORTER. The Catalog of Federal Domestic Assistance (CFDA), where almost all federal grants are listed was fully explored. The CFDA codes are searchable by keywords like USAID, CDC, and PEPFAR, which were three main government entities we chose to focus on. We also looked at the information portal Grants.gov, which lists almost all federal grants announcements available for application as well as most closed and archived grant announcements. During our information gathering phase we also looked at the RePORTER website, which lists grants funded under various bodies associated with the National Institute of Health (NIH).

Further, we explored the websites of USAID, PEPFAR, and CDC, and after exhaustive online searches, we contacted them directly. We also contacted the World Bank as well as the Health Metrics Network. Not only did our research look into the funding bodies that disbursed US federal grants, but it also identified and contacted organizations that implemented projects. The following non-government organizations were contacted in our search for financial data regarding US federal funding as well as data measuring the impact and outcomes of programs funded by US tax payers.

1. John Snow Inc.
2. Management Sciences for Health Inc.
3. Abt Associates Inc.
4. Voxiva Inc.

Additionally, we researched websites of Ministries of Health that had e-Health programs implemented in their respective countries that were funded by US federal funds. We hoped
to extract financial information as well as their health statistics that might help evaluate the impact of e-Health initiatives.

**FINDINGS**

The goal of this project was to evaluate the impact of US federal funding on global e-Health interventions in developing countries. In order to increase transparency of the impact US taxpayer money has on government initiatives, most federal financial information has been “made accessible” in the public domain. After tedious research we concluded that this was not the case.

After extensive research we came to the understanding that there was little or no information that could be used to evaluate the impact of e-Health initiatives funded by the US government on developing nations.

The Global Health Information Forum Report of 2010 identifies the current levels of external funding around the world for e-Health initiatives as US$295 million: This was further broken down as follows:

- WB (US$103 million)
- PEPFAR (US$100 million)
- GF (US$73 million)
- GAVI (US$12 million)
- HMN (US$7 million)

This lump sum of US$295 million was further divided into 85 countries. However we realized that there was an uneven distribution of these funds, where 2 countries received US$116 million, while the rest of the 83 countries averaged $2.1 million each (39 countries
less than $500 thousand and one country $25,000). The accuracy of these figures is questionable, as we gathered data from other sources that conflicted with these numbers.

The challenges and constraints we faced while looking for data to support our project are outlined below.

- In theory there is much transparency with regards to federal funding. However we found no annual or quarterly reports that were specifically broken down by activity for USAID, PEPFAR, or CDC.
- National Health Account is a tool to track money flow for Health systems but has no data on e-Health initiatives.
- OECD_STAT is one of the biggest databases for tracking Organization for Economic Co-operation and Development (OECD) funds. This database tracks OECD funds using 17 health components, but nothing related specifically to e-Health.
- Even within these OECD health components, substantial amounts of funds that have a donor project ID and a specific disbursement amount have no channel of delivery (implementing agency or organization) code and name.

After finding that there was insufficient information on all US federally funded e-Health initiatives to evaluate its impact, we decided to reduce the scope of our topic and focus on the countries that already had HIS strategic plans. We identified: Afghanistan, Kenya, Uganda, Sierra Leone, Cambodia, Ethiopia and Rwanda. The following set of criteria was used as a reference to start our evaluation:

- Identify principal donors of the country's e-Health Strategic Plan and how much they contribute.
- Find financial information for Health Information Systems (e.g.- Budgets, actual spending)
- Articulate a listing of e-Health deliverables.
Within this group of countries, we selected Afghanistan and Rwanda based on our contacts that were willing to share information.

**Rwanda**

Rwanda is a country with approximately 10 million people, and is the most densely populated country in the African continent. It is a poor rural country with about 90% of the population engaged in (mainly subsistence) agriculture and some mineral and agro-processing. (Central Intelligence Agency, 2010) The war and genocide of 1994 left much of the country destroyed and more than 1,000,000 dead. This caused a mass exodus from the country, instigating a shortage of human resources in all sectors, including the health sector.

Since the Rwandan genocide there have been some significant improvements in the health sector. The most notable success is the government campaign against HIV/AIDS which drove down prevalence of the disease to 3%. (WHO, 2010) It can be argued that the TRACnet (Center for Treatment and Research on AIDS) program, an e-Health initiative played an important role in achieving this success.

The Rwandan TRACnet System is a national central database of HIV and AIDS-program information. It is intended to deliver real-time HIV information to decision-makers to help them assess challenges and provide targeted responses to improve availability and quality of care and treatment.

After extensive research we were able to identify the total funding provided by PEPFAR for the year 2010. PEPFAR reports indicate that they funded US$ 6,575,622 for all e-Health initiatives in Rwanda. The information from PEPFAR went as far as breaking down the total
funding by allocation to the implementing organization (see Appendix 1). The accuracy of this figure is questionable as information released by the Global Fund shows that the amount of US funding was larger. The breakdown of the funding as well as outcomes of the program or project is crucial in order to carry out an impact analysis. Such information was unavailable. Many of the implementing organizations were unwilling to provide this information as they were “privately held institutions”. Reporting standards for privately held institutions are lax, as they are not governed by the same legal framework as public institutions.

We were able to access information on e-Health initiatives implemented in Rwanda through contacts in the Ministry of Health (MOH) as well as in organizations implementing e-Health projects. We were able to access information on the outcomes of the TRACplus program through the Rwandan MOH. However these benefits were not broken down further to show the direct impact of the TRACnet program, which was an e-Health project.

Afghanistan

The Islamic Republic of Afghanistan is a country weakened by decades of conflict, with a population of approximately 29,835,392 people. (Central Intelligence Agency, 2010) Afghanistan is severely impoverished, and has been ranked 173rd out of 183 countries based on GDP (PPP) per capita. (International Monetary Fund, 2010) Agriculture is the primary source of employment in the country, providing a livelihood for roughly 75% of the population. Roughly 36% of its citizens live below the poverty line, while 42% of the population live on less than $1 a day, according. (Central Intelligence Agency, 2010) The country is heavily dependent on foreign aid.
In the case of Afghanistan we were able to identify principal donors of the country’s e-Health initiatives and how much they contributed. Appendix 2 presents the budget under broad categories and the unfunded amount under each category. We identified some of the main donors: USAID through Management Sciences for Health (MSH), World Bank through John Hopkins University (JHU), European Commission through EPOS Health Management, Global Fund, Basic Package of Health Services donors (USAID, EC, and WB), GAVI and some others. However, we could not carry out a thorough analysis as program evaluation data and health outcomes were not available in the public domain. Information systems development is usually incorporated into the broader category of service or program development, making it difficult to tease it out. Also, since a project is usually funded by more than one donor, differentiating funding sources is usually complicated. In the case of Afghanistan we were provided with financial information that was broadly categorized by activities. The information could have been broken down by activity, donor, and cost to make it more useful for our impact study.

**RECOMMENDATIONS**

In order to increase efficient and transparent spending of US federal funds, especially on e-Health initiatives, there is an urgent need to gather information and increase the use of performance and outcome assessments. In general, there’s a need to adopt one standard e-Health resource reporting system across agencies and one standard definition for e-Health. It may be ideal to begin this process by working with organizations that focus primarily on the development and implementation of e-Health projects. Tracking US federal funding and analyzing outcomes of e-Health projects being implemented would help form a framework
that may be used to track such funding. It is also recommended that a database that tracks all funding related to e-Health initiatives is created. After creating such a platform it is crucial to build the capacity of staff to appropriately use it.

**For resource tracking search engines**

It is essential to create a universally accepted form of reporting. Grant.gov, is the governments’ data portal to grant information that is accessible by the public, it might be ideal to classify e-Health as a project title, separating it from the general category of health. With the adoption of the HIS classification system designed by Health Metrics, it may be easier to generate specific funding numbers linking the funds to the e-Health. The form of reporting should be accepted and adopted by all resource tracking search engines (e.g. OECD) making comparison of data and information seamless.

**At the country level**

Create a National Health Accounts subaccount for e-Health which will enable countries to report their e-Health expenditures on:

- Financial source- Financial-agent matrix
- Financial agent- provider matrix
- Financial agent- function matrix
- Provider-function matrix

**Financing and implementing agencies**

Financing and project implementing agencies should report their expenditure by descriptive activities, enabling the easier measurement of outcomes. It is essential that all agencies agree to universal standards of reporting. Donor agencies should also require
implementers to provide information on outcomes and finances to the general public, when
tax payer dollars are used for a project.

THE FUTURE OF US FEDERAL FUNDING ON E-HEALTH INITIATIVES

We realize that there is not much focus on assessing performance or impact. There are no
process indicators, structural indicators, or outcome indicators that have been made public,
which can be used to assess the impact of e-Health initiatives; and there are very few
countries that have successfully implemented e-Health initiatives.

Many donors, specifically the US who gives the largest ODA, understand the importance of
improving health information systems, which in turn can affect the outputs of all the other
building blocks of any health system. Unfortunately, even the foreign aid agencies of the
richest and most powerful country in the world don't efficiently track the resources
invested in e-Health initiatives. There are no standardized processes of data collection at a
country and agency level for Health Information systems funding, which makes available
data scattered and harder to interpret. The importance of measuring the effectiveness of
aid programs, especially those that are publicly funded, makes it imperative that significant
data is collected. Our findings explicitly identified that there is little data published, which
suggests that the data gathered is underutilized, and at the very least that transparency is
lacking.

In the wake of the economic crisis, US foreign aid is threatened as domestic initiatives
trump international ones. Within this context, it is critical for the foreign aid agencies to
assess the impact of US federal funds on interventions by linking investment to results, if
they want alleviate both the probability and the proportion of possible budget reductions.
As mentioned in the report, Development assistance for health: trends and prospects by Murray et al, growth in global health spending will probably slow and might contract in 2011 and competition will intensify for resources to address the many important global health priorities. It is recommended that program implementers provide compelling evidence that past and continuing investments have significant impact; while highlighting that resources devoted to health programs are an effective means to advance health and broader development goals. In order to provide real evidence of success and help sustain global e-Health financing in coming years it is important to track financial data as well as program outcomes.
APPENDIX

Appendix 1: PEPFAR Funding for e-Health Initiatives in Rwanda

<table>
<thead>
<tr>
<th>Organisation</th>
<th>Amount (US$)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Treatment and Research AIDS Center</td>
<td>$1,527,831.00</td>
</tr>
<tr>
<td>Voxiva Inc.</td>
<td>$990,000.00</td>
</tr>
<tr>
<td>Management Sciences for Health</td>
<td>$695,591.00</td>
</tr>
<tr>
<td>Ministry of Health, Rwanda</td>
<td>$550,440.00</td>
</tr>
<tr>
<td>Treatment and Research AIDS Center</td>
<td>$510,736.00</td>
</tr>
<tr>
<td>Ministry of Health, Rwanda</td>
<td>$350,000.00</td>
</tr>
<tr>
<td>Management Sciences for Health</td>
<td>$297,383.00</td>
</tr>
<tr>
<td>Association of Public Health Laboratories</td>
<td>$222,750.00</td>
</tr>
<tr>
<td>Partnership for Supply Chain Management</td>
<td>$201,045.00</td>
</tr>
<tr>
<td>MACRO INTERNATIONAL</td>
<td>$200,000.00</td>
</tr>
<tr>
<td>Social and Scientific Systems</td>
<td>$198,000.00</td>
</tr>
<tr>
<td>University of North Carolina</td>
<td>$187,100.00</td>
</tr>
<tr>
<td>National AIDS Control Commission (CNLS)</td>
<td>$178,200.00</td>
</tr>
<tr>
<td>Association of Public Health Laboratories</td>
<td>$125,000.00</td>
</tr>
<tr>
<td>Drew University</td>
<td>$25,000.00</td>
</tr>
<tr>
<td>Drew University</td>
<td>$24,750.00</td>
</tr>
<tr>
<td>US Agency for International Development</td>
<td>$19,960.00</td>
</tr>
<tr>
<td><strong>Strategic Information Total</strong></td>
<td><strong>$6,575,622.00</strong></td>
</tr>
</tbody>
</table>

Source: PEPFAR
### Appendix 2: Total Funding for e-Health Initiatives in Afghanistan

<table>
<thead>
<tr>
<th>Components</th>
<th>Development (US$)</th>
<th>Recurrent (US$)</th>
<th>Funded (US$)</th>
<th>Unfunded (US$)</th>
<th>Total (US$)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Legislation, Coordination, and Data Sharing</td>
<td>757,918</td>
<td>0.00</td>
<td>739,918</td>
<td>18,000</td>
<td>757,918</td>
</tr>
<tr>
<td>Surveillance and Data Use</td>
<td>5,791,932</td>
<td>0.00</td>
<td>4,746,445</td>
<td>1,045,487</td>
<td>5,791,932</td>
</tr>
<tr>
<td>Data Quality and M&amp;E</td>
<td>2,102,830</td>
<td>4,748,660</td>
<td>344,196</td>
<td>6,507,294</td>
<td>6,851,490</td>
</tr>
<tr>
<td>Capacity Development</td>
<td>6,026,419</td>
<td>864,000</td>
<td>6,717,813</td>
<td>172,606</td>
<td>6,890,419</td>
</tr>
<tr>
<td>Admin Data and RBF</td>
<td>991,552</td>
<td>0.00</td>
<td>888,647</td>
<td>102,905</td>
<td>991,552</td>
</tr>
<tr>
<td>Quality of Care and Hospital Service Monitoring</td>
<td>402,980</td>
<td>0.00</td>
<td>0.00</td>
<td>402,980</td>
<td>402,980</td>
</tr>
<tr>
<td>Total</td>
<td>16,073,631</td>
<td>5,612,660</td>
<td>13,437,019</td>
<td>8,249,272</td>
<td>21,686,291</td>
</tr>
</tbody>
</table>

*Source: John Snow Inc.*
Works Cited


