

Final Technical Report

Open Architectures, Standards and Information Systems (OASIS II) –
Developing Capacity, Sharing Knowledge and Good Principles across
eHealth in Africa

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1 Abbreviations

| Abbreviation | Full Name / Description |
|---------------------|---|
| CHW | Community Health Worker |
| CIEL | Columbia International eHealth Laboratory |
| EA | Enterprise Architecture |
| EHSDI | eHealth Software Development and Implementation |
| HEAF | Health Enterprise Architecture Framework |
| HEAL | Health Enterprise Architecture Laboratory |
| HIE | Health Information exchange |
| HI-PPP | Health Informatics Public Private Partnership |
| HIV | Human Immunodeficiency Virus |
| ICD-10 | International Classification of Diseases version 10 |
| MCL | Maternal Concept Laboratory |
| MVG-Net | Millennium Villages Global Network |
| MVP | Millenium Villages Project (www.millenniumvillages.org) |
| NoN | Network of Networks |
| OASIS | Open Architectures, Standards and Information Systems |
| OCC | OpenMRS Concept Collaborative |
| OGAC | Office of the United States Global AIDS Coordinator |
| OpenMRS | The Open Medical Record System (www.openmrs.org) |
| PEPFAR | United States President's Emergency Plan for AIDS Relief |
| PIH | Partners in Health (www.pih.org) |
| PoC | Point of Care |
| REACH | Research in Enterprise Architecture for Coordinated Healthcare |
| RHEA | Rwanda Health Enterprise Architecture Project |
| SDMX-HD | Statistical Data and Metadata Exchange – Health Domain |
| SMS | Short Message Service |
| TSB | Terminology Service Bureau |
| UKZN | University of Kwa-Zulu Natal |
| WHO | World Health Organization |

2 Abstract

The OASIS II project aimed to build on aspects of the Open Architectures, Standards and Information Systems for Healthcare in Africa (OASIS) project, previously funded by IDRC through the South African Medical Research Council. The objectives of the project included over-arching, network-wide objectives and individual project objectives. In addition, OASIS II aimed to investigate a shared research purpose and combine existing methods between one existing and four new projects and partners to: 1) elaborate a network-wide OASIS II research methodology, 2) establish an open enterprise architectural framework for eHealth in developing countries and 3) create a collaborative framework for sharing new evidence regarding the impact of eHealth solutions in resource-poor settings.

The five OASIS II sub-projects and partners were:

| Sub-Project | Partner |
|--|-----------------------------------|
| • Millennium Villages Global Network (MVG-Net) Project | Millennium Villages Project (MVP) |
| • OpenROSA / JavaROSA Project | D-Tree International |
| • Rwanda eHealth Software Development and Implementation Project | Partners in Health (PIH) |
| • OASIS Core Project | Jembi Health Systems (JEMBI) |
| • Open Architectures Project | Jembi Health Systems (JEMBI) |

Substantial outputs, outcomes and impact were achieved during the project, although not always in ways that were originally expected or predicted.

Project Activities

A major part of the OASIS II activities were devoted to elaborating the core objectives of individual sub-projects, and substantial outcomes were reported by each of the individual partners.

Network Development

OASIS II was originally conceptualized as a network but, for a variety of reasons, did not develop as a conventional network. Instead, individual groups appeared to grow their own internal networks. This was probably due to the fact that some of the Partners came into the project with substantial pre-existing commitments that benefited from a committed focus. However, substantial sharing and convergence between partners occurred within an emerging collaborative action network. In some areas, such as the OpenMRS network, the Maternal Concept Laboratory initiative (Dimagi, PIH and MVP) and the growing partnerships in Rwanda (PIH, Jembi, MVP) and in Ethiopia (MVP and Dimagi), a mature collaboration exists between some of the Partners who will certainly continue working together into the future and may develop further additional networks.

Ongoing opportunities are still being explored for collaboration and future coordination of activities. For example, an opportunity exists in Rwanda to integrate several of the OASIS II sub-projects, particularly the use of the enterprise architecture and health information exchange along with the standardized health data dictionary. MVP is piloting an integrated CommCare-MoTeCH-OpenMRS platform in Senegal and Kenya, and, in Ethiopia, a pilot project involving CommCare and OpenMRS has the potential to be scaled nationally.

Sustained support for the OpenMRS Implementers community helped OpenMRS develop into a broad-based community-driven network supporting a successful open source

application. The group also extended this approach to provide more focused training in OpenMRS and related tools, such as the Maternal Concept Laboratory (MCL) and OpenMRS Concept Collaborative (OCC).

Capacity Building and Workforce Development

OASIS made significant achievements in the area of capacity building and organizational development which, in some way, took the focus off the network development. The partners employed a variety of different approaches to develop capacity, including promoting in-country software development, training mentorship, strengthening local responsibility and development of local institutions associated with the MoH and local universities. Initiatives that were developed during the OASIS II project, included the Rwanda eHealth Software Development and Implementation training courses, the OASIS Core and MVG-Net in-country eHealth nodes and the OpenROSA/JavaROSA group in Tanzania and Coded in Country initiative. The lessons learned from these approaches are a significant output of the OASIS II project and are one of the two principal focal areas of the utilization-focused evaluation program.

The OASIS core sub-project also developed Jembi Health Systems, a South African non-profit company, that was formed at the start of the project with nine Africans. During the OASIS II project, the network, grew into a substantial organization including 43 Africans in 4 countries, and attracting almost \$6m USD of supplementary funding over the course of the grant. In particular, the Mozambique node expanded to include 18 Mozambicans working directly under the Ministry of Health in a public-private partnership that seems like a highly useful model for Africa and which is currently being expanded in South Africa, Rwanda and Zimbabwe. The OASIS core group also consolidated much of the organizational development activities for the network of OASIS nodes and developed a business plan and sustainability models for the groups within its internal network. D-Tree / ROSA developed a substantive model for Coded in Country which is another useful model for growing capacity in individual developers as is the eHealth Systems Development Initiative developed by PIH.

MVP demonstrated how the need for local eHealth capacity can be initially established through an academic project, and then lead to the creation of a sustained eHealth specialist position for implementation within an international organization. This model is similar to the original OASIS model developed by Jembi at universities in South Africa, Mozambique, Rwanda and Zimbabwe.

Shared Research Methodology

Originally, OASIS II was envisioned to operate as a tightly coordinated network which would employ harmonized research methods. However, as the project got underway the different sub-projects each developed their own research design, methodology and methods. It became clear that coordinating at the level of methods or research instruments would not be feasible given the different project outcomes. The groups no longer expected to share research methods or instruments to be deployed in the timeframe of the grant. MVP's evaluation methodology and instruments have been shared with HI-PPP¹ and others and the OASIS II partners have agreed to adopt these methodologies.

¹ The Health Informatics Public Private Partnership (HI-PPP) is an initiative funded by the US President's Emergency plan for AIDS Relief (PEPFAR) promoting the application of advanced and reusable informatics solutions in low resource settings (see www.hi-ppp.org)

The OpenROSA / JavaROSA and MVG-Net² projects carried out research focused on improvement in health outcomes during the period of the OASIS II project. MVG-Net was also evaluated as part of this project.

Collaborative Framework for Sharing New Evidence

The OASIS II Partners appointed an evaluation team and participated in the development of an evaluation framework for the OASIS II project as well as the UFE itself. This is a start for a process for evaluation and reflection that can be generally applied in other projects. The collaboration model that has emerged is project-based and the partners tend to partner on projects according to the project needs.

Interoperability

Several interoperability projects were developed during the course of this project, including the MCL, the OCC and the Rwanda Health Information Exchange (HIE). More recently, an initiative in Ethiopia has seen two of the Partners (MVP and Dimagi) partnering on an important new initiative funded by the Gates Foundation.

The OpenROSA/JavaROSA group has developed interoperability through work on APIs agreed to by a number of organizations working on mobile data collection. OASIS II has made a significant contribution to the development of interoperability between software components developed and maintained by the group as well as by groups developing and maintaining related software. The health information exchange shows promise to provide a core infrastructure to promote and enable interoperability among diverse applications using open standards. One of the new initiatives derived from the Rwanda HIE is a number of open source communities formed around foundational technologies, such as the patient, provider and facility registries, the terminology service and the shared health record. Experiences in growing the OpenMRS Community will be valuable in this regard.

The MCL is playing an important role in interoperability by sharing a common data dictionary and bringing that dictionary and tools such as report indicators and rules created from it to programs working on maternal and child health globally and has recently received funding from the Mobile Health Alliance/UNF to expand the work with MOH Rwanda, Dimagi and MVP. Continued emphasis on creating interoperability solutions between open source software applications and open standards as well as support for open source groups and open source connect-a-thons will likely assist with adoption in low resource settings and development of interoperable systems.

The Rwanda Health Enterprise Architecture (RHEA) project developed a framework for a health information exchange that will promote interoperability between MCH PoC systems in Rwanda and serve as a model for other countries trying to promote interoperability. The Health Enterprise Architecture Framework (HEAF) project has developed a first draft of a framework for interoperability that is being used regionally to develop designs for national health information systems.

As a whole, the OASIS II group has also shown significant reuse of tools within the community, including OpenMRS, CommCare, MVP shared concept dictionary and Rwanda training courses.

3 Keywords

Health Information Systems; Capacity Building; Workforce Development; Open Architecture; Health Information Exchange; Enterprise Architecture; Health Informatics

² Note that the Millennium Village Global Network was changed to the Millennium Villages Global Network (MVG-Net) to remain consistent with other MV trademarks.

4 The Research Problem

In general, there are many eHealth and health information systems development and implementation initiatives, yet relatively little understanding of how to develop systems that promote consolidation of infrastructure and lessons learned to minimize unnecessary variation and promote reuse. With this in mind, the OASIS II project established a shared fundamental research question that encompassed many of the important issues in health information systems development:

How can decision-makers be informed and motivated to allocate resources for integration of effective and sustainable HIS solutions into health systems of low resource settings, leading to improved health and healthcare.

In addition, five cross-cutting research questions were identified for the OASIS II network:

1. How can electronic information systems be integrated into African healthcare delivery?
2. How can local capacity and local ownership be strengthened?
3. Do electronic information systems improve healthcare delivery and health outcomes?
4. How can interoperability among these systems be improved?
5. How can coordination and collaboration among those developing electronic health systems be improved?

OASIS II developed a Framework to address these research questions, as shown in Figure One, below.

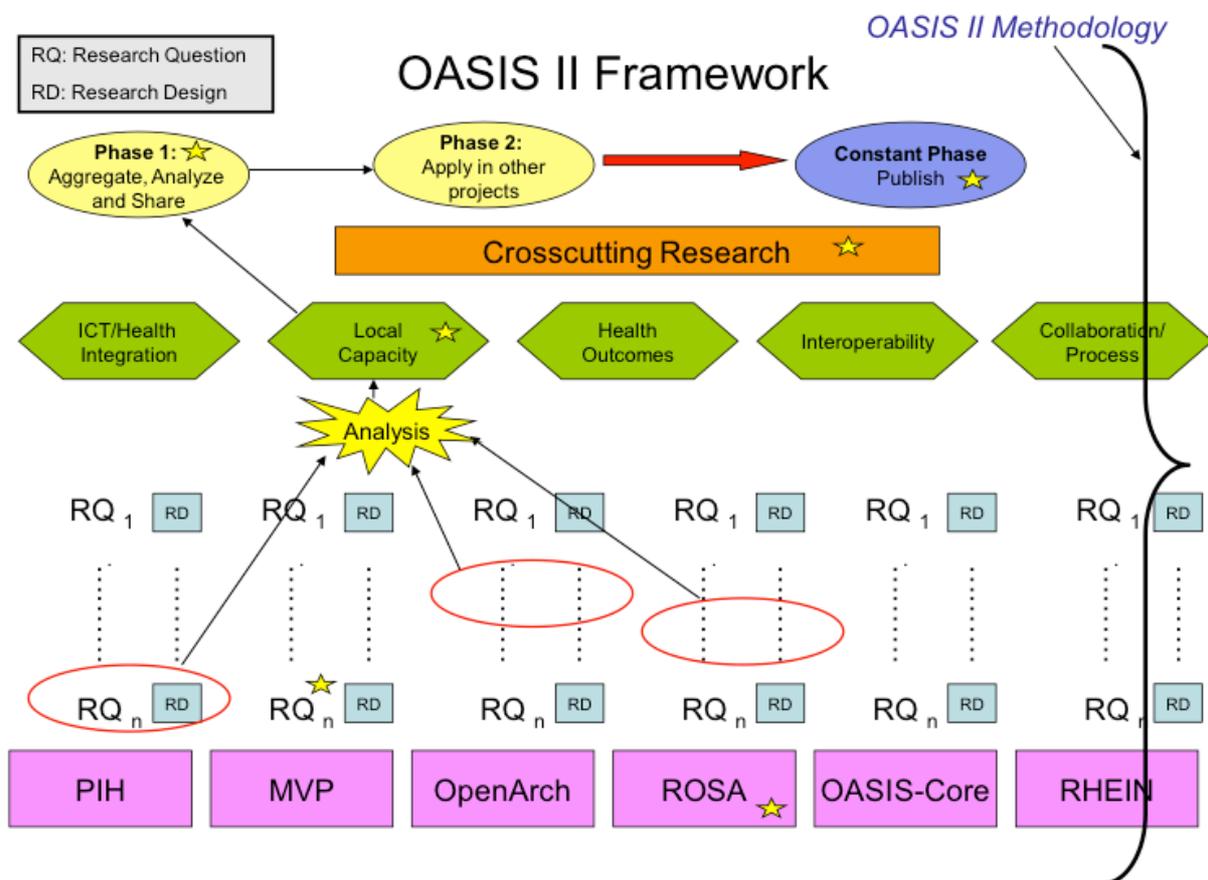


Figure One. OASIS II Research Framework

Individual OASIS II sub-projects (pink boxes in the above schematic) have specific research questions with associated designs and relating to specific themes. In addition, there are cross-cutting research questions and designs across more than one sub-project. The sub-projects planned to analyse and share these research questions and designs with the aim of evolving a common OASIS II research methodology that could be applied to the OASIS II project and, subsequently, to other eHealth and HIS implementation projects. OASIS II identified the following themes:

- ICT/Health Integration
- Local Capacity
- Health Outcomes
- Interoperability
- Collaboration/Process

OASIS II held occasional workshops to share experiences and develop the methodology and framework.

5 Objectives and Methodology

The methodology for addressing the research questions is detailed in Table One, below. Each sub-project set specific sub-objectives and tasks that, individually, contributed to elucidating the research questions, described above. Originally, OASIS II was envisioned to operate as a tightly coordinated network which would employ harmonized research methods. However, as the project got underway the different sub-projects each developed their own research design, methodology and methods. It became clear that coordinating at the level of methods or research instruments would not be feasible, nor would it be necessarily be useful for everyone involved. The groups no longer expected shared research methods or instruments to be deployed in the timeframe of this grant. However, the groups did still hope to synthesize the methods into a compendium of methodologies that covers the approaches taken by the groups.

Table One: Sub-Objectives and Tasks by Project and Theme

| Theme | Project | Sub-Objective | Task |
|----------------------------------|----------------|--|---|
| 1. ICT/Health Integration | OASIS core | Continue to investigate the implementation of a sustainable network of OASIS nodes in South Africa, Mozambique and Zimbabwe, developing relevant health information systems using open technologies and supporting the MoH and other in-country partners and harmonizing with other members of the OASIS II network. | <ol style="list-style-type: none"> 1. Design and develop open health information systems; 2. Set up interoperability laboratory and pilot application integration; 3. Develop and implement health information systems with the MoH and other partners |
| | MVP | Support development of MVG-Net and the interoperable multinational, | <ol style="list-style-type: none"> 1. Create additional open source software tools to work with MVG-Net to |

| | | | |
|--------------------------|--------------|--|--|
| | | multilingual eHealth infrastructure and research tools. | integrate into MVP country health systems. |
| 2. Local Capacity | OASIS core | Nurture the OpenMRS implementers and developers network and expand support into other African countries through activities such as the annual OpenMRS Implementers meeting and the OpenMRS Internship program. | <ol style="list-style-type: none"> 1. Develop local capacity through the OASIS nodes and programs such as the OpenMRS Internship Program; 2. Continue to support the annual OpenMRS Implementers meeting |
| | OpenArch | Investigate the feasibility of developing a global collaborative of contributors to the development of enterprise architecture as well as relevant building blocks and artifacts in African countries | <ol style="list-style-type: none"> 1. Develop a global collaborative of contributors; 2. Develop local capacity to implement and support the architectural framework. |
| | MVP | Compare methods of supporting eHealth interventions across a multinational enterprise. | <ol style="list-style-type: none"> 1. Assessment of whether local outsourcing of eHealth specialists can support and maintain ICT for Health systems compared to distributed, regional or remote support. 2. Provide place for recipients of partner capacity building programs to implement systems within integrated health care system. |
| | OpenROSA | Promotion of "Coded in Country" (CIC) approach, and improved understanding of what works best. | <ol style="list-style-type: none"> 1. Define 'Coded in Country' (CIC) criteria, and design and execute a 'launch' for CIC 2. Conduct and assess long-term internships with paid mentors and describe with case studies. 3. Present and promote CIC at meetings |
| | PIH Training | Assessment of training Rwandan programmers to implement and support OpenMRS. Assess the ability of previous trainees to take over the mentoring of new groups of students in collaboration with expat mentors initially. | <ol style="list-style-type: none"> 1. Document the training materials and assess success of each component of training 2. Created an internship program for undergraduate students. |

| | | | |
|-----------------------------|----------|--|---|
| 3. Health Outcomes | MVP | Assessment of whether ICT for Health systems have an impact on the MDGs and how much compared to other interventions. | <ol style="list-style-type: none"> 1. Support research into the effectiveness of MVG-Net in addressing health outcomes; 2. Provide a multi-national testbed in which mHealth and eHealth interventions can be implemented in an integrated fashion within a large population. 3. Assess whether scale-up of MVG-Net is possible. |
| | OpenROSA | Rigorous assessment of whether CommCare can improve community health worker and client behavior. | <ol style="list-style-type: none"> 1. Controlled study comparing CHWs with and without CommCare in Tanzania using a controlled comparison with objective measures. |
| 2. Inter-operability | OpenArch | Developing and evaluating a first version of an eHealth Framework Architecture, consisting of (i) a general methodology for architectural framework development and customization for eHealth, and; (ii) a library of software artifacts that can be used to assemble health system, including relevant health Informatics standards, reviews of current successful experiences and an eHealth Assessment Toolkit that can be used to assess the country readiness to deploy an integrated eHealth system. | <ol style="list-style-type: none"> 1. Develop an open architectural framework; 2. Evaluate adoption of standards and harmonization of implementations; 3. Evaluate data integration and application interoperability from architecture. |
| | MVP | Assessment of what components are required to operate a common enterprise-wide health information system across multiple countries in multiple languages. | <ol style="list-style-type: none"> 1. Create a multilingual, multinational common data dictionary for OpenMRS; 2. Integrate the Terminology Service Bureau; 3. Create a common data warehouse for research purposes. |
| | OpenROSA | Standardization among mHealth projects, improved links to other eHealth systems. | <ol style="list-style-type: none"> 1. Document OpenROSA XForms specification; 2. Create robust link between JavaROSA and OpenMRS. |
| | PIH | OpenMRS-TracNET Interoperability | <ol style="list-style-type: none"> 1. Develop reporting framework to generate indicators for the SDMX-HD module allowing |

| | | | |
|---|------------|--|---|
| | | | interoperability between OpenMRS and TRACnet in collaboration with Voxiva. |
| 4. Process Learning/ Collaboration | OASIS core | With inputs from other project leaders, coordinate the OASIS II project, including development of the research methodology, regular meetings, research outputs and overall evaluation of the project. | <ol style="list-style-type: none"> 1. Build a research methodology framework and evaluate the OASIS II project; 2. With other partners, evaluate the different subprojects and synthesize the lessons learned; 3. Host OASIS II meetings; 4. Provide collaborative workspace/wiki to allow for sharing of research among OASIS II partners and disseminate results. |
| | Open Arch | Investigate the feasibility of developing a global collaborative of contributors to the development of enterprise architecture as well as relevant building blocks and artifacts in African countries. | <ol style="list-style-type: none"> 1. Develop enterprise architectural framework based on best practices; 2. Develop a global collaborative of contributors. |
| | OpenROSA | Strengthened networks of mHealth research and implementers. | <ol style="list-style-type: none"> 1. Hold OpenROSA meeting July 2009; 2. Consolidate the code of JavaROSA under ownership of a single entity and open source license. 3. Improve website 4. Hold Coders meeting in December, 2009. |
| | PIH | Strengthening collaboration on programming | <ol style="list-style-type: none"> 1. Work on training and module creation to support broader objectives of OpenMRS and OASIS |

6 OASIS II Sub-Projects and Activities

6.1 MVP Project

6.1.1 Introduction

The Millennium Villages Project (MVP) seeks to empower communities to address poverty using a multi-sectoral approach that integrates initiatives in the following sectors: agriculture, education, infrastructure, enterprise and health. The health interventions, which are overseen by the Center for Global Health and Economic Development at the Earth Institute at Columbia involves the coordinated delivery of a package of

scientifically-proven health and development interventions and their evaluations that are aimed at accelerating progress towards achieving MDG targets. The overarching MVP health research agenda includes three main components: 1) a cluster-level analysis to assess the impact of the MVP model on child mortality over a 5 year period; 2) a portfolio of implementation science to document the specific components of the intervention package; their timing and sequence; key contextual barriers and facilitators to implementation; and potential synergies achieved; and 3) an economic costing study to assess the total cost of the interventions.

To achieve this goal, MVP is investing in health information systems to strengthen health systems in a way which can improve care, help share successes stories, and be scaled up to national level. The platform MVP is using is called the Millennium Villages Global Network (MVG-Net). MVG-Net is a comprehensive, open source electronic health service delivery platform that also generates data that can be used to track progress and inform decision-making and management. While leveraging both computer and mobile technology based applications that provide support at the point-of-care for community health workers (CHWs) and facility-based staff, MVG-Net enables:

- Facility-based data capture of individual-level information
- Community-based data capture of individual-level information
- Data storage of individual patient health records
- Automated mechanism for aggregating data and generating reports and feedback to healthcare providers and managers

MVG-Net enables data capture in the field (e.g. from CHWs using cell phones) and facility-based data at the clinic level, which is all entered and stored within OpenMRS as individual health records. This platform in the villages provides an automated method for generating reports for the Millennium Village Information System (MVIS) and Ministries of Health (MOH) in addition to other reporting for service providers. MOH reporting can be created automatically from the OpenMRS database for either entry onto paper forms and submission through standard paper-based channels, or through automated systems such as the District Health Information System (DHIS2).

The household level data collected by CHWs and facility-based information is aggregated into the central database within each cluster, OpenMRS. This amalgamated data is made available to the care provider in the form of an electronic medical record. Collecting data is a necessary step of the MVG-Net intervention; however, without proper feedback to providers/stakeholders the data is underutilized and the intervention is ultimately incomplete. Improved decision making by healthcare providers/stakeholders should result in more efficient resource management; improved quality and coverage of patient care; promotion of early detection, referral and treatment for targeted risk signs; and ultimately reduced morbidity and mortality, particularly for children under 5 years and pregnant and post-partum women.

The three most important contributions from MVP to the OASIS II project included: 1) development of open source components for eHealth systems, 2) increasing capacity to design, implement and maintain eHealth systems in Africa, and 3) to rigorously evaluate one such system, MVG-Net.

The detailed evaluation of the MVG-Net system systematically evaluated the impact of MVG-Net components (e.g., ChildCount+ and OpenMRS) on various aspects of the health service delivery system including:

- service coverage;
- quality of services;
- early detection, referral, and treatment for danger signs;

- morbidity and mortality;
- management of resources (human, financial, etc.).

The primary research question was:

- ***Does MVG-Net (including ChildCount+, OpenMRS, and other components) improve the quality, timeliness, and use of data toward the achievement of better health outcomes in low-resource health systems? If so, what technical and operational factors contribute to the improvement?***

6.1.2 Activities

The assessment of eHealth systems by MVP applied a mixed methods approach including quantitative and qualitative data collection approaches and analyses. The individual components of the MVG-Net system were analyzed quantitatively using a variety of methodologies. The study comprised the following three components: ChildCount+ repeated measures, MVG-Net repeated measures and ChildCount+ retrospective analysis. A repeated measures (longitudinal) study design in two sites examined pre-mobile and post-mobile data collection to evaluate the specific impact of ChildCount+ on improved ability of CHWs to diagnose, treat and track diseases amongst children under five years old and pregnant women (including routine and follow-up care). In addition to the ChildCount+ retrospective and repeated measures components, an MVG-Net repeated measures study was conducted in four sites: Bonsaaso, Ghana; Mayange, Rwanda; Mbola, Tanzania and Ruhira, Uganda. A retrospective assessment in all 14 MVP sites is still underway and will include a case-control design to evaluate health outcomes given varying levels of exposure to the ChildCount+ intervention among the community members in all sites.

6.2 OpenROSA/JavaROSA Project

6.2.1 Introduction

There is growing excitement around the use of mobile phones to help improve healthcare delivery in low-income countries. The OpenROSA consortium, launched with funding and continued support from IDRC, is a group of organizations working to foster open source, standards-based tools for mobile data collection and decision support. It has produced the JavaROSA codebase, which has emerged as a prominent open source software for data collection on a wide range of Java-enabled phones. OASIS II will provide support for the OpenROSA community as well as one of its applications for using JavaROSA to provide task-guidance support to community health workers to help them plan their day, manage OASIS II Funding Proposal.

One application of the OpenROSA application, called CommCare, is a case management solution for community health workers (CHWs). Each CHW is equipped with an inexpensive phone running free and open source software that contains registration forms, checklists, danger sign monitoring, and educational prompts. CommCare helps manage enrolment, support, and tracking of all of the CHW's clients and activities. CommCare captures data from each home visit and sends the data to a central cloud, CommCareHQ (that is maintained by Dimagi from Boston) for program improvement, health surveillance, and workflow interventions. CommCare is easily customizable for widely different environments; it can run on inexpensive Java-enabled phones or higher-

end Android phones, easily handle multiple languages, and incorporate multimedia elements for low-literate users.

The primary research questions addressed by the OpenROSA group were:

- ***Do SMS reminders improve follow-up rates of CHWs to their clients?***
- ***Is the data collected by CommCare sufficient for health surveillance?***

6.2.2 Activities

The question of whether SMS reminders improve follow-up rates of CHWs to their clients was answered through a randomized-controlled study with one arm in which CHWs received SMS reminders during the intervention period, and a control-arm in which CHWs did not receive SMS reminders. Neither groups received SMS reminders in the baseline period, and thus the impact of SMS reminders can be compared within the intervention arm (baseline vs. intervention period) and between groups. As described below, the reminder system improved timeliness of visits by 85%.

The question of whether the collected by CommCare is sufficient for health surveillance was investigated through a data consistency study in which the same questions were asked of the same client by two different CHWs, one after the other, and the answers compared for consistency. As showed below, this study revealed that the data collected by CommCare is of high quality for certain data elements and not others, and provided insight into how to modify the CommCare application and the training of CHWs who use it to improve data quality.

6.3 Rwanda EHSDI Project

6.3.1 Introduction

Open source software offers the promise of local ownership, implementation and innovation in developing countries without the costs and restrictions of proprietary software licenses. To realize that promise there need to be local developers trained to program the software and understand the specific characteristics of medical software.

For the last three years, Partners In Health (PIH), in partnership with the Rwanda Development Board (RDB) and more recently the Kigali Institute of Science and Technology, has run a training course, entitled "eHealth: Software Development and Implementation" (EHSDI)." This course was created to satisfy a need for local computer programmers with the necessary skills to support the government's planned national rollout of OpenMRS. A curriculum was developed that would give students a solid understanding of all the technologies used by OpenMRS and a 9 month fulltime course was started at RDB. The course offered scholarships to attract strong students who not otherwise have invested in an unaccredited course. The course ended this year having produced 34 graduates. Many of the graduates are now working for the MOH and other partner organizations to develop software to support the national rollout.

The overarching research question to be addressed here is "can sophisticated ehealth systems like OpenMRS be created and supported in developing countries?" The research question relates to the points below on overall research goals for OASIS II particularly points 1 and 2:

- ***How can electronic information systems be integrated into African healthcare delivery?***

• ***How can local capacity and local ownership be strengthened?***

6.3.2 Activities

The research questions were assessed by how successful the OpenMRS project in Rwanda is making use of the skills of graduates from the program and how soon and how completely they can move away from support of expatriate programmers. It was also measured in the employment success of programmers with PIH, the MOH and other employers.

6.4 OASIS Core Project

6.4.1 Introduction

Country ownership and capacity development are key principles of modern development aid projects as embodied in initiatives such as the Paris Declaration on AID Effectiveness and The Accra Agenda for Action³ as well as the United States Global Health Initiative. The original OASIS I project, funded by IDRC, primarily aimed to investigate models for sustainable country ownership and capacity development while strengthening eHealth and health information systems in low and middle income African countries. This aim was elaborated through the development of specialist in-country eHealth groups and a regional network supporting national eHealth projects. The three countries selected during the original OASIS I project were: South Africa, Mozambique and Zimbabwe. The OASIS I project also initiated support for the OpenMRS Implementers Community. The OASIS II project aimed to continue this work and investigate a network of networks model with the other partners. The OASIS core sub-project was also tasked with coordinating the network between OASIS II partners. The idea was to use the partnership to strengthen the OASIS network.

The fundamental research question that was addressed in this sub-project was:

• ***How can local capacity and local ownership be strengthened?***

6.4.2 Activities

During the OASIS II project, the OASIS core sub-project developed the following four nodes:

1. Jembi Health Systems, a non-profit company registered in South Africa, including a head office in Cape Town and a regional office in the School of Computer Science at the University of KwaZulu-Natal (UKZN-SCS) in Durban, South Africa.
2. The Mozambique Open Architectures, Standards and Information Systems (MOASIS) group at the University of Eduardo Mondlane (UEM) in Mozambique.
3. The Jembi Rwanda country office.
4. An informal node at the Health Informatics Training and Research Centre (HITRAC) at the University of Zimbabwe.

3

http://www.oecd.org/document/18/0,3746,en_2649_3236398_35401554_1_1_1_1,00.html

In addition to the development of the above nodes the OASIS core sub-project built capacity through active participation and leadership in software development and other technical health systems strengthening activities to extend the experience of the teams being developed.

6.4.3 South Africa OASIS Node

6.4.3.1 Jembi Health Systems

Jembi Health Systems (Jembi) was registered as a non-profit company in South Africa as an output of the OASIS I project, funded by IDRC. Jembi was nominated to be the prime on the OASIS II project partly to strengthen the organization. During the OASIS II project, Jembi continued to develop its core infrastructure and also established country offices in Mozambique and Rwanda. It provided the administrative coordination for the OASIS II project and managed two of the sub-projects (the OASIS core sub-project and the Open Architectures project). Jembi also continued to elaborate its core business model of starting or partnering with in-country institutions to work on projects identified by the National Ministry of Health. Jembi played a significant role in attracting supplementary funding for its own growth and that of the country offices with a view to becoming a sustainable non-profit enterprise. Jembi also managed the fifth OpenMRS Implementers annual meeting and successfully transitioned this flagship open source community to the Regenstrief Institute that will host the OpenMRS Foundation, in future.

Over the course of the the OASIS II project, Jembi focused its efforts in growing sustainable capacity through the following high level activities:

1. Developing its core infrastructure and that of its country offices.
2. Elaborating its core business model of starting or partnering with in-country institutions to work on projects identified by the National Ministry of Health.
3. Attracting supplementary funding for its own growth and that of the country offices with a view to becoming a sustainable enterprise.
4. Furthering the understanding of the needs and challenges in Health Information Systems development and growing both human capacity and technical expertise to address these challenges within the local context.
5. Identifying the value and need to ensure that networks were well connected and facilitated the coordination and meetings of some key groups to share the experiences and advance the thinking in the field of Health Systems development in low resource settings.

Jembi also developed a general vision and strategy including four general directions:

1. Capacity building, skills development and organizational strengthening
2. Architectural design of national e-Health and health information systems
3. Development of health information system components and building blocks
4. Health information system implementation and integration

This evolution in vision and strategy has stemmed from Jembi's internal investment into the reflection of the organization as a whole and the development of a strategic direction for the organization.

Jembi attracted funding for its own organizational development program. Working with IDRC's Donor Partnership Division, Jembi developed an organizational development plan that will guide future development of the organization and strengthen its ability to attract longer term project and core funding. This plan and the results of the initial strategy development workshop have been foundational instruments in guiding Jembi in the creation of its internal structure.

Jembi has focused its activities to ensure that it delivers a core set of business functions including:

- A Stable Financial and Administrative system

- Program Management capabilities and experience
- Software Architecture, Engineering and development expertise
- A first hand understanding of low resource settings and focus on local capacity development and ownership.
- An organic organization model adapting to the developing environment in which Jembi works

6.4.3.1.1 Capacity Development and Sustainability

As one of the activities undertaken to further Jembi's sustainability and capacity development Jembi, as an organization, focused on growing the core and has continued to attract supplementary funding enter into partnerships to scale up its in-country research projects and ensure long-term sustainability. Jembi took the recommendations coming out of the internal strategy development and vision and direction of Jembi to refine Jembi's internal structures into team areas of Corporate Services (Finance and Administration) and Programs (Country Programs and Technical Development Programs). This task has been focused towards ensuring that Jembi is tooled to meet the needs of Health Information Systems Strengthening in low resource settings.

As part of the capacity being developed Jembi is partnering with the new Health Enterprise Architecture Laboratory (HEAL) project, housed at the University of KwaZulu Natal Computer Science Department, to develop core research and development activities that support our active programs and better equip Jembi internal staff to meet the technical needs of Health Information System strengthening.

6.4.3.1.2 Financial and Administrative services

Jembi grew a strong capacity for grant administration through the active creation of a Corporate Services division. This group is focused on the day to day administration of Jembi and the grants, contracts and partnership agreements Jembi enters into. Jembi has ensured that the organization is strictly adherent to grant policies and procedures and that the "strictest" rules apply throughout the teams thus ensuring all regulations are met.

6.4.3.1.3 Program Management Capabilities and Experience

Jembi Health Systems also developed the internal capacity to manage and drive programs forward through the ongoing adoption and implementation of a rigorous programs methodology. The methodology was pioneered in the MOASIS node and was adopted and refined by the South African Team to drive forward the technical work as well as future programs and projects.

6.4.3.1.4 Software Architecture, Engineering and Development Expertise.

Jembi developed the ability to match technical software development expertise to the health development needs and focused on taking on a range of technical development projects over the course of the grant which both (i) allow the team to apply knowledge gained to better develop systems and (ii) allowing the team to grow in experience and technical capacity through delivering projects.

Each of the projects stepped Jembi towards the objective of becoming a leading organization in the area of technical expertise of health information systems development and is evident by the level of technical assistance requested of Jembi and the technical team.

6.4.3.1.5 Network Participation, Facilitation and Creation

Jembi identified the need to facilitate communications between teams and contribute to as well as leverage off of existing networks and knowledgebases to grow expertise and understanding of the field in which Jembi is involved. Towards this goal Jembi contributed to and is still an active member of the following networks, communities and discussion groups:

- Open Health Tools group
- Collaborative Health Platform Project⁴
- OpenMRS Community
- South African Government National eHealth Stakeholder forum
- ISO Working Groups

These collaborations and networks allowed a range of experiences to be shared and to leverage these communities to enhance existing projects. In addition to enhancing Jembi's projects the participation in these communities aimed to enhance other team projects.

This collaboration or partnership took different forms in different countries, although the underlying principles remain the same. In Mozambique, the MOASIS group is a project within the national Universidade Eduardo Mondlane which has an Agreement with the Ministry of Health. This is currently the most mature node. In Rwanda, Jembi has started a separate company. In Zimbabwe, the OASIS node is affiliated with the national university.

6.4.3.2 Jembi (Durban Office)

Through the Durban office Jembi has actively sought collaborations to further understanding and expertise in HIS development and architecture. These have been through strategic and contractual relationships with local academic organizations, other NGOs, Research Groups, Foreign teams and networks.

In addition Jembi has actively focused on developing a research unit closely associated to the work being undertaken and has partnered with similar minded teams to ensure the work done is both innovative and impactful.

6.4.4 Rwanda OASIS Node

As part of the OASIS II project, Jembi has actively participated in the Rwandan eHealth sector. The particular areas of contribution and involvement, or objectives aiming to be met, are primarily summarized as (i) Health Information Systems Strengthening and Development; and (ii) Local Capacity Development. Under these areas Jembi has undertaken a range of activities with the aim of achieving these objectives.

Towards the objective of contributing towards and strengthening health information systems Jembi has undertaken the following activities:

- Jembi has coordinated and developed the first version of an Enterprise Architecture (EA) model of Rwanda through the implementation and refinement of the HEAF (Health Enterprise Architecture Framework). This has been undertaken in collaboration with a team of experts and co-funded through the Rockefeller foundation and has been named the Rwanda Health Enterprise Architecture (RHEA) Project.
- Refinement of the Health Enterprise Architecture Framework (HEAF) through the practical applications of theorized processes and the implementation and evaluation of the hypothesis of an implementation driven approach to EA development providing a more usable architecture for Health Care in Low Resource Settings.
- The work undertaken in the modelling of Rwanda's health system using an enterprise architectural approach has provided the foundation platform for a practical implementation of the EA based solution in the Hi-PPP / PEPFAR funded Health Information Exchange project. This project was/is focused on the reduction

⁴ <http://www.healthunbound.org/group/collaborative-health-platform>

in infant mortality and improved ANC care under MDGs 4 & 5. Under this project Jembi Rwanda is currently involved in the following implementation, customization and development projects:

- Provider Registry - Application solution able to provide a single consistent list of all providers in Rwanda
- Client Registry - Application solution able to provide a single consistent list of all clients or patients in Rwanda.
- Facility Registry - Application solution able to provide a single consistent list of all health care facilities in Rwanda
- Shared Health Record - An application storing a centralized and holistic care record for patients within Rwanda.
- Terminology Service - Application solution able to provide a single consistent list of all standards and published terminologies in Rwanda
- Interoperability Layer - a service that facilitates the linking of the various registries and service applications described as part of the health information exchange.
- Point of Care Application Components to meet needs of Health Information Exchange.

Towards the objective of capacity development Jembi has undertaken the following activities supporting the key objective of ensuring in-country capacity and long-term sustainability:

- Actively invested in the creation of a local workforce able to understand and undertake tasks in Health Systems Strengthening;
- Collaborated closely with the MoH and partners to develop a training & skills needs assessment process and the development of a capacity plan to support the pilot implementation;

In addition to the software experience development and local staff capacities development Jembi has actively engaged with both local and international partners and actively attracted additional supplementary funding to the office and initiatives.

6.4.5 Mozambique OASIS Node (MOASIS)

The Mozambique node (MOASIS) focused its activities around the (i) development of HIS solutions suitable for the Mozambique context and (ii) the strengthening local capacities in the area of HIS/eHealth involving the public, private and research sectors.

Under the abovementioned areas of work MOASIS had undertaken the following activities:

6.4.5.1 Strengthen local capacities/capabilities

The MOASIS node has actively undertaken the expansion of the team to meet the growing requirements and demands on time placed on the node by the Ministry of Health of Mozambique. In addition to the internal capacity development and goal of expansion of the local team to meet demands the MOASIS team has added the training component to all suitable systems in under the joint workplan with the MoH.

6.4.5.2 HIS/eHealth development

MOASIS has actively sought and contributed to the national ehealth strategy through the delivery of software solutions requested by the Ministry of Health of Mozambique. The MOASIS team has contributed to the development of two main National systems in 2008-2009 (the Mortality system SIS-ROH and the Monitoring and Evaluation system Módulo Básico); currently MOASIS supports the Mozambique MoH in 19 projects ranging from

maintenance of previous or already developed systems to the creation and development of new ones according to the needs of the MoH.

6.4.6 Zimbabwe OASIS Node

The OASIS project in Zimbabwe was initiated in 2008 in the Centre for Evaluation of Public Health Interventions (CEPHI) Department of Community Medicine, College of Health Sciences to serve as a local centre of expertise to provide technical know-how and capacity to promote open source solutions for health service providers, mainly focused in the public sector through the Ministry of Health and Child Welfare.

The main goal for the centre of expertise is to strengthen Health Services in Zimbabwe in the development or adoption of open source health solutions that are well integrated and interoperable, from patient level database systems to population level databases.

In the first year of the project, CEPHI concentrated on the process of raising awareness in open source solutions for health service providers, researchers and the Ministry of Health and Child Welfare (MoHCW). However, through consultation of policy makers and system users it became apparent that before technological implementation there was need for a coordinated process in the implementation of all health related solutions. During the OASIS II project, CEPHI developed four objectives, including the development of a MDPCZ (Medical and Dental Practitioners Council of Zimbabwe) application and OpenMRS module development as part of a collaborative project with Jembi. Since then CEPHI, now called Health Informatics Training and Research Advancement Center (HITRAC) completed the development of the MDPCZ system. It is now supporting the integration of this system into the wider health information system. This is meant to serve as a template for more widely applicable enterprise architecture of systems. In addition, HITRAC continues to provide technical advice to the Ministry of Health as part of the e-Health Technical Working Group.

The objectives also included implementing an Enterprise Architecture and e-Health technologies, such as electronic medical records, although these projects will take much longer than the lifespan of the OASIS II project cycle.

6.5 Open Architecture Project

Activities

The Open Architectures project was funded jointly by the IDRC, through the OASIS II project, the Rockefeller Foundation and PEPFAR through the HI-PPP project and will survive the end of the OASIS II project, largely as part of the Health Informatics Public Private Partnership (HI-PPP). The project aimed to elaborate the concept of enterprise architecture to promote the ability of countries to plan, design and control the development of in-country health information systems. The main activities were:

1. Develop an enterprise architecture for Rwanda
2. Implement a health information exchange in Rwanda
3. Document the Health Enterprise Architecture Framework (HEAF)
4. Populate and validate the HEAF with artifacts collected through HIS implementations primarily in Rwanda and Mozambique
5. Contribute to the development of the specifications for an Architectural Framework for low resource settings (ISO 14639).

The group also worked on a review of developed and developing country EA implementations and integrated eHealth systems, as well as designs for an integrated eHealth repository of tools.

The open architectures project was initiated at a project convened by the WHO in September 2008 and then through numerous follow-up meetings in Rwanda and South Africa. In addition, a meeting was held in Geneva and several meetings with international

Standards Development Organizations (SDOs), including the International Standards Organization (ISO), HL7 and the Joint Initiatives Council (JIC). Collaborators participated in an ISO initiative to develop an open architectural framework for low resource settings (ISO 14639)^{5,6}.

The bulk of the activities were devoted to the development of a Health Information Exchange (HIE) for maternal and child health in one district in Rwanda. The Rwamagana district was specifically chosen as it does not overlap with other activities in Rwanda.

7 Project Outputs

A detailed list of outputs of the OASIS II project is detailed in Appendix One, including the following categories:

- Capacity
- Papers
- Presentations
- Posters
- Policy
- Reports
- Grants
- Staff
- Projects
- Software and Tools
- Communications

7.1 Research Findings

7.1.1 MVP Project

MVP completed the final research report for the OASIS II evaluation of MVG-Net. Due to issues with timing on the Kenya implementation (with ChildCount+ already running) it was decided to drop it from the multi-country evaluation. The current MVG-Net countries included in the final evaluation included: Ghana, Rwanda, Tanzania and Uganda. Forty three CHWs, 20 clinic providers and 13 other key project personnel were interviewed at the last follow up research stage. This added to the last two follow-up research periods where the same respondents were interviewed on their usage and assesment of MGv-Net components. This report includes a summary of the findings of all research stages with a focus on the results in the last stage of research, with interm reports available for in depth analysis (the full final MVP report is attached as an appendix).

Training and capacity building were constantly mentioned in the OASIS qualitative research, and now all MVP sites have hired eHealth Specialists based upon this recommendation. As part of the transition at the end of OASIS, each of these has been hired as a local employee and no longer requires grant support. In depth training workshops have been held in both East and West Africa, and regional eHealth coordinators have been hired to facilitate additional training and assist in data quality and other processes.

⁵ <http://www.iso.org/iso/pressrelease.htm?refid=Ref1275>

⁶

http://www.iso.org/iso/iso_catalogue/catalogue_tc/catalogue_detail.htm?csnumber=54902

In addition, quantitative data is being collected from each of the sites with initial results included here and in the final report. There are over 180,000 patients and over 320,000 encounters already captured within the MVG-Net system in the four OASIS sites and even larger number if you include the other non-OASIS sites. As described in Table 2, the quantitative analysis is still very much in process, but even initial analysis has shown a substantial increase in immunization coverage of the SMS-based CC+ system as compared to the paper-based CC+ system and there have been small increases in the percent of complete ANC visits and facility-based deliveries.

MVP has submitted and published a substantial number of papers, presentations and book chapters based on the OASIS work, and has spawned additional follow-on research projects for 2 PhD students and two Masters students. Local MVP teams have not only contributed to all existing publications but have begun additional action research based on the OASIS model which will continue into the future.

A strategic planning process was also begun for the eHealth team during the OASIS research period and the eHealth team produced a set of tools covering the Why, Who, What, Where and How of ehealth for MVP. These are also provided as an attachment to the final report.

In addition to the outcomes research and capacity building outcomes above, MVP has also provided (either by creating or helping to create) important open source tools to the community, including the TSB, MCL, OCC, RapidSMS-OpenMRS bridge, ODK Clinic 1.1 (for Verbal Autopsy and PoC entry), and the Pentaho OpenMRS data warehouse. The CIEL/MVP multi-lingual, multinational standardized data dictionary is now widely accessed and has been downloaded by the following organizations and countries:

Table One. Registrations for MVP Database

| Registrations for MVP Database | |
|---|--------------------|
| Organization | Country |
| Unspecified | Afganistan |
| Epilepsy | Argentina |
| Unspecified | Brazil |
| WAHO | Burkina Faso |
| INSTEDD | Cambodia |
| University Research Co | Cambodia |
| Better Health Service Project | Cambodia |
| Mbingo Baptist Hospital | Cameroon |
| Unspecified | Cameroon |
| Unspecified | Chile |
| Unspecified | Dominican Republic |
| Unspecified | Gambia |
| MSF | Geneva |
| University of Leeds | Ghana |
| Wuqu' Kawoq | Guatemala |
| Unspecified | Haiti |
| BI | Haiti |
| Unspecified | India |
| HISP | India |
| Public Health School Dian Nuswantoro University | Indonesia |

| | |
|--------------------------------------|-------------------|
| Krida Wacana University | Indonesia |
| Regenstrief | Kenya |
| Shinging Hope Communities | Kenya |
| AMPATH | Kenya |
| Regenstrief | Kenya |
| MIT | Kenya |
| Jacaranda Health | Kenya |
| Kibera Medical Record Initiative | Kenya |
| PIH | Malawi |
| PIH-Neno | Malawi |
| Unspecified | Malawi |
| Vanderbilt | Mozambique |
| Unspecified | Nicaragua |
| UCSC | Nigeria |
| Unspecified | Nigeria |
| Duke | Nigeria |
| Unspecified | Pakistan |
| CDC | Panama |
| Unspecified | Peru |
| PANACEA | Philippines |
| University of Telehealth Philippines | Philippines |
| National Telehealth Center | Philippines |
| Holy Angel College of Nursing | Philippines |
| MOH | Rwanda |
| IDRC | Senegal |
| HISP | Sierra Leone |
| Jembi | South Africa |
| Unspecified | South Africa |
| Thingsprime | Tanzania |
| UCC | Tanzania |
| SANA | USA |
| Baltimore Albert Schweitzer Fellow | USA |
| Doctors without Walls | USA/Santa Barbara |
| Charis Health | Zambia |
| Upenyu Health Group | Zimbabwe |

7.1.2 OpenROSA / JavaROSA Project

Four research studies were supported and published through the OASIS II grant.

7.1.2.1 SMS Reminders for CHWs

To evaluate the impact of SMS reminders on CHW performance, OpenROSA conducted a small pilot study in Dodoma, Tanzania followed by two larger studies in Dar es Salaam, Tanzania. The Dar es Salaam studies ran over a 9-month period with 87 CHWs. These two studies augmented a deployment of CommCare with a CHW program run by D-tree International and Pathfinder International, where CHWs make monthly home visits to

chronic care patients. To supplement the automatic data captured by CommCare about visits, we interviewed 30 CHWs and a supervisor on their experience during the studies.

This work is fully described in a paper published in the ICTD 2012 conference, described in ROSA attachment B . The contributions of the work can be summarized as follows:

- A randomized controlled study showing that an escalating reminder system causes a significant increase in CHW performance, with the average number of days clients are overdue dropping from 9.7 to 1.4 days (85.6%).
- A second randomized controlled study showed that the step of escalating to supervisor is integral: removing that step from the process and sending SMS reminders to only the CHW significantly decreases performance.

The figure below depicts the results of the experiment. The system is still running and has sent more than 25,000 SMS messages.

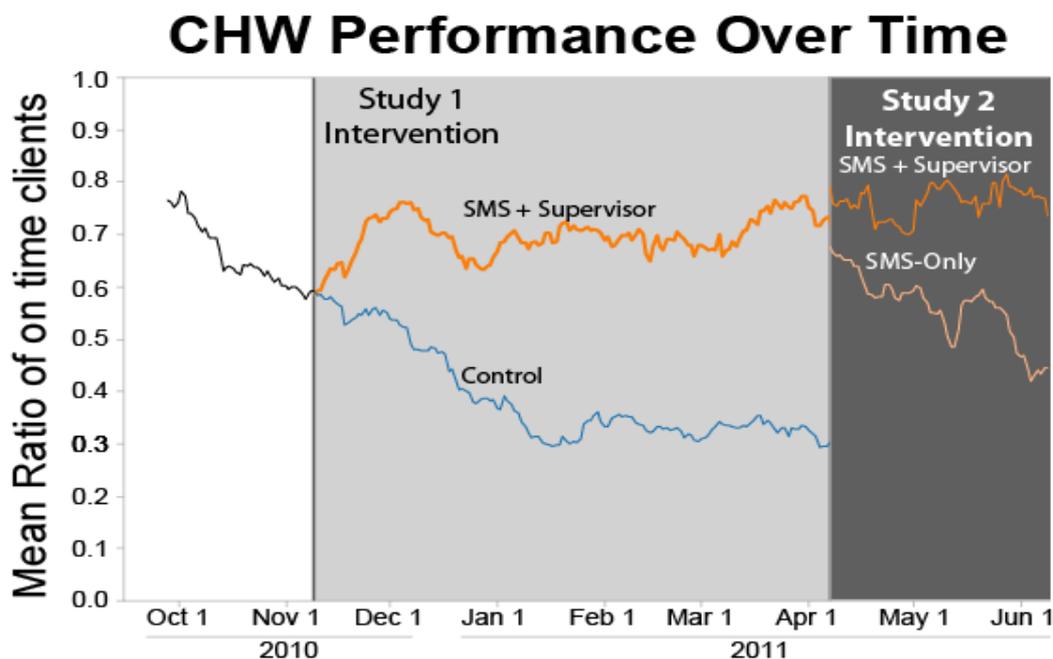


Figure Two. CHW Performance Over Time

7.1.2.2 Quality Control of Mobile Data

Surveys and health surveillance efforts involving human interviewers face concerns about low-quality data because of misunderstanding or deliberate falsification. Although little has been published on fabrication rates, in one survey from the United States Census Bureau, at least 6.5% of interviewers were found falsifying data [40]. Because of this, most surveys involve quality control efforts to try to detect and resolve sources of systematic interviewer error.

The work in Dodoma supported an effort to create tools to assist data quality control teams to identify suspicious or surprising trends that could be the result of interviewer misunderstanding or falsification in low-income countries. The results of this work were reported in a paper by Benjamin Birnbaum, Brian DeRenzi, Abraham D. Flaxmany, and Neal Lesh in the ACM DEV 2012 conference. See ROSA – Attachment C for the full paper.

A set of test data was captured in Dodoma by having the CHWs there deliberately create fake data, and using the data from the data consistency study shown below which was known to be correct data. This created a test set of forms in which each form could be labeled “true” or “false” that was used to test and develop the algorithms.

The team at University of Washington developed outlier detection techniques for finding anomalous data that, to our knowledge, are novel algorithms. As shown in the attached paper (ROSA – Attachment C) the algorithms performed well on this test data.

7.1.2.3 MultiMedia in CommCare

Many Information and Communication Technology (ICT) systems are currently used to support Community Health Workers (CHWs) in impoverished populations. However, the majority of these systems are text-based, making them difficult to use in areas of low literacy. Through work in Dodoma and elsewhere (primarily India), we added multimedia to CommCare, to aid CHWs in counseling clients and promoting healthy behaviors in their communities.

Derek Treatman and Neal Lesh reported on this work in the M4D 2012 conference. See ROSA – Attachment D for the full paper. The paper explores the benefits and challenges introduced by using multimedia CommCare through a qualitative review of CHW/client interactions and implementer interviews. The research team conducted independent, qualitative interviews with 8 implementers (including ones that worked in Tanzania) to understand common benefits and challenges introduced by the inclusion of multimedia to CommCare. We analyzed notes taken during interviews, identified recurring concepts, and assigned a weighted score for each concept mentioned, based on the contextual importance of the concept as described by the interviewee or the number of times the concept was mentioned. Concepts with highest frequency and ranked with highest importance are compared here.

The most important benefits to using multimedia CommCare were related to the simple fact that multimedia were presented on a mobile phone. Mobile phones are a status symbol in LMICs and the fact that CHWs could use them to show their clients images and play audio messages was seen as “cool” and “fun”. Implementers cited that mobile phones are far more convenient and portable than conventional job aids which are often “heavy” or “bulky”, resulting in them being left behind at CHWs’ homes while out on counseling sessions. At a recent, unrelated CHW training attended by one implementer and her cadre of CommCare-using CHWs in India, the trainers handed out illustrated flip-charts on a new topic. The implementer quoted one CHW saying, “we have mobiles, why do we need another flip-chart?”

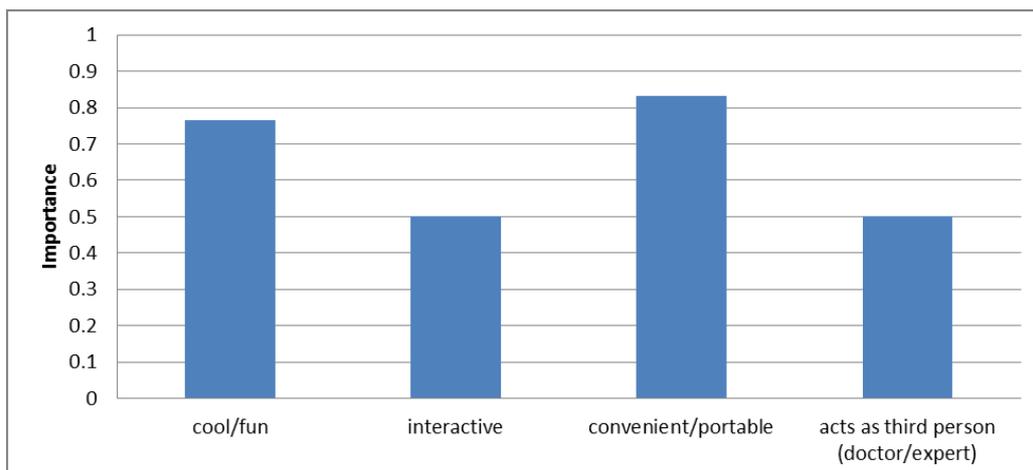


Figure Three. Multimedia in CommCare

7.1.2.4 Data Consistency

An extensive data accuracy study was conducted in Dodoma, Tanzania with support from this grant. It is fully described in Brian DeRenzi's thesis, in chapter 6 (See ROSA attachment E). In this study, the same client is interviewed with the same form by two CHWs, and the results are compared to see if they match. There were two phases of the study. In the first phase, the form would prompt the CHW to ask if anybody was ill in the household, and if so would ask which symptoms (cough, fever, etc) the ill person was experiencing. This followed the workflow that was designed by the NGO who initially trained the CHWs. Based on the results in the first phase, the form was revised to explicitly ask about the presence of any cough, fever or diarrhoea in the household. The results from the second phase are shown below. The results of the second phase are shown in Table Three, below. Our analysis suggests that the data being collected with CommCare is of high quality and thus sufficient for data surveillance except for the fever question, which needs further revision.

| Question | Both CHWs say yes | Both CHWs say no | First CHW says no, second says yes | First CHW says no, second says yes | Agreement |
|----------|-------------------|------------------|------------------------------------|------------------------------------|-----------|
| Cough | 20 | 56 | 8 | 8 | 82.6% |
| Fever | 11 | 56 | 13 | 12 | 72.8% |
| Diarrhea | 5 | 84 | 2 | 1 | 96.7% |
| Sick | 23 | 38 | 21 | 10 | 66.3% |
| Using FP | 40 | 51 | 0 | 1 | 98.9% |
| Pregnant | 9 | 81 | 0 | 2 | 97.8% |
| Under-2 | 8 | 72 | 6 | 6 | 87.0% |
| Newborn | 1 | 87 | 1 | 3 | 95.7% |
| Death | 2 | 89 | 0 | 1 | 98.9% |

Table Two. Results from data accuracy study

A table summarizing OASIS II Research Findings is detailed in Table Two, below:

Table 2. Summary of Current Research Findings

| | Aggregation across projects | OpenROSA Project | MVP Project | PIH Project | Open Architectures Sub-Project | OASIS Core Sub-Project |
|---|--|--|--|---|--|--|
| How can electronic information systems be integrated into African healthcare delivery? | An opportunity exists in Rwanda to integrate several of the OASIS II projects. In particular, the use of the enterprise architecture and health information exchange along with the maternal concept laboratory and OCC represents a conversion of methods innovated by all four Partners. | Engagement with local government and stakeholders in Dodoma, Tanzania has led to integration with health services, including Red Cross trainings for the CHWs. | MVP continues to collaborate with other OASIS partners in Rwanda and is looking at how elements of MVG-Net can be scaled up to national implementation in Nigeria, Kenya, Ghana and Ethiopia. Also working with groups in Mozambique and Malawi that may lay the groundwork for collaboration including integration with the Baobab touchscreen system. Created or helped create a suite of open source components including the TSB, OCC, MCL, RapidSMS-OpenMRS bridge, ODK Clinic 1.1 and ETL processes for a Pentaho data warehouse. | There are two key points addressed by the EHSDI course: firstly the ability of local nationals to work with eHealth software and respond to local needs, and secondly the longer term sustainability of the software when programmed locally. | An Enterprise Architecture approach is being used to develop an architectural blueprint that will assist MoH to orchestrate the development, implementation and acquisition of HIS that complements and strengthens health systems in-country. A Health Information Exchange is being implemented to test whether it can improve interoperability between diverse HIS and applications implemented in-country | A systems approach to integration of HIS is fundamentally important to ensure that eHealth systems effectively improve healthcare delivery. Longterm, effective HIS and improvements in healthcare delivery ultimately require strengthening of systems developed and maintained by the MoH. Organizations that support activities and systems supported by the MoH have most chance of successfully intergating HIS into African healthcare delivery. |
| How can local capacity and local ownership be strengthened ? | The OASIS II project contains a rich selection of different approaches to capacity development, including promoting in-country software development, training mentorship, strengthening local responsibility and development of local | Coded in Country is a promising and popular initiative. After skill building, giving responsibility and mentorship is needed to fully | High turnover of staff in Tanzania and Rwanda necessitated additional training. MVP is decentralizing operations and is increasing the eHealth capacity of regional centers, such as Nairobi for East Africa and Bamako for West | By training the developers in the EHSDI course and their subsequent hiring by the MOH, NGOs and companies | A Health Enterprise Architecture Framework (HEAF) is being developed to consolidate implementation experiences and 'patterns' into a methodology and set of artifacts that can be used to assist in generating | The model of developing and supporting in-country eHealth specialist 'nodes' in collaboration with a local university to support the MoH is proving very succesful in Mozambique. More evidence is needed to establish whether the model will be successful in |

| | | | | | | |
|---|--|---|--|---|---|---|
| | institutions associated with the MoH and local universities. The lessons learned from these approaches will likely be a significant output from the OASIS II project and are one of the two principal focal areas of the formal Utilization-Focused Evaluation (U-FE) study. | develop local capacity and ownership. Providing space and some small resources to the CHWs greatly helped them take charge and form their own association. The association has lived on beyond the research project, and enabled substantial (non-tech related) development efforts by (and for) the CHWs. | Africa. eHealth Specialists have now been hired in all MVP sites and all have been transferred to local employees. | | country-specific architectures and promote reuse. Local developers and analysts in Mozambique are being developed to assist with skills and architecture development Training material, courses and documented examples will be developed to assist with uptake | other countries. An important question is whether the model will strengthen the eHealth capacity of the MoH that generally struggles to retain skilled computer and information systems staff. In some cases the MoH may be able to retain eHealth implementation skills but these are often sourced from external partners. However, eHealth policy-making and design skills are highly appropriate for the MoH. |
| Do electronic information systems improve healthcare delivery and health outcomes? | As a whole, the group has shown significant uptake of tools and techniques, including OpenMRS, CommCare, MCL, CIEL and OCC and Rwanda training courses. MVG-Net and the OpenROSA/JavaROSA project are the OASIS II projects that will likely be in a position to show an improvement in health outcomes during the period of this project. The other two projects are using proxy indicators to show improvement. | SMS reminders improve CHW follow rates by 85%. (Preliminary results indicate data collected from CommCare is sufficient for health surveillance for many data elements. | Second and third follow-up research post-intervention indicate that CHWs and clinic workers notice significant improvement in their ability to deliver timely diagnosis and treatment by using CC+ and OpenMRS. Areas mostly mentioned are in the surveillance of child nutrition and monitoring of pregnant women clinic visits. Initial quantitative results show benefits of SMS over paper CC+ for immunization coverage (with an 18% increase | Local evaluation studies have been performed by PIH staff in Rwanda (Amoroso, Medinfo) but this is not strictly within the PIH OASIS II work. These studies showed that the EMR system with a new lab component improved the | The Open Architectures project will not be able to demonstrate an improvement in healthcare delivery and health outcomes during this project. More time is needed and some of the methodologies elaborated by others in the OASIS project, particularly the MVG-Net implementation science techniques may be incorporated, in future. In the meantime, specific proxy measures will be developed to try | The OASIS project will not be able to demonstrate an improvement in healthcare delivery and health outcomes during this project. More time is needed and some of the methodologies elaborated by others in the OASIS project, particularly the MVG-Net implementation science techniques may be incorporated, in future. In the meantime, specific proxy measures will be developed to try and monitor progress. |

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| | | | over paper-based CC+) small increases in ANC visits and facility-based delivery. | access by clinicians to timely and accurate CD4 counts. It also showed that the EMR could improve case finding for children of HIV positive mothers who had not been tested for HIV | and monitor progress. | |
| How can interoperability among these systems be improved? | <p>OASIS II has made significant contribution to the development of interoperability between software components developed and maintained by the group as well as by groups developing and maintaining related software.</p> <p>The health information exchange shows promise to provide a core infrastructure to promote and enable interoperability among diverse applications using open standards.</p> | More support needed to achieve standard APIs between mobiles and servers. A champion is needed to drive these efforts. | <p>Created multilingual Multinational Standard data dictionary across MVP sites mapped to international standards.</p> <p>Also cross-mapped to others such as PIH, AMPATH, MoTeCH, REACH and in the Philippines. The shared concept-mappings makes it possible to share modules (MDR-TB, Rwanda Primary Care) and HTML and Xforms between different implementations in different countries and projects.</p> | <p>EHSDI programmers have helped develop and deploy the SDMX-HD tools for OpenMRS-TRACnet interoperability (we are still waiting for the TRACnet component to be finalized).</p> <p>A graduate was hired by MVP in Rwanda and developed the "immunization decision-support module". Which was adapted from code developed for another system.</p> <p>We are already seeing collaboration</p> | <p>.</p> <p>A HIE has the potential to implement the architectural and standards approach to solving the problem of reuse and standardization such that multiple systems will be able to interoperate instead of the usual monolithic solution that is often promoted to solve this problem. Any findings?</p> | <p>We hypothesize that having a local in-country organization, acting as an 'honest broker' and owning a coherent country architectural blueprint approved and maintained by the MoH can promote interoperability among systems by coordinating and collaborating activities among partners working in-country.</p> |

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| | | | | between Rwandan programmers and Kenya programmers and expect this to expand in 2012. | | |
| How can coordination and collaboration among those developing electronic health systems be improved? | <p>The OASIS II group has explored several technologies and approaches to improve coordination and collaboration among developer and groups developing eHealth systems. The OpenROSA/JavaROSA group has helped through the development of a platform technology.</p> <p>Sustained support for the OpenMRS Implementers community has helped OpenMRS develop into a broad-based community-driven application. The group has also extended this approach to provide more focused training in OpenMRS and related tools, such as the MCL, OCC and concept collaborative.</p> <p>In the next iteration, specific architectural approaches may be useful.</p> | <p>Supporting the new leadership of OpenROSA will help improve collaboration in mHealth space.</p> <p>Maternal concept lab continues to provide an opportunity for greater collaboration around enabling technologies and shared/reused components among the OASIS network.</p> | <p>Maternal concept lab continues to provide an opportunity for greater collaboration around enabling technologies and shared/reused components among the OASIS network leveraging the common dictionary curation provided by CIEL/MVP.</p> | <p>We are working on joint training projects for developers including helping to train MVP staff in Capetown. We are starting to work on a joint training program for data managers in Rwanda with MOH. Better understanding of the benefits and costs of collaboration could help increase it.</p> <p>MCL is a good example of an effective international collaborative project</p> | <p>An open enterprise architecture blueprint can provide the basis for coordination and collaboraiton in several ways. The elaboration and documentaiton of defined systems enables simple systems to cooperate in delivering a system that can deliver value. The adoption of open standards allows individual systems to cooperate and collaborate in developing interoperable systems.</p> <p>A HIE provides a method and technology to coordinate and collaborate between specific applications</p> | <p>In Mozambique, we have found that having a local in-country organization, acting as an 'honest broker' has generally been supported by in-country funders and implementing partners. At this stage, the model has been to have a strong partnership with the MoH that develops an operational plan aligned with the MoH strategic plan. The group is improving coordination and collaboration among funders and implementing partners around these plans.</p> |

7.2 Capacity Development

7.2.1 MVP Project

- a) MVP developed its eHealth Specialist (eHS) and data clerk infrastructure and hired a graduate of the PIH Rwanda training program to replace an existing eHealth specialist in Rwanda. However, loss of the Tanzanian eHS due to family issues required training an acting eHS while awaiting a formal replacement. MVP has now arranged to hire an eHS for all MVP countries and these staff are now local employees.
- b) MVP organized a training session for programmers working on the ChildCount+-OpenMRS project that was held in Kumasi, Ghana in April 2011.
- c) MVP trained the eHealth Specialists and Health Coordinators at the MVP annual retreat in Dar es Salaam in September 2011.
- d) MVP trained all of the eHS and data managers from ten countries in the use of ChildCount+, OpenMRS, Verbal Autopsy, reporting scripts and the use of Pivot Tables to provide dynamic reporting capabilities to the sites at two regional sessions in early 2012.
- e) As part of a larger decentralizing of its project, MVP elevated Maurice Baraza from an eHS to a regional eHS assisting with MVG-Net implementations and OASIS research throughout East Africa. Casey Iiams-Houser is now acting as field implementation coordinator assisting with MVG-Net deployment and providing "customer support" to all MVP sites. Rob Borland has been given responsibility for managing the MVP development team and continues to play an important role in supporting the rollout of MVG-Net throughout MVP.
- f) As part of its interoperability component development, MVP has helped increase coding capacity in Africa by supporting the Coded-in-Country initiative.

7.2.2 OpenROSA / JavaROSA Project

- a) There was extensive capacity development for the CHWs, CHW supervisors, and project managers in the CommCare deployment in Dodoma, Tanzania. Ken Bayona (the project manager of the project in Dodoma), and Jacob Mtalitinya, the head of ITIDO, receive frequent guidance from Neal Lesh. The CHWs receive weekly training in Dodoma. Ken Bayona now has a full time job at D-tree International.
- b) The CHWs in Dodoma formed an association and, with help from Neal Lesh and other Dimagi staff, secured a \$5,000 grant from the Segal Family Foundation which they used to establish a dispensary in an underserved area and provide a great number of community services including a taxi-service to hospital, gifts for new mothers, and free health counseling at their dispensary.
- c) Three Coded in Country projects were initiated in which African developers were funded \$5,000 to complete a software application by a mentoring organization.

7.2.3 Rwanda EHSDI Project

During the project, the EHSDI training course produced 34 graduates. These graduates have a demonstrated high level of ability in programming and good understanding of the fundamental ideas and concepts of medical informatics. Many of the graduates are working on eHealth projects in Rwanda including building the distribution of OpenMRS used by the MOH for the national rollout, developing reports and tools for IMB, and teaching other programmers.

The EHSDI course used standard assessment methods to select students based on written tests and interviews. Students were then tested regularly during the course mainly with practical project assignments. To graduate they had to develop a significant OpenMRS module. Two key evaluation questions were:

- How well do the programmers perform in the "real world" working for other organizations on OpenMRS or similar systems

- How sustainable is the course when students are required to pay their own fees and living expenses

PIH also carried out more formal evaluation of the graduates performance and satisfaction with the positions that they were hired into. Preliminary results showed that many of the graduates were doing well in a variety of positions. Programmers working with PIH were making important contributions to OpenMRS and one had been offered a job with other organizations based on his performance. Graduates working for the MOH were also building software modules for OpenMRS that were being deployed in the field. Six graduates hired by the Rwanda development board in early 2011 were also performing well according to feedback from RDB-IT officials who were interested to take more graduates. The software company that hired a graduate from the 2010 class was looking for another from the 2011 group of students. The OASIS II project included a survey of its own experiences.

The table below shows the employment of the graduates as of April 2012.

| Year | No. of graduates | No. currently doing eHealth dev. | No. currently doing OpenMRS dev. |
|------|------------------|----------------------------------|----------------------------------|
| 2009 | 10 | 8 | 7 |
| 2010 | 12 | 5 | 5 |
| 2011 | 12 | 2 | 1 |

Table 4: EHSDI Graduate employment status

In addition many graduates are taking the Oracle Java Certification Course. The results as of April 2012 are:

- 14 -- Passed
- 9 -- Failed
- 6 -- Didn't attend the exam
- 3 -- Still waiting to sit the exam.

We are encouraged that 14 have passed this challenging and internationally standardized exam and continue to work with the others to prepare and encourage them to sit it.

The true longer term impact is on the growth of ehealth in Rwanda and impressions of the benefit of ehealth programming staff from policy leaders, which is, of course, harder to measure. The primary goal of this project is of course to grow the supply of well trained developers with a focus on eHealth. The impact of that may occur in multiple ways including strengthening specific organizations like the MOH and key NGOs as has happened already. For example MVP hired a graduate who has worked out extremely well as the eHealth Specialist in Mayange/Rwanda and is also helping to manage the EzVac immunization decision-support module with Jembi as a mentor. In the future we hope the development of locally run software companies in the eHealth space. In addition the course is already having international impact. Two of the graduates from the class taught on training courses for OpenMRS programmers and users at AMPATH in Eldoret, Kenya in 2011.

7.2.4 OASIS Core Project

Capacity development was a core focus area of the OASIS core project and Jembi grew a strong staff complement as part of the OASIS II project. By the end of the project, Jembi had hired 34 new staff and was supporting 43 African staff in five different offices in Southern Africa, including sites in South Africa (2), Mozambique, Rwanda and Zimbabwe. In addition to the actual capacity that was developed, there was also a strengthening of country ownership and investment in country-led plans as well as increased self-sustainability, including the following indicators of progress:

- The South Africa nodes in Jembi and Jembi (Durban) have undergone consistent growth and development of core competencies. In addition to its core competencies in software development and HIS implementation, Jembi has also strengthened its competencies in program and project management, financial administration and grant administration. Jembi has also invested in developing internal systems and core organizational competencies. As a result, Jembi has improved its ability to coordinate the activities of the OASIS II nodes and manage the activities of certain partners.
- The Rwanda OASIS node has registered a company in Rwanda that will serve as the basis for ongoing development of the node. The node has also developed a relationship with another software development company in Rwanda (Pivot Access), and is using project funding to build competencies in health informatics and eHealth software used in Rwanda.
- The MOASIS group has entered into discussions with UEM to become a center or institute in Mozambique and is receiving funding from a number of donors and implementing partners directed to MOASIS through Jembi.
- The CEPHI group successfully applied to the University of Zimbabwe to become a specialist eHealth and health informatics group (HITRAC) and also won a funding award from CDC based on the software and systems development work that was funded through the OASIS II project and IDRC, among other donors.

The organic growth of the OASIS nodes has required careful management of resources, country needs and capabilities of the node. The IDRC funding through OASIS I and II has been fundamental and catalytic to the growth of this important emerging African eHealth network.

Jembi has, as a result of the activities outline earlier, achieved the following outputs:

7.2.4.1 Capacity Development and Sustainability

The full complement of Jembi staff is shown in Table Four, below, and the growth of Jembi personnel in Figure four, below.

| JEMBI STAFF | | |
|----------------------|---------------------------|---|
| Organisation | Total Staff | Roles |
| Jembi Health Systems | Executive Management Team | Executive Director Director of Corporate Services Programs Director Assistant Director of Programs |
| | Administrative Team | Office Administrator Finance Officer PA to ED |
| | Program and Project Team | Program Manager |

| | | |
|---------------|-----------------|---|
| | | Program Officer-Mozambique Project Officer Program and Project Team |
| | Technical Team | Developers x 5 Junior Developer x 1 Remote Developer x 1 Intern |
| MOASIS | In-Country Team | Country Director Program Coordinator Projects Manager Office Administrator Systems Analyst Senior Implementer Senior Developer x 4 Implementer Developer x 2 IT Technician |
| CEPHI-HI-TRAC | In-Country Team | X 3 |
| Jembi Rwanda | In-Country Team | Program Coordinator Finance Officer Systems Analyst Office Administrator Developer x 2 Driver Groundsman/Security Guard |

Table Five. Roles and Numbers of Jembi Staff

The addition of staff members has been in direct relation to requirements on programmatic, technical and strategic objectives.

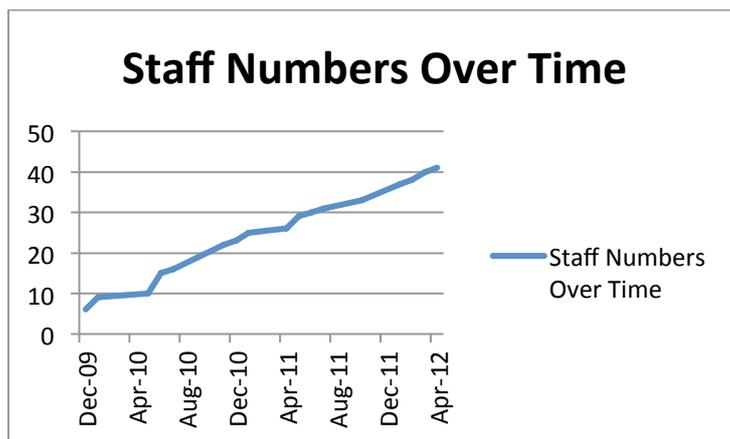


Figure Four. Jembi Health Systems Staff Numbers Over Period of OASIS II

As part of the activities of the organizational development project within Jembi the team have delivered “Jembi’s Vision and Mission Statement” outlining an agreed upon set of principles and objectives that Jembi seeks to achieve. In addition to this the activity is currently producing a strategy document complete with Lead and Lag indicators that will be completed in the next Quarter and published on the Jembi website.

The expansion of the Jembi team, increased workload and strategic guidance gained from the organizational development work underway Jembi has restructured the internal operations of the organization through the formal addition of a Programs division lead by an appointed Director of Programs. This is proving to provide a stronger service offering of Jembi to meet the needs of strengthening health information systems in developing countries.

Jembi has actively encouraged staff to personally pursue the advancement of their skills in the field of Health Information Systems strengthening and two of the technical software developers have taken up Masters level degrees through the collaboration with the HEAL project.

7.2.4.1.1 Financial and Administrative services

As a result of the activities invested in the creation of a Corporate services division and the investment in the correct personal Jembi Health Systems has successfully administered approximately USD\$9,6 million in grants and contracts to date. This number is expected to increase as the level of programs increases and the expected level deliverables increase too.

An indicator of the strong competency Jembi has developed to administer a range of grants and awards is that Jembi has been audited and received an unqualified audit from the auditors (KPMG), this is in testament to the administration and finance team’s diligence to adhering to policies and regulations of the range of grants received.

Jembi has leveraged its experience and expertise to administer funds received from the following organizations:

- CDC
- European Space Agency (ESA)
- Health Metrics Network (HMN)
- IDRC
- Médecins Sans Frontières (MSF)
- Partners In Health (PIH)
- PEPFAR, CDC, Cardno

- Rockefeller Foundation
- South African non-profit companies
- Sports Science Institute of South Africa (SSISA)
- Twinning Centre
- University California San Fransisco (UCSF)
- University of Pretoria
- USAID
- Vanderbuilt University
- World Health Organization (WHO)

A list of the grants and their associated values can be found in the project outcomes document.

In addition, Jembi also attracted supplementary income in the region of \$5,6 million over the period of the OASIS II project with commitments of another \$4 million USD until August 2015, excluding additional income. The income is a combination of grants, contracts with Jembi in various roles including the prime and as a collaborator.

The accumulated income over the period of the OASIS II project and a projection based on committed funding is shown in Figure five, below.

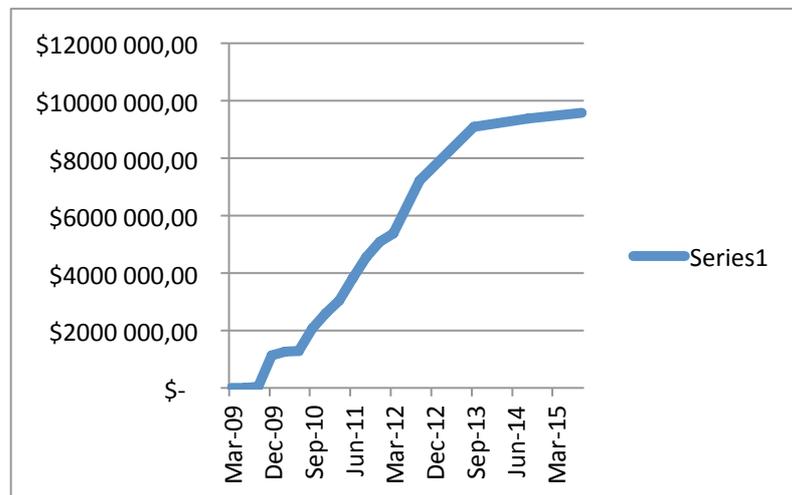


Figure Five. Growth in JEMBI Income during the period of the OASIS II project

7.2.4.1.2 Program Management Capabilities and Experience

As a result of the activities undertaken to strengthen Jembi's program management protocols Jembi Health Systems. The MOASIS node has been asked by the CDC in Mozambique to allow the generalization and adoption of the developed program management methodology for many of their subcontractors and ministry of health of Mozambique.

7.2.4.1.3 Software Architecture, Engineering and development expertise.

Over the course of the grant Jembi Health Systems has been involved in a range of technical and support projects, each of which adding to its goal of gaining and implementing the experience gained in the field of Health Information Systems Development. Each of the projects Jembi has been involved in and contributed to stands as a credit to its ability to understand it's environment and illustrates Jembi Health

Systems developing local capacity to resolve local challenges. Below are a listing of projects undertaken and their key areas of work/competencies.

7.2.4.2 Project and Services Performed

A list of OASIS II projects is detailed in the Table of Outputs in Appendix One. In addition to the software development Jembi has been involved in Jembi has been invited to provide technical assistance and staff mentoring and or training on a range of occasions:

- Cameroon Implementation Technical Assistance in the implementation of OpenMRS.
- InSTEDD iLAB Cambodia introduction and training of staff on OpenMRS.
- Blood-Bank System Review: a review of the Malawian Blood Bank Software system for a NGO Safe Blood For Africa⁷ in the light of scoping a larger open source blood bank software project.
- Staff Mentoring – Jembi mentored an MVP developer in Rwanda as they became familiar with OpenMRS.
- MSF OpenMRS Pilot Demonstration – developed a rapid OpenMRS pilot application to showcase the possibility of OpenMRS meeting the needs of the MSF future planned implementations.

Each building towards Jembi's standing as a leader on a technical level when it comes to Health Systems Development.

7.2.4.3 Network Participation, Facilitation and Creation

Jembi was actively involved in a range of communities and networks over the course of the OASIS II project. The OpenMRS Community is one of the largest networks Jembi participated in over the period of the grant. Jembi's involvement in the community includes involvement and communicating with the OpenMRS teams on the weekly implementer's calls, Dr Chris Seebregts actively participated on the OpenMRS leadership calls and meetings.

Jembi also contributed on a technical level to the OpenMRS community in the form of:

- Google Summer of Code mentoring
- OpenMRS Ticket days

7.2.4.4 Google Summer of Code

Jembi's technical staff participated in Google Summer of Code projects in the support of the OpenMRS community. Jembi staff played active mentoring roles on the following themed Google Summer of Code Projects:

- Genome Data Storage and Drug Resistance Prediction⁸
- Human Resources Module⁹:
- WYSIWYG Form Designer for Html Form Entry Module¹⁰

7.2.4.5 OpenMRS Code Ticket Days

Jembi began a process where portions of a day (once a week) were allocated a "free/OpenMRS development time" these days developers were encouraged to actively participate in OpenMRS Core sprints and working towards solving tickets that were open within the OpenMRS ticket repository.

⁷ <http://www.safebloodforafrica.org>

⁸ <https://wiki.openmrs.org/display/RES/Summer+Of+Code+2010>

⁹ <https://wiki.openmrs.org/display/projects/Human+Resources+Module>

¹⁰ <https://wiki.openmrs.org/display/RES/Summer+Of+Code+2009>

In addition to the technical work and community calls Jembi South Africa was an active member and facilitator of the OpenMRS implementers meetings over the period of the grant. These events included:

- 2010 OpenMRS Implementers Meeting: facilitated and organizes, in conjunction with staff at the South African Medical Research Council¹¹, by Jembi staff. Jembi's responsibility included the structuring and running of sessions – facilitating the un-conferencing style iconic to the OpenMRS meetings.
- 2011 OpenMRS Implementers Meeting: Jembi was not directly involved in the organizing of the event but more to the active participation and sharing of results and feedback from our implementation experiences.

7.2.4.6 Meetings and Events

Over the course of the grant Jembi attended a range of meetings and workshops, some funded under the OASIS II project, others by invitation or other funders. These meetings are often towards the goals of (i) better network facilitation and collaboration; (ii) promotion and review of work and methodologies Jembi employs; (iii) Technical Assistance to other teams and governments. These meetings and events have been the result of active collaborations and recognition of Jembi's work and position to meet the needs of Health Information Systems strengthening in low resource settings.

1.1.1.1 Jembi (Durban Office)

During the grant period, Jembi partnered with ecGroup in the REACH (Research in Enterprise Architecture for Coordinating Healthcare) project, funded by IDRC through the system integration and interoperability laboratory within the School of Computer Science at the University of KwaZulu-Natal (UKZN) which has become the core of a new Health Enterprise Architecture Laboratory (HEAL)¹². Together, the team developed an interoperability showcase at the Medinfo 2010 conference. Heal was subsequently awarded a grant¹³ from the IDRC and is presently collaborating with Jembi and other NGOs, including the Meraka Institute in the South African Council for Scientific and Industrial Research (CSIR), to develop a collaborative model involving real-world projects. Jembi is participating in the HEAL program and two scholarships were awarded for Masters degrees to Jembi Staff. The HEAL Innovation cycle is shown in Figure Two, below, and illustrates the close relationship between HEAL and Jembi resulting in innovative software development and translation into practice.

¹¹ www.mrc.ac.za

¹² Moodley D, Pillay AW and Seebregts CJ. Researching and Developing Open Architectures for National Health Information Systems in Developing African Countries. Z. Liu and A. Wassung (Eds.): FHIES 2012, LNCS 7151, pp. 129–139, Springer-Verlag Berlin Heidelberg 2012.

¹³ Health Enterprise Architecture Laboratory (HEAL). IDRC Grant Number: 106452-001.

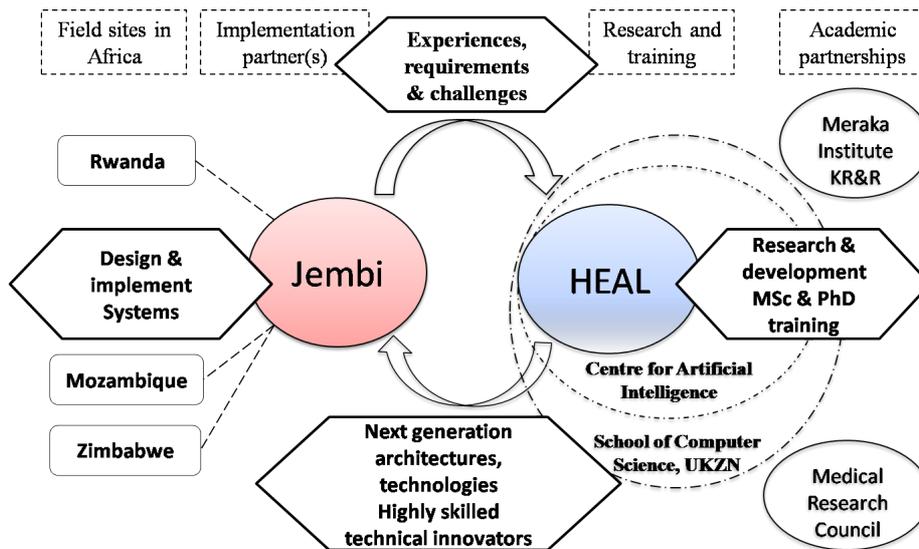


Figure Six. The HEAL Innovation Cycle

1.1.1.2 Rwanda OASIS Node

During the period of the OASIS II grant, Jembi registered a private company in Rwanda, under guarantee to Jembi; (ii) opened an office in Kigali; (ii) appointed eight staff and started collaborating with a local Rwanda company, Pivot Access, and a range of international companies such as Apelon, Intrahealth, Mirth Corp and SYSNET International (the level of interaction ranges from introduction discussions to formal contracting).

Jembi attracted significant supplementary funding for the Rwanda OASIS node and the RHEA project from the Rockefeller Foundation and Health Informatics Public Private Partnership (HI-PPP), funded by the Office of the US Global AIDS Coordinator (OGAC) and United States Presidents' Emergency Plan for AIDS Relief (PEPFAR).¹⁴

From the work performed under the objective of strengthening health information systems and promoting interoperability the project lists the following outputs:

- The documentation of the high-level enterprise architecture of the Rwandan health system, outlining the various business areas and the initial information models for the primary care sector particularly focused around antenatal care.
- A major outcome of the activities in Rwanda is the launch of the RHEA Project. Under the banner of the project there are a list of outcomes:
 - Proof of concept prototype application which demonstrated the technical ability to the teams to implement a solution based on the information collected as part of the enterprise description (the EA design) at the RHEA workshop held in March 2011. This concept prototype showcased the use of open standards to communicate patient level data across the system and validate the usefulness of the sharing of data to improve care in a showcase setting.

¹⁴ HI-PPP: Health Informatics Public-Private Partnership is a US Government effort to provide adaptive technical assistance in health information exchange (HIE) within the world's most resource poor environments.

- Definition of a component based architecture to meet the requirements of the EA description and the business case identified in Rwanda around antenatal care.
- Documented requirements for the foundational components of the health information exchange i.e. the Client, Provider & Facility Registries, the Shared Health Record, the interoperability layer, the Terminology Service, and for the integration with two point of care applications (RapidSMS and OpenMRS);
- Messaging specifications outlining the message formats and content to facilitate the exchange of data within the Health Information Exchange. This document is based on and utilizes open standards to ensure a uniformity of data and standardized uptake.
- Interoperability profiles for each of the components within the RHEA HIE, outlining the expected data exchange profiles for each component (Provider Registry, Client Registry, Facility Registry, Shared Health Record, Terminology Server, Point of Care Applications) and the standards and interfaces the solutions are expected to adhere to.
- First version of the interoperability layer and facilities registry;

Under the objective of building capacity in Rwanda the OASIS II project has observed the following outputs:

- Jembi Health Systems South Africa has registered a local company in Rwanda, Jembi Health Systems Rwanda, to support the work undertaken in the RHEA project and ensure that the skills required to continue the support of the solution are available in Rwanda.
- The Jembi Rwanda office has been set up in Kigali and consists of a full-time staff of eight persons: a project co-ordinator, a finance and grant administrator, a systems analyst and two developers, and 3 support staff; These staff members are mentored and supported by Jembi South Africa on a range of levels, each intending to ensure that the activities and objectives of the project are met but there exists a secondary motive of developing the capacity within the country to ensure that the level of support needed as time progress evolves as the local capacity increases.
- The Jembi Rwanda office, a capacity development outcome in itself, has and is continuing to develop a capacity development plan for the pilot implementation project; This plan includes the various staff profiles, skills needed and protocols envisioned to ensure the support of the RHEA HIE project in the long term.

7.2.5 Mozambique OASIS Node

As a result of MOASIS role, work and importance within the MoH Strategic Plan, the number of projects with the MoH have doubled from 2010 (total of 10 projects) to 2012 (total of 19 projects), consequently MOASIS have expanded the human resources available to meet the MoH HIS project needs as well as the national HIS/eHealth needs countrywide.

The main HIS/eHealth solution outputs with the Mozambique MoH included:

- SIS-Enterprise Architecture Project Framework development and Current situation: The overall aim is to provide the MOH with a contextualized Health Enterprise Architecture
- SIS-ROH 1.0 and 2.0 – A national mortality system designed to meet the needs and requirements of the Ministry of Health of Mozambique.
- Hospital information system SIS-H (aggregated data): SIS-H consists of Implementation of a Hospital Information System (System of Hospitalization Data

Aggregation), and the aim of the project is to develop and implement a system for data aggregation on hospital admissions.

- National Monitoring and Evaluation System (Módulo Básico) and SIS-MA (the new Módulo Básico): The main aim is to execute any necessary emergency maintenance and corrections including automated integration of some forms resulted from the current review of SIS in the official application and manage the development of the new Modulo-Básico (SIS-MA)
- SIS-Resources and Services (former National Inventory of services and infrastructures - IIESS): Refers to Maintenance and Dissemination of the Register of Infrastructure, Equipment and Health Services (formerly known as SAM). The system provides data of Infrastructure, Equipment and Services in the NHS through, a new module incorporate in the Modulo-Básico.
- MoH Data warehouse: The project aims at developing a National Health Repository (Data warehouse). Moasis role was to support the MOH on the design, implementation, maintenance and management of a health data registry (National Repository/Data warehouse) integrated into the overall project design of overall architecture of e-Health.
- Database NGO Reports: Project that provides support from MoH to MOASIS to answer technical questions with the company (MzBusiness) responsible for developing and implementing a technological solution (Database) for registration and management of activities undertaken by their partners in cooperation with the Health Sector across the country replacing the mechanism for submission of reports on paper so far used
- SESP (Individual based system policies) and SIBI (SESP software): The aim of SESP is to define National policy, rules and procedures for individual patient record systems and develop Mozambique MOH's own SESP application/system.
- SIS-COLERA: Consists of Development and implementation of epidemiological surveillance system for cholera outbreaks. The project's aim is to develop and implement an easy to use application for cholera outbreak epidemiological surveillance in Mozambique providing daily data.
- SIS-HCM: It is the new information system for the Maputo Central Hospital

In response to the increased workload requests the MOASIS team has increased the number of staff from 2009 to 2012, beginning with 4 staff members (1 senior HIS specialist and 3 developers) and the office currently consisting of 12 professionals ranging from developers, HIS specialist, project and program's managers and experts, and administrators.

The afore mentioned undertaking of the addition of the training curriculum has seen MOASIS become responsible for the training of health workers dealing with the national system at a district level as well as training of the MoH staff at a central level in key areas such as project management and linguistic improvement. The training has expanded to include the provision of training in Health Information System for Provincial Health workers at Centro de Desenvolvimento Regional em Saúde (CDRS) [Centre of Regional Health Development].

7.2.6 Zimbabwe OASIS Node

Significant results are available for the Zimbabwe OASIS node, as detailed, below. The objectives of the current project implementation are:

1. E-Health Policy Development
2. Enterprise Architecture for Health care
3. Development and Support of Human Resource Information Management Systems
4. OpenMRS Pharmacy Module Work
5. Capacity Development

7.2.6.1 Objectives 1 and 2 - E-Health Policy Development and Enterprise Architecture for Health

7.2.6.1.1 *Care*

Objectives 1 and 2 are discussed as one since they are linked. CEPHI continued to sit in the National Health Information System Technical Committee (NHISTC) whose mandate is to steer the direction of the country's health information systems. Some of the tasks assigned to this task force were:

- Establishing technical subcommittees on different aspects of the NHIS
- Reviewing and approving the work of technical sub-committees and consultants
- Reviewing data collection tools and software in line with the National Health Information System requirements
- Reviewing the utilization of information in planning, implementing, monitoring and evaluating health programmes at all levels
- Advising on training programmes for health information staff to ensure availability of adequate skills for the implementation of the health information strategy
- Monitoring the production of quality and timely health profiles and any other health reports
- Establishing and monitoring an integrated system for sentinel disease surveillance
- Develop a vision and strategic approach to E-health
- Exploring how the NHIS can be integrated with other health information systems.

Two NHISTC meetings were held between January 2011 and March 2012, and CEPHI participated in both of them. The key result was the establishment of technical working groups working in specific specialised areas.

Five technical working groups were proposed;

- *District Health Information System (DHIS):* management, development, expansion and use of DHIS and inclusion in the general architectural design and aggregate data reporting system.
- *E-Communication facilitation and data transfer* (To include disease surveillance; expansion of coverage of internet access or radio systems for district level facilities; application of protocol development; Ministry of Health HQ network development using SMS or Radio systems)
- *E-Health, Architecture development, inter-ministerial co-ordination;* Ministerial E-Health policy paper; Linking E-health with National ICT policy, Public Private Partnership linkage with PEPFAR/CDC
- *Report Production and follow-up, Provincial and District Support TWG;* assessment of DHIS generated data; guidelines, interpretation and lay-out for report production at different levels of national reports.

- *Human Resource Development and Training Needs* (staff, level, type, methods, etc.) course material development, course implementation; methodology for on the job training and support.

7.2.6.1.2 *Objective 3 - Development and Support of Human Resource Information Management Systems.*

CEPHI was awarded a grant to further strengthen the national Human Resource Information Systems. The project is expanding on the regulatory authorities' database application that was started off through OASIS funding. The task now is to develop web based applications for the 7 regulatory councils in country and to interoperate with the human resource information system with the Ministry. During the OASIS II project period, two Councils (Medical and Dental Practitioners Council, and Allied Health Practitioners Council) were computerised. The Ministry of Health database was in the design stage. The CEPHI team was renamed to HITRAC. The final outcome was an enterprise wide human resource information system covering Councils, Ministry and Private Sector, giving the country an overview of the human resource capacity in both the private and public health sectors.

7.2.6.1.3 *Ministry of Health and Child Welfare HRIS*

CEPHI continued to support the nation-wide deployed HRIS. Key issues arising were the following:

- How useful has the system been to the users?
- What are the current and future needs of the system?
- How reliable has the system been?

No such evaluation had been done and it was anticipated with further availability of funding these points would be addressed. The system must be adapted for an enterprise platform. It was noted that the Ministry HRIS must interface with health practitioners councils' database systems in particular the Nurses Council and MDPCZ databases. The Centers for Disease Control (CDC) local office provided funding to make this possible through a US based organisation but this was not achieved. CEPHI, as the Health Informatics Training and Research Advancement Center (HITRAC) and in collaboration with a number of organisations, applied for the next funding opportunity announcement to continue with this work.

7.2.6.1.4 *Medical and Dental Practitioners Council of Zimbabwe (MDPCZ) database application.*

CEPHI secured a contract to develop, support and implement the medical and dental practitioners licensing database. The following was achieved:

Requirements Gathering

Detailed requirements documentation was carried out. Key requirements included:

- Online self registration
- Online payments for practitioners
- Searches for practitioners by the general public
- Integration with other databases especially Ministry of Health and Child Welfare database and other clinically oriented databases.
- Integration within the general Enterprise Health System architecture.

System Design

A detailed data model was developed and documented for further reference.

Software Development

The software development technologies used were based on the OpenMRS architecture namely: MYSQL database platform, Hibernate in the persistence layer, and Spring framework to model the business processes, and JSP front end. It is estimated the application will be fully developed by 30 May 2011. The group explored linkages with iHRIS software and submitted a funding proposal to the CDC to develop an integrated application for HR.

7.2.6.1.5 Objective 4 - OpenMRS Pharmacy Module Work

CEPHI was subcontracted to work on a Pharmacy Dispensing module for OpenMRS database application. The module is able to record dispensing transactions and export data to an external pharmacy system using an HL7 stream.

A one week training session was carried out for CEPHI developers by Jembi developers. Four developers were trained in the OpenMRS development methodologies, after which weekly developer sessions were held. CEPHI successfully managed to meet the above specifications and is submitting a final build by 5th May 2011. This module is being evaluated as a bridge between OpenMRS and the PIH developed OpenBoxes supply chain management system.

7.2.6.1.6 Capacity Building - Studentships

In order to strengthen human resource capacity within CEPHI and for future needs CEPHI continued to support studentships from various local universities. A total of 7 students were trained, 5 from the University of Zimbabwe, Dept of Computing Science, 1 from Chinhoyi University Department of Information Systems, and 1 From Solusi University Information systems. Three trainees were retained within CEPHI to work as full time developers/systems administrator. Had this program not been started it would not have been possible to get the human resource capacity needed for the current projects.

8 Project Outcomes

8.1 Program Implementation

8.1.1 MVP Project

Perhaps the most significant output of the MVP subproject is the intensive research/evaluation study of MVG-Net. The MVG-Net mixed methods evaluation summary of qualitative findings of four research periods is attached. Quantitative findings are to be integrated with qualitative research. Interim reports for each of the research periods are also available for more indepth analysis in attached appendices. The health impacts of the MVG-Net system are perhaps the most tangible outputs, but the results are still preliminary. MVP plans to continue analysis of the MVG-Net quantitative data using the OASIS II toolset even after the end of the grant period.

As for interoperability, MVP plans to complete its first integrated deployment with PIH in Rwanda by the end of the Summer 2012 using the Rwanda Primary Care Module, HTML forms and the MVP/CIEL data dictionary. MVP also continues to deploy the MVP/CIEL data dictionary throughout the MVP sites as well as the large number elsewhere. Working with Baobab Health, MVP plans to integrate its Malawi systems with the touchscreen application already in use in many Malawi clinics. We have already described the potential of MVP's OpenMRS-DHIS2 integration to influence integration in national scale-ups in Ghana and Kenya (and possibly Ethiopia). MVP continues to scale-up health information systems as part of the MDG health roll-out in 113 LGAs in Nigeria, and we expect that the results of OASIS II will inform patient-level data systems for that scale-up.

MVP also supported the implementation of a verbal autopsy and vital statistics application running on Android ODK to integrate with MVG-Net in all the MVP sites. As part of Coded-in-Country, MVP worked with Mindflow, a Kenyan development firm, to enhance ODK Clinic to allow for remote patient registry, better clinician interface and compatibility with MVP's dictionary. MVP used this not only throughout its network for verbal autopsies, but continues to study its use as an immunization decision-support tool in Tanzania (which will have wide-ranging applicability if successful).

MVP has been working with OpenMRS so that the CIEL/MVP concept dictionary with enhanced concept-mapping to reference terminologies is now available standard in the OpenMRS standalone version 1.9.

The hiring of eHealth Specialists in each country (at a sub-district level, although these positions could be transferred eventually to a district-level position) and the hiring of regional eHealth Coordinators has substantially increased local capacity to implement, customize and operate the MVG-Net system throughout the MVP sites in East and West Africa.

Development of an open source immunization decision-support module reusing the DBMI-created EzVac system has allowed for an additional study of how this could enhance immunization programs in MVP countries and is currently underway in Tanzania. Other areas of Action Research begun under OASIS II will be continued after the end of the grant period and will be submitted for publication/presentation.

Finally, the enterprise data warehouse was created in collaboration with a team from Pentaho. Using Pentaho's open source Kettle platform, we created a set of Extract-Transform-Load (ETL) scripts to extract deidentified data from each of the MVP OpenMRS servers and create a star-schema data warehouse. This allowed for creation of an OLAP analysis cube around the ChildCount+ indicators. Currently, the system is designed to bulk load data on vital statistics from all sites into a common warehouse. Following the end of the OASIS II grant, MVP plans to continue work to 1) increase the model for more data elements/indicators, 2) make the loads incremental to reduce burden on the remote servers, and 3) develop further visualizations/dashboards to make the data more accessible to the end users.

8.1.2 OpenROSA / JavaROSA Project

There were some tangible health impacts from the ROSA Work:

- a) The 30 CHWs in Dodoma served about 100 households each for the duration of the project. They promoted routine care. They also conducted special follow up on newborns visits, incentivized by a small baby gift package that new mothers receive if our CHWs visit them within one day of birth at home or returning home from birth in clinic.
- b) The reminder system significantly increased the number of home visits that HIV+ clients in Tanzania received from their home based care providers. It continues to operate to this day:
- c) The multimedia extensions to CommCare have enabled engaging messages to be shown to thousands of CHW's clients worldwide.

Lessons learned and next steps from the ROSA research studies include:

- a) Any automated system basically builds on personal relationships. The CHWs were quick to understand the escalation process:

"when the the [sic] message come to her or to him second times she know that 'ok,[the supervisor] will call'. Therefore she tried to complete her work. even if she see that 'ok there is a problem that I cannot--even if I visit that client I cannot send the message' sometimes they call me that

'oh, [supervisor] my phone message failed to be sent' or sometimes they call the [phone number that the automated SMS comes from]"

The CHWs understood what was happening and were comfortable enough to tell the supervisor—even contacting her proactively on their own if there was a problem or another reason that the visit could not be completed.

- b) It became immediately clear after deploying the initial reminder system that any automated communication system must support two-way communication. The CHWs had been originally instructed CHWs to follow up with the D-tree supervisor if there was any confusion with any aspect of the system. However, within three days of starting the intervention period in Study 1, a CHW tried to call the automated number (it will just ring indefinitely). During the 40-day intervention period, there were a total of 21 attempts to contact Dtree or the research team over SMS or voice with the automated number, not counting CHWs who called more than once in a row.
- c) The algorithms on automated quality control will be integrated into CommCare and made available to all users.
- d) The work on automated quality control has opened up a rich area of research. Next steps include:
 - a. Getting more realistic fake data sets—beyond the simple “fake data party” held in Dodoma.
 - b. Improve the algorithms to take advantage of a richer set of metadata than timing information alone that are available from mobile data collection tools such as skipped questions, questions answered out of order, the amount of scrolling attempts to input out-of-range values.
- e) When developing multimedia for mHealth systems, it is important to invest sufficient time to find a good illustrator and speaker. The illustrator should ideally be native to the intervention area to a degree that he or she is familiar with the typical style of dress, foods available, personal appearances, habitats, and general way of life of the target population.
- f) When developing multimedia for mHealth systems, pre-existing images can be used, but they must first be tested for usability on the mobile device and all available images should be inventoried. If using pre-existing images it must be taken into account that content outside of the existing inventory will not be covered which may cause future problems if modifications are needed or new content is desired.
- g) When recording audio for a mHealth system, the speaker should ideally be native to the intervention area to the degree that he or she speaks the same language shared amongst the CHWs and the majority of the target population. If the intervention covers a geographical area including multiple different dialects, use the CHWs as the common denominator. If the CHWs themselves speak different dialects, it may be worth the time commitment to create different version audio recordings to appropriately cover each primary language spoken. The speaker’s voice should be clear and annunciated and he or she should be able to speak naturally at a pace slower than normal conversation for better clarity.
- h) Dimagi will continue to invest heavily in multimedia content for CommCare, and work towards methods for easily sharing such content.
- i) An important lesson learned from the ROSA work overall is not to automate broken systems. If a community health program is not functioning well, then it is unlikely that adding an mHealth component will solve the underlying problems. These systems are best seen as tools that can strengthen a program, rather than salvage it.
- j) It is important to consider the gap between how a health program was originally designed to work and how it is functioning in the field. This has a significant impact when trying to introduce automation, because automating the original design will fail if what is happening in the field deviates significantly. As an

example, a community health program is often designed to include a large number of visits and material to be covered at each visit. However, CHWs may find it impractical to follow the program design fully. When an automated system that provides more tools for supervision is introduced, this tension is brought to the surface.

- k) Substantial effort and validation is required in order to use data collected by CHW for surveillance. Their systems must be designed with this in mind (rather than just supporting service delivery) and tracking issues such as rates of fever may require careful training.

8.1.3 Rwanda EHSDI Project

Most of the 22 EHSDI graduates from years one and two are now working in Rwanda on software development for eHealth, mainly with the MOH and PIH but one is also being shared between MVP and Jembi. One of the first year graduates works with the Clinton Foundation, and another studied for a Masters degree in the US in 2011 and is back working with the MOH. One graduate worked in Haiti with ITech in 2011 on improved interoperability between OpenMRS and the OpenELIS laboratory management information system. Another graduate is working with a small Rwandan software company doing eHealth work. Six graduates were hired by the Rwanda Development Board to work on software development. The graduates from the 2011 class are in the process of finding jobs. So far 2 have been hired for eHealth work.

8.1.4 OASIS Core Project

8.1.4.1 South Africa OASIS Node

The South Africa OASIS node continues to have significant impact in the region. Following its inclusion in the National eHealth Stakeholder Forum in South Africa, Jembi is well-positioned to play a positive role in the development of eHealth in South Africa and to follow the same partnership model developed in Mozambique and Rwanda. The 'honest broker' role has been found to be attractive to the South African National DoH and Jembi now leads one of five working groups coordinating eHealth in South Africa and playing a role in the development of a National Health Insurance Scheme and universal healthcare.

Much of the actual on-the-ground impact occurs through the OASIS nodes which are structured as programs within Jembi. However, Jembi plays a critical coordination and managerial role, providing almost all of the organizational development (policies, procedures), grant administration, financial control (fund-raising, funding, financial control systems, financial reporting), strategic and operational control. In addition to actual management of the nodes, Jembi also provides mentoring and nurturing the nodes with a view to eventually becoming self-sustaining.

The Jembi South Africa node, in addition to the aforementioned coordination and managerial roles, encompasses a strong technical development team that continues to support the existing OASIS nodes from within South Africa as well as providing technical support to remote teams and outside organizations. Technology sharing has been less than expected but is an aspect we hope to develop, in future. In addition to the sharing of technologies and methods between nodes Jembi is currently investigating the development of a suit of tools based on the components previously used and generalized to meet the broader needs Jembi encounters.

8.1.4.2 Rwanda OASIS Node

As a result of the activities performed and the outputs delivered as a result of the activities the OASIS II project has observed the following outcomes:

- The Jembi Rwanda office has developed a close relationship with the Ministry of Health that is continuing to evolve as the projects grow to ensure that Jembi

Health Systems Rwanda is actively contributing towards the eHealth strategy of Rwanda.

- The creation of a local Rwandan company actively engaged with the MoH in strengthening HIS and offering support and capacity development in the areas of HIS.
- A foundational EA of Rwanda's Health sector intended to form the basis from which the remaining EA for the country is leveraged off.
- The recognition of Jembi Rwanda as an up and coming organization focused on eHealth by the existing partners within the country and the willingness of partners and stakeholders to assist and collaborate with Jembi on both technical and strategic levels.

8.1.4.3 Mozambique OASIS Node

The MOASIS node is having substantial impact in Mozambique. The organization is officially recognized by the MoH, donors and partners working in Mozambique and is achieving many of the goals established by the OASIS II networks.

The MOASIS and Jembi teams have set up a highly efficient office with 12 Mozambican professionals, a solid base for interactive planning and monitoring technical and financial tools, internal procedures and in general a way of enthusiastically working and networking that can be considered unique in this region.

This is evident and continues to be supported through the innovative, living-lab, PPP model, acting as focal point for multiple USG-funded programs (UCSF, I-Tech, Vanderbilt), as well as building standard procedures suitable for HIS/eHealth projects in developing countries that include planning, workplan, system development, monitor and evaluation procedures, and administration procedures.

The MOASIS team has built a South-South Cooperation between MOASIS and Jembi HS regarding HIS/eHealth technical support, project and program's management, training and Institutional development all contributing to a repeatable model that is being developed.

The organization is highly cost effectiveness and elaborates the following core principles:

- Encourages country ownership and investment in country-led plans
- Builds sustainability through health systems strengthening
- Strengthens and leverages key multilaterals and other partnerships
- Increases impact through strategic coordination and integration
- Improves metrics, monitoring and evaluation
- Promotes research and innovation

The team has a highly effective and productive working relationship with the MoH as well as the CDC in Mozambique, with other National Institutions, including the Ministry of Justice, the National Institute of Statistics, the Ministry of Science and Technology, others USG partners involved in HIS development particularly UCSF and Vanderbilt University.

This is evident from the existing 5 years Memorandum of Understanding between MOASIS and MoH (MISAU), the Establishment of a formal and official synchronized workplan between MOASIS and the MoH regarding all HIS projects underway; and the creation and establishment of specific, suitable and formal mechanisms and methodologies in any HIS/eHealth project between MOASIS and MoH.

The expansion of MOASIS role in the public HIS network by synergizing projects of multiple government departments (Ministry of Justice, National Institute of Statistics,

Ministry of Science and Technology) is also evident of the teams ability to collaborate with the Mozambique MoH.

The network is being extended and interacting with a significant number of specialized international experts and organizations, e.g. the Rwanda Enterprise Architecture group, the Bruno Kessler Foundation, the South African Medical Research Council etc.). The MOASIS model of organization and networking has been recognized internationally as highly effective with significant potential for replication.

8.1.4.4 Zimbabwe OASIS Node

The Zimbabwe OASIS node at CEPHI has faced many difficulties related mainly to the political and economic instability in the country. Several promising students have been trained but then lost to industry or other programs. Despite these challenges, the Zimbabwe OASIS node has continued to deliver significant value for the MoH on Zimbabwe. Notably, it has developed human resources information systems that are used by the MoH and which have resulted in CEPHI leading a substantial grant application to the CDC. The node has also played a significant role in the roll-out of the DHIS in Zimbabwe. The node also advises the MoH on eHealth and plays a significant role in the formulation of eHealth policy. Efforts will be made to strengthen the Zimbabwe OASIS node in the last months of the project.

8.1.5 Open Architecture Project

It became clear at the beginning of the project that some skepticism exists for enterprise architecture (EA) in some quarters while being highly supported in others. Some people seem to inherently understand the concept while others see EA as hype and a distraction from the real task of developing systems and solutions. Some see EA as too ambitious for low resource settings in the sense that 'we can't even implement paper systems in Africa' never mind introduce advanced informatics design concepts. Others cite 'analysis paralysis' as a central problem that is exacerbated by the voluminous methodologies geared towards mature systems. Others see the relative green field situation in low resource settings as an opportunity to introduce a design component that will help prevent some of the explosion of disconnected systems in well-resourced environments.

At the beginning to the OASIS II project, little was known concerning the impact of open architectural design on health information systems development. The OASIS I project had elaborated work on open source software and information systems but little on open standards and architectures. A single paper by Stansfield et al¹⁵, explained the potential of enterprise architecture to harmonize design of HIS. The Health Metrics network (HMN) was championing the EA approach but this was lost during the restructuring of HMN in 2011. General awareness of the concept of EA increased significantly during the course of the OASIS II project and a significant number of EA projects started during this period. Henry Mwanyika became the first PhD graduate in EA for low resource settings. As a result of its work in EA and interoperability, Jembi has been appointed to lead a working group as part of the new National ICT4 Health Stakeholder Forum in South Africa.

The team did not achieve all the aims as the task is probably larger than originally envisaged. However, we have made substantial progress and, in some respects have made more progress than originally envisaged. As mentioned above, in many respects, OASIS II yielded results that were different from expected. Jembi has developed significant expertise in enterprise architecture and has consulted widely on the topic. Several EA projects are currently underway and the HEAF project is collating these

¹⁵ S. Stansfield, et al. (2008). 'The Case for a National Health Information System Architecture; a Missing Link to Guiding National Development and Implementation'.

experiences into an implementation-based EA framework. Although several top-down frameworks exist, there are few frameworks that exist for low resource environments. A summary is presented in Appendix Four and the full technical report is planned for later in 212.

Several individual architectures are being developed and are informing and being informed by HEAF, including efforts in Rwanda, Mozambique, Zimbabwe and South Africa. A collaboration has also been established in the Philippines as part of the mHealth Alliance initiative to create National Stakeholder Councils and South-to-South collaboration.

Architectural Artifacts

Another outcome for the Open architectures project are a range of architectural artifacts (assets) associated with the architecture projects. These are currently being compiled into a final format and distributed through the Health Ingenuity Exchange¹⁶ (HINGX), a collaborative project with Open Health Tools.

8.2 Project Implementation and Management

8.2.1 MVP Project

As part of the m/eHealth effort at Columbia, collaborative work with the Mailman School of Public Health and Department of Biomedical Informatics has led to the creation of a Columbia International eHealth Laboratory (CIEL). CIEL is housing the OASIS-MVP work in addition to other m/eHealth efforts at Columbia. It does not host the Maternal Concept Lab (MCL) website, but provides the dictionary used by MCL.

MVP is has completed the final qualitative assessment for the four OASIS sites, integrating research from the four periods of research. Data collection and analysis has proceeded a bit slower than we had originally anticipated. MVP currently has nearly 180,000 patients (46,000 under 5s, 87,000 15-49 year olds) and nearly 320,000 encounters recorded in the four OASIS databases. Over the next several months, these will be deidentified, extracted and loaded into a common data warehouse. Quantitative analysis will continue into the foreseeable future.

As part of further integration efforts, links between OpenMRS and DHIS2 means that MVP will be involved in MOH reporting integration in Kenya and Ghana (and probably Ethiopia). Specific projects to integrate with national DHIS2 implementations are already underway in Kenya and Ghana MVP sites, and a grant proposal to scale to the entire district in Ghana has been submitted to USAID. It is expected that because national rollouts of OpenMRS and DHIS2 are anticipated in both Kenya and Ghana, that MVP's initial integration work will be essential to guide national plans.

In addition to the ChildCount+ and OpenMRS integration completed in all MVP sites, MVP is also piloting a CommCare-MoTeCH-OpenMRS platform in two sites (Potou, Senegal and Sauri, Kenya). This platform is expected also to be used in Karnataka, India (as part of a joint project with WHO) and as the base platform for a national scale-up project in Ethiopia (lead by the Federal Ministry of Health and supported by the Bill and Melinda Gates Foundation). This would represent a fulfillment of the OpenMRS-OpenROSA integration hoped for with the initial OASIS collaboration.

As part of a Glaxo PULSE volunteer project, the MVP m/eHealth team (including eHealth Specialists) participated in a strategic assessment of the m/eHealth organization in MVP. This lead not only to the hiring of the additional eHealth Specialists, but also to better circumscribing of the operational eHealth team from the eHealth development team,

¹⁶ <http://heart.itghealth.com/HEART.Registry/>

more focus on “customer support” and closer management of the data quality and information flows. The assessment produced a set of important artifacts which help explain the Why? What? Who? When? Where? and How? of the eHealth effort at MVP. A powerpoint presentation of this work is attached as an appendix.

8.2.2 OpenROSA / JavaROSA Project

OpenROSA shifted leadership from Neal Lesh, based in the US, to Jacob Mtalitinya, who is based in Tanzania. An advisory board was formed to support Jacob in his new role, including Neal.

The project management for the OpenROSA Application (CommCare) in Dodoma, Tanzania went extremely well. The project was managed by ITIDO, a Tanzanian innovation organization. The project was led by Ken Bayona, a Tanzanian hired initially as research assistance. He is supported by his wife, Deborah Gitonga, for finance and admin. Among other things, Ken arranged for the Red Cross to provide training and medical kits for the CHWs. Dimagi funded a field fellow from the United States, Nick Amland, to live in Dodoma for most of 2011 and report to Ken. See ROSA Attachment A for a detailed report produced by Ken.

Unfortunately, D-tree and Dimagi were unable to obtain continued funding for the CommCare project in Dodoma, and so are no longer supporting it. However, through the course of the grant, the CHWs using CommCare used the small bonuses paid to them and formed an association, with support from Deborah and Ken. They saved money and using it to start four businesses. On World Aids day, the CHWs organized on their own initiative to distribute blankets (provided by the Red Cross) at a local hospital. We helped the CHWs obtain \$5,000 from the Segal Family Foundation which they have used to start a dispensary in an underserved area outside Dodoma.

The three ‘Coded in Country’ internships were reasonably successful. The Albert Schweitzer in Haiti worked with Afrisis in Mozambique to eventually produce a useful version of OpenMRS-jr for entering data into OpenMRS with JavaRosa (<https://wiki.openmrs.org/display/docs/OpenMRS-jr>). This took longer than expected but the system was rolled out to at least 13 CHWs in by April 2012. The wiki documents 19 bugs which are still being worked on by Afrisis. MVP’s mentoring of Mindflow in Kenya was successful in that MVP is hiring Mindflow for follow on work. There were many challenges relating to communication and supervision through the first process though, as well as estimating the difficulty of the work to be done with the small budget provided. In future engagements, more effort should be spent up front to define clear roles of communication and to ensure that the mentoring agency has authority to control payment of funds.

Dimagi recruited and mentored Nate Barthel to spearhead the Coded in Country initiative, however, who has pushed forward the initiative by launching a new website (<http://www.codedincountry.org>), soliciting content for it, and speaking about CiC at several meetings.



Figure Seven. CHWs Distributing Blankets

8.2.3 Rwanda EHSDI Project

The EHSDI course completed its third year with 10 students graduating in 2009, 12 in 2010 and 12 more in at the end of 2011.

The course moved location from Telecom House in Kigali to the Kigali Institute of Science and Technology (KIST) in 2011. Two rooms were provided by KIST as part of the agreement to host the course and funded by student fees. The rooms were renovated and painted by the course.

Fees were charged for the first time in 2011 with half of the students qualifying for bursaries to cover them. Originally 16 students were recruited but 4 dropped out mainly due to the cost of the fees.

There have been changes in the Rwanda eHealth Center plan which has resulted in a shift from KIST to the Kigali Health Institute. This resulted in some disruption of the course and was one of the reasons that the course was not run in 2012.

8.2.4 OASIS Core Project

Jembi has consolidated all of its company structure and is fully operational as a registered NGO. The organization has begun the process of carefully adopting the business structures pertinent to the continued effective functioning of the organization as a whole.

Jembi has formalized the in-country OASIS nodes as their own internal programs within Jembi headed up and supported by the programs teams and administration teams developed within Jembi.

The UKZN node has developed into an effective research group within the School of Computer Science. A company has been registered in Rwanda to host the Rwanda OASIS node and options are being investigated in Mozambique to register MOASIS. CEPHI is investigating several options to stabilize its position within the University of Zimbabwe.

An OASIS Project newsletter was developed at the end of 2010 and distributed through the IDRC stall at the First Global Conference on Health Systems Research in Montreux, during November of 2010. The content has been posted to a new OASIS Project web site¹⁷ and updates to the content will be managed through the web site.

8.3 Evaluation and Assessment

8.3.1 OASIS II Network

The OASIS II project did not develop into a tightly coordinated network sharing harmonized research methods, as originally envisaged. As the project got underway the different sub-projects each developed their own research design, methodology and methods and it became clear that coordinating at the level of methods or research instruments would not be feasible, nor would it necessarily be useful for everyone involved. Several important themes have emerged, including interoperability and capacity building which became the focus of the OASIS evaluation.

The Utilization-Focused Evaluation (UFE) process was applied in this project. UFE works off of the premise that evaluations should give careful consideration to selecting the most appropriate content and methods for the primary stakeholders and their intended uses of the evaluation findings. A UFE can include one or several evaluative purposes based on multiple kinds of data (quantitative, qualitative, mixed), by applying one or several methodologies (observational, experimental, etc.). Generally, UFEs follow the 12 step "checklist". For this evaluation, a modified version was applied based on 1) the timing of the evaluation team involvement in the project progress (towards the end of the project period instead of from the beginning), and 2) the tight timeline of the evaluation itself (April – September 2011). The primary intended users for this study were the four PIs of the different sub-projects and the umbrella project. The users are central to UFE studies and as such are involved in different points of the process.

8.3.1.1 Interoperability

Interoperability was a central focus of much of the work of the OASIS II Partners and several important collaborative efforts emerged between members for promoting interoperability – from social and professional networking to coordination between groups on data concept exchange to collaboration on the definition and application of open architecture approaches. Two new substantial and complementary efforts are: the Health Enterprise Architecture Framework (HEAF) and the Maternal Concept Lab (MCL). These efforts take two fairly different approaches to collaborations, and we conducted an investigation of how these efforts came about and what positive (or negative) impacts they have had. Interoperability will likely be a significant activity, in future, and these two activities complement each other in providing a complete solution for data integration, messaging and semantic interoperability. These will be essential components, in the future, as we begin to move towards the development of national health information systems and enterprise systems at scale based on a loosely-coupled component architecture. It would be useful to compare the relative strengths and

¹⁷ <https://sites.google.com/site/oasisopenarch/>

limitations of the two architectures that have emerged to improve interoperability between applications, ie the RHEA health information exchange and CommCare-MoTECH architecture. This could be the subject of a future evaluation and paper considering that members of the OASIS II consortium are involved in both projects.

8.3.1.2 Capacity Building

This evaluation attempted to address the larger question of how changes in the way eHealth services are delivered in Africa have changed as a result of capacity building efforts under OASIS II projects. The overall goals of the investigation relative to Capacity Building / eHealth Workforce Strengthening efforts were (1) to clearly articulate the greater objectives of OASIS II in building local capacity for eHealth technology development and implementation in Africa, and (2) to understand to what end the work through the OASIS II projects can contribute to approaching these objectives.

Specific goals of this component of the evaluation include (1) describing the current efforts by the primary OASIS II project groups as well as related "secondary" networks through the Jembi, OpenMRS, OpenROSA, and Millennium Village Project communities, (2) identifying gaps and overlaps in these efforts, and (3) compiling lessons-learned to share experiences about what efforts have worked and which have not been as successful as hoped.

9 Recommendations

9.1 Research Related Recommendations

Based on the OASIS experience of coordinating a Network of Networks:

- a) There is a need for more investment in common tools and framework for research in this area. This proved to be much more challenging than expected within the OASIS project.

Based on the OASIS experience in Interoperability:

- b) It is important to continue to invest in interoperability efforts that are supported by existing communities of practice - whether organized around tools (e.g. OpenMRS, CIEL dictionary), or research questions and implementation goals (OASIS, OASIS II, RHEIN, RHEA), communities of practice build relationships and support the development of best practices that can be codified into common standards;
- c) It is it important to support further research in designs for unreliable Internet connectivity - Enterprise architectures that use a web services model need to be modified to deal with low connectivity environments. Technical experts and developers need to understand more about health care services, work flows and information flows (including data management and decision making contexts) in order to be able to fully engage in a support capacity for improving health service provision.
- d) It is important to continue efforts to introduce open architecture and a design approach to HIS development. There is much to be gained from this approach although the methodologies and artifacts need to be refined to the point where they are more usable.
- e) At the current level of maturity, there is probably more emphasis on design at the information and computation viewpoints than at the enterprise viewpoint level

Based on the OASIS experience in Capacity Building:

- f) Successful research in this area benefits from vigorous and regular training of health staff (every 6 months) on eHealth technology, local language translation of applications, and regular feedback and reporting.

9.2 Process-related Recommendations

Based on the OASIS experience of coordinating a Network of Networks:

- a) Future efforts to create Network of Networks models should dedicate substantial budget to coordination and carefully consider the value proposition for the networks involved.
- b) The reporting burden was a substantial challenge, especially when working across the busy PIs across the Network of Networks. A lighter weight reporting process, especially for interim reports, should be considered.

Based on the OASIS experience in Capacity Development:

- c) It will be most effective to engage in both top down and bottom up capacity building efforts to include decision makers, implementers and programmers at upstream and end-user points. Without all three kinds of stakeholders involved in actual implementations at scale (both as indirect support teams and at the clinic or field worker level), there is limited sustainability, regardless of funding available and local health priorities.

9.3 Organizational-Related Recommendations

Based on the OASIS experience of coordinating a Network of Networks:

- a) When trying to establish a Network of Networks, it is important to assess the value proposition of the overarching network to each of the sub-networks and appreciate how much effort each sub-network may be expending to maintain its own cohesion.

Based on the OASIS experience in Interoperability

- b) Projects should be designed with enough time for interoperability efforts to gain traction among many stakeholders.
- c) Promotion of Maternal Concept Lab and the MVP/CIEL concept dictionary would be enhanced through a meeting of key stakeholders. WHO had recommended a meeting to discuss the OpenMRS Concept Collaborative and concept use within OpenMRS. This could play an important role in sharing best practices and expanding beyond OpenMRS to include other m and eHealth initiatives.
- d) An open architectural approach is challenging to implement but has substantial potential benefits for low resource settings (in addition to high resource settings). Any methodology can be used but the fundamental issue is to include a design phase when implementing systems. National architectural blueprints are likely to be useful in this regard. Countries should consider a lightweight approach to implementing an enterprise architecture methodology.

Based on the OASIS experience in Capacity Development:

- e) There is a need for more project management, professional development skills and agile problem solving approaches to eHealth tool / system use and maintenance. Respondents to interviews across all four projects consistently referred to a lack of codified focus on problem solving skills in local East and Southern African education systems (and universities and computer science programs in particular). Several key interviewees directly referred to how most of the eHealth and mHealth efforts (theirs respectively included) don't put enough time into capacity building in general and in specifically promoting and cultivating critical thinking on the parts of their trainees or project participants. Projects should be designed with enough time to build capacity before it is needed. There is a natural tendency for grantees to promise too much to be achieved too quickly.

- f) Organizational development approaches were found to be important for some of the capacity development initiatives of the OASIS project to ensure longer-term sustainability. Jembi is currently working with IDRC on an organizational development plan for Jembi itself that may be useful for other organizations, including the Mozambique, Rwanda and Zimbabwe OASIS nodes. It is difficult to create sustainable African non-profit companies supporting eHealth efforts solely using project-based funding. Many funders (not including IDRC) deny or restrict indirect costs on grant applications from African NGOs. Some degree of core funding is very important for longer term sustainability.
- g) Migrating CEPHI to a center of health informatics: CEPHI, which stands for the Center for Evaluation of Public Health Interventions was setup primarily to support monitoring and evaluation of public health interventions. It was developed with two subunits namely Monitoring and Evaluation Unit and Health Informatics Unit. Over the years it has evolved to meet the different emerging local needs in both these specialties. There has been growing need to set up a dedicated center of excellence in informatics to take on a wider informatics portfolio. This portfolio now includes support for other key projects at the College such as Novell Education Clinical Trainees and Researchers Program (NECTAR). This is a PEPFAR funded program one of whose goals is to leverage on Informatics to deliver best practice medical education. As CEPHI intends to support this and other PEPFAR funded projects in the country the Health Informatics Unit was upgraded to a separate center of informatics known as Health Informatics Training and Research Advancement Center (HITRAC). This center is governed at College level with the governance structure composed of the Departments of Community Medicine, Medicine and the Southern Africa Consortium for Research Excellence (SACORE). It is anticipated this structure will provide a wider resource base to support current and future informatics projects.
- h) Countries with a similar level of existing capacity and intentions for OpenMRS usage should consider reproducing a course similar to what was created in Rwanda. This course served a specific need to create capable local OpenMRS developers and did that very successfully. All of the materials from the course have been made available which would allow other countries to easily reproduce it. In countries where there is better existing software development capacity, the early units of the course which focus on general programming skills could be omitted. Rwanda's eHealth capacity needs have evolved considerably since the EHSDI training course was created. Going forward Rwanda does not need to keep training software developers with such a specialist knowledge of OpenMRS as the course has already produced 34 such developers. However there are other systems and other technologies that make up Rwanda's eHealth architecture. Lessons learnt from this training course could shape short courses tailored to those other systems.
- i) There needs to be investment and improvement in the computer science courses. The EHSDI course devoted the majority of teaching time to general software development topics which are not being adequately covered in computer science courses at Rwandan universities. Improving these would allow the development of a true health informatics course which is not tied to a particular system and enables research and development of any of the systems in use in Rwanda.

10 Appendices

10.1 Appendix One. OASIS II Outputs

| Capacity | | | | |
|----------------------|-------------------|--|---|-------------|
| Project(s) | Partner(s) | Output | Output Type | Type |
| MVG-Net | MVP | 11 new eHealth Specialists and 2 regional eHealth coordinators hired and trained | eHealth Capacity Development | Capacity |
| Rwanda EHSDI Project | PIH | 34 graduates of the Rwanda eHealth: Software Development and Implementation Course | eHealth Capacity Development | Capacity |
| OASIS core | JEMBI | Company registration - Jembi South Africa | Organizational Development | Capacity |
| OASIS core | JEMBI | Company registration - Jembi Rwanda | Organizational Development | Capacity |
| OASIS core | JEMBI | Company registration - Jembi Mozambique (preliminary) | Organizational Development | Capacity |
| OASIS core | JEMBI | Jembi Strategic Plan | Organizational Development | Capacity |
| OASIS core | JEMBI | 11 existing and 32 new Africans trained and supported within JEMBI during the grant period | Job Creation and eHealth Capacity Development | Capacity |
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| Papers | | | | |
|-------------------|-------------------|--|---|---|
| Project(s) | Partner(s) | Output | Output Type | Author(s) |
| MVG-Net | MVP | Information Needs and Technical Self-Efficacy of Midwives in Rural Ghana | Manuscript submitted to peer reviewed journal | Olivia Vélez, RN, MS, MPH, MPhil, Patricia Mechael, MHS, PhD, Andrew Kanter, MD, MPH, Suzanne Bakken, RN, DNSc. |
| MVG-Net | MVP | Capitalizing on the Characteristics of mHealth to Evaluate Its Impact. Journal of Health Communications | In Press | Patricia Mechael, Bennett Nemser , Roxana Cosmaciuc, Heather Cole-Lewis, Seth Ohemeng-Dapaah , Schadrack Dusabe , Nadi Nina Kaonga, Patricia Namakula , Muhadili Shemsanga , Ryan Burbach and Andrew S. Kanter. Capitalizing on the Characteristics of mHealth to Evaluate Its Impact. Journal of Health Communications |
| MVG-Net | MVP | The importance of using open source technologies and common standards for interoperability within eHealth: Perspectives from the Millennium Villages Project. Health Care Communications and Marketing | In Press. Book Chapter | Andrew S. Kanter, Rob Borland, Mourice Barasa, Casey Iiams-Houser, Olivia Velez, Nadi Nina Kaonga, Matt Berg. |
| MVG-Net | MVP | Improving health care delivery in Ruhiira MVP through the use of data generated from the OASIS Implementation | | Patricia Namakula, Dr Patricia Mechael, Dr.Martins Okongo, Dr.David Siriri, Bennett Nemser, Roxana Cosmaciuc, Heather Cole-Lewis, Maurice Baraza, Nadi Nina Kaonga, , Dr. Andy S. Kanter. |

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| MVG-Net | MVP | OASIS II Implementation and Preliminary Results in Bonsaaso, Ghana | | S. Ohemeng-Dapaah, P. Mechael, E. Akosah, J. Mensah-Homiah, B. Nemser, R. Cosmaciuc, H. Cole-Lewis, O. Velez, M. Baraza, N.N. Kaonga, A.S. Kanter, and N. Amadou. |
| OpenROSA | D-Tree | Mobile Phone Tools for Field-Based Health care Workers in Low-Income Countries | Published in (peer reviewed) Mount Sinai Journal of Medicine, 2011 | Brian DeRenzi, Gaetano Borriello, Jonathan Jackson, Vikram S. Kumar, Tapan S. Parikh, Pushwaz Virk, and Neal Lesh. |
| OpenROSA | D-Tree | A framework for Case Based Community Health Information Systems | Published in (peer reviewed) 2011 IEEE Global Humanitarian Technology Conference | Brian DeRenzi, Clayton Sims, Gaetano Borriello, Jonathan Jackson, Neal Lesh. |
| OpenROSA | D-Tree | Technology for Workforce Performance Improvement of Community Health Programs | | Brian DeRenzi. |
| OpenROSA | D-Tree | Strengthening Community Health Systems With Local Multimedia | Published in (peer reviewed) M4D 2012 conference. | Derek Treatman, Neal Lesh. Strengthening Community Health Systems With Local Multimedia |
| OpenROSA | D-Tree | Improving Community Health Worker Performance Through Automated SMS | Published in (peer reviewed) ICTD 2012 conference. | Brian DeRenzi, Leah Findlater, Jonathan Payne, Benjamin Birnbaum, Joachim Mangilima, Tapan Parikh, Gaetano Borriello, Neal Lesh. I |
| OpenROSA | D-Tree | Automated Quality Control for Mobile Data Collection | Published in (peer-reviewed) ACM DEV 2012 conference. Won Best Paper award. | Benjamin Birnbaum, Brian DeRenzi, Abraham D. Flaxmany, and Neal Lesh |
| PIH-EHSDI | PIH | Training Software Developers for Electronic Medical Records in Rwanda. Stud Health Technol | Manuscript published in peer-reviewed journal/Proceedings | Seymour RP, Tang A, DeRiggi J, Munyaburanga C, Cuckovitch R, Nyirishema P, Fraser HSF. |

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| | | Inform. 2010;160:585-9 | | |
| OASIS core | JEMBI | The OpenMRS implementers' network. International Journal of Medical Informatics, 78(11):711-720, November 2009. | Manuscript published in peer-reviewed journal | Christopher J. Seebregts, Burke W. Mamlin, Paul G. Biondich, Hamish S. F. Fraser, Benjamin A. Wolfe, Darius Jazayeri, Christian Allen, Justin Miranda, Elaine Baker, Nicholas Musinguzi, Daniel Kayiwa, Carl Fourie, Neal Lesh, Andrew Kanter, Constantin T. Yiannoutsos, and Christopher Bailey. |
| OASIS core | JEMBI | Human factors for capacity building. Lessons learned from the OpenMRS implementers' network. IMIA Yearbook, pages 13-20, 2010. | Manuscript published in peer-reviewed journal | C. J. Seebregts, B. W. Mamlin, P. G. Biondich, H. S. F. Fraser, B. A. Wolfe, D. Jazayeri, J. Miranda, J. Blaya, C. Sinha, C. T. Bailey, and A. S. Kanter. |
| OASIS core | JEMBI | A best practices approach to health information systems strengthening in Mozambique | Manuscript submitted to peer reviewed journal | Alessandro Campione, Christopher J. Seebregts. |
| OASIS core, UKZN-HEAL | JEMBI | Position paper: Researching and developing open architectures for national health information systems in developing African countries. Lecture Notes in Computer Science, Submitted, November 2011. | Manuscript published in peer-reviewed journal | Deshendran Moodley, Anban Pillay, and Christopher J. Seebregts. |
| MVG-Net, OpenROSA, Open Architecture | MVP,D-Tree, JEMBI | Comprehensive yet scalable health information systems for low resource settings: a collaborative effort in sierra Leone. AMIA ... Annual Symposium proceedings / AMIA Symposium. AMIA Symposium, | Conference Proceeding | Jørn Braa, Andrew S. Kanter, Neal Lesh, Ryan Crichton, Bob Jolliffe, Johan Sæbø, Edem Kossi, and Christopher J. Seebregts. |

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| | | 2010:372–376, 2010. | | |
| OASIS | Jembi | An Interoperability Architecture for the Health Information Exchange in Rwanda'. In <i>International Symposium on Foundations of Health Information Engineering and Systems</i> , vol. Submitted. | Conference Proceeding | R. Crichton, D Moodley, A Pillay and CJ Seebregts (2012). |

| Presentations | | | |
|----------------------|-------------------|--|---|
| Project(s) | Partner(s) | Conference / Workshop | Description |
| MVG-Net | MVP | PHI 2011 | |
| MVG-Net | MVP | GSMA | |
| MVG-Net | MVP | MVP meHealth Strategic Assessment | PowerPoint of strategic assessment and proposal for reorganization of MVP eHealth Team |
| MVG-Net | MVP | Health Systems Research 2012 | Dragon's Den Pitch_2012 Submitted |
| OpenROSA | Dimagi | "mHealth: Changing Health Care Delivery at the BoP" webinar on December 8, 2011 sponsored by Business Call to Action | Dimagi CEO, Jonathon Jackson, was a featured speaker in this webinar discussion will focus on mHealth trends and opportunities that will likely emerge in the near future, barriers to the growth of this sector, and the role of partnerships in scaling up these initiatives. |
| OpenROSA | Dimagi | mHealth summit, 2012 | Derek Treatman spoke as one of the "Top 11" innovators for work on |

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| | | | CommCare |
| OpenROSA | Dimagi | mHealth summit, 2012 | Jon Jackson spoke on panel on interoperability |
| OpenROSA | Dimagi | HUB NYC and MIT Club of New York Professional Programs Social Innovation panel, New York, Nov 2011 | Dimagi CSO Neal Lesh was a panellist. Neal discussed the role of information and communication technologies in social innovation. |
| OpenROSA | Dimagi | Annenberg School for Communication ICT4D series | Dimagi CSO Neal Lesh presented CommCare to an interdisciplinary audience at an ICT4D speaker series Annenberg School for Communication. Video available here: http://www.asc.upenn.edu/ict4datpenn/ . |
| OASIS core | JEMBI | OpenMRS Implementers Meeting (2010) | Hosted (JEMBI) and participated (PIH, MVP) in the Fifth Annual OpenMRS Implementers Meeting in 2010 |
| OASIS core | JEMBI | 2010 January - Prince Mahidol Award Conference (Bangkok) | Jembi organized two side meetings and delivered a presentation at the Prince Mahidol Award Conference in Bangkok during January 2010. The meeting was an important event to launch a global enterprise architecture approach for HIS strengthening in developing countries. The meeting was also important from the perspective of developing a global collaborative for this work and harmonizing donor funds. |
| OASIS core | JEMBI | 2010 March - HMN/ISO Standards Meeting (Bellagio) | Jembi attended an ISO Meeting to develop an enterprise architecture framework for low resource settings standard specification at the Rockefeller Foundation Conference Centre in Bellagio from 30 March to 3 April 2010 and also organized funded a number of representatives from African countries, including Dr Richard Gakuba (Rwanda), Dr Alessandro Campione (Mozambique) and Dr Rosemary Foster (South Africa). The group is writing a standard for enterprise architecture for developing countries and the inputs from developing countries, such as Rwanda and Mozambique, will greatly assist this group develop something which is relevant and can be used in-country. |
| OASIS core | JEMBI | 2010 June - COACH / IDRC eHealth EA Workshop | Posters were presented by at the IDRC Vancouver eHealth EA Workshop on 3 June 2010 and a keynote address delivered within the |

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| | | (Vancouver) | main COACH meeting (Jembi). |
| OASIS core | JEMBI | 2010 August – PEPFAR Annual Meeting (Cape Town) | A presentation on the open architecture project was delivered at the PEPFAR Annual meeting in Cape Town on 10 August 2010. |
| OASIS core | JEMBI | 2010 September – OpenMRS Implementers Meeting (Cape Town) | The fifth OpenMRS Implementers meeting was held during September 2011 in Cape Town and was attended by over 140 delegates from 25 different countries and over 50 different organizations, ranging private companies and individuals to NGO's, research organizations and universities. |
| OASIS core | JEMBI | 2010 September – OASIS Meeting (Cape Town) | The first OASIS II project meeting was held in Cape Town during September 2010 attended by representatives from Jembi Health Systems (including the Mozambique and Zimbabwe nodes), MVP, OpenROSA and PIH. |
| OASIS core | JEMBI | 2010 September – HMN Meeting (Cape Town) | OASIS core also facilitated a meeting of the ISO expert group working on a technical report on enterprise architecture for low resource settings. |
| OASIS core | JEMBI | 2010 September – Medinfo (Cape Town) | An interoperability showcase outlining the use of an Open Enterprise Architecture Solution for Health Information Systems in an African Setting was demonstrated at MedInfo 2010. |
| OASIS core | JEMBI | | A paper was presented at MedInfo 2010. |
| OASIS core | JEMBI | 2010 November – Africomm (Cape Town) | Chris Seebregts and Alessandro Campione attended the Africomm meeting in Cape Town during November 2010. The meeting resulted in a collaboration with a group from the Bruno Kessler Institute in Italy that are developing an eGovernment framework for Mozambique and which will connect with the Mozambique Open Architecture project. |
| OASIS core | JEMBI | 2010 October – OASIS (Harare) | Chris Seebregts and Alessandro Campione visited the Zimbabwe OASIS node in October 2010 and met with representatives of CEPHI, the Ministry, HI-PPP, CDC and USAID. |

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| OASIS core | JEMBI | 2010 October - MOASIS (Maputo) | Chris Seebregts and Alessandro Campione visited the Mozambique OASIS node in October 2010 and met with representatives of MOASIS, the Ministry, HI-PPP, CDC and USAID. |
| OASIS core | JEMBI | 2010 November - First Global Conference on Health Systems Research (Montreux) | Chris Seebregts presented a workshop on open architectural approaches with the IDRC, Rockefeller Foundation and other collaborators. |
| OASIS core | JEMBI | 2010 December - Strategic Planning Workshop (Cape Town) | Jembi held a strategic planning and organizational development workshop in Cape Town during December 2010. |
| OASIS core | JEMBI | 2011 January - eHealth Association of Pakistan (eHAP) Meeting (Islamabad) | Chris Seebregts presented a keynote lecture and went on a site visit to various eHealth and telehealth implementation sites with a team from the PANACEA network to Gilgit-Baltistan in Northern Pakistan. |
| OASIS core | JEMBI | 2011 February - MOASIS (Maputo) | Alessandro Campione and Jonnea Smith visited the Mozambique OASIS node in February 2011 and met with representatives of MOASIS, the Ministry and UEM to implement and strengthen operational, administrative and financial policies and procedures. |
| Open Architecture | JEMBI | 2011 February - Open Architecture (Kenya) | Carl Fourie attended the launch of the enterprise architecture project in Kenya during February 2011, hosted by the World Bank. |
| Open Architecture | JEMBI | 2011 March - Rwanda Health Enterprise Architecture Workshop (Kigali) | Jembi hosted an open architecture workshop in Kigali during March 2011. |
| Open Architecture | JEMBI | 2011 October - Rwanda Health Enterprise Architecture Workshop (Kigali) | Jembi hosted the workshop on the RHEA project. |
| OASIS core | JEMBI | 2012 March - Strategic Planning Workshop (Cape Town) | Jembi held a strategic planning and organizational development workshop in Cape Town, attended by delegates from Jembi's in-country offices (Mozambique, Rwanda and Zimbabwe) as well as all local South African staff members. |

| Open Architecture | JEMBI | 2012 March - Rwanda Health Enterprise Architecture Workshop (Kigali) | Jembi Health Systems Rwanda hosted the RHEA workshop, which included a session on the HEART project. | |
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| OASIS core | JEMBI,MVP,D-Tree | OpenMRS Implementers Meeting (2011) | Participated in the Sixth Annual OpenMRS Implementers Meeting in 2011 | |
| MVG-Net, OpenROSA, Open Architecture | JEMBI,MVP,D-Tree | 2009 October - ACACIA Meeting (Dakar) | Several members of the OASIS II group attended the IDRC ACACIA meeting in Dakar, Senegal from 4-7 October 2009. | |
| Posters | | | | |
| Project(s) | Partner(s) | Conference / Workshop | Description | Author(s) |
| MVG-Net | MVP | AMIA 2011 | Information Needs and Technical Self-Efficacy of Midwives in Rural Ghana | Olivia Vélez, RN, MS, MPH, MPhil, Patricia Mechael, MHS, PhD, Andrew Kanter, MD, MPH, Suzanne Bakken, RN, DNSc. I |
| MVG-Net | MVP | AMIA 2012 | The OASIS II Research Project: Evaluating an Sub-Saharan Africa eHealth Architecture (submitted) | Andrew S. Kanter, MD MPH, Nadi Nina Kaonga, Patricia N. Mechael, PhD, Olivia Velez-Benson, PhD MSc, Roxana Cosmaciuc, MPA, Seth Ohemeng-Dapaah, PhD, Eric Akosah, Nicholas Addofoh, MS, Joe Sakyi-Baah, MS, Muhadili Shemsanga, MBBS, Killian Mahembe, Patricia Namakula, Julius Ssempiira, Emmanuel Toko, Benjamin Rukundo, Schadrack Dusabe, Mourice Barasa, Rob Borland, PhD, Casey Iiams-Hauser, Bennett Nemser, MPH. |
| MVG-Net | MVP | AMIA 2012 | Usability of an mHealth Application to Promote Knowledge Work Among Rural Ghanaian Midwives (submitted) | Olivia Vélez, PhD, MS, MPH, RN, Portia Boakye Okyere, BSc, Andrew S. Kanter, MD, MPH, FACMI, Suzanne Bakken, DNSc, RN, FAAN, FACMI. Usability of an mHealth Application to Promote Knowledge Work Among Rural Ghanaian Midwives (submitted) |

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| MVG-Net | MVP | AMIA 2012 | A Communicative Landscape of Health Information Needs for Malaria Management in the Millennium Villages Project in Bonsaaso, Ghana (submitted) | Lorena Carlo MS, MBA, Nadi Kaonga BS, Richmond Kodie BS, Olivia Velez PhD,MS, Andrew S. Kanter MD, MPH. A Communicative Landscape of Health Information Needs for Malaria Management in the Millennium Villages Project in Bonsaaso, Ghana (submitted) |
| MVG-Net | MVP | IDRC Vancouver eHealth EA Workshop | Millennium Villages Project (MVP) | Millennium Villages Project (MVP) [A Kanter, Millennium Villages Project, USA |
| OpenROSA | D-tree | mHealth Summit, December 5-7, 2011. Washington D.C. | Semi-Automated Workforce Performance Improvement via SMS | Semi-Automated Workforce Performance Improvement via SMS Brian DeRenzi, Leah Findlater, Benjamin Birnbaum, Joachim Mangilima, Grace Mshana, Tapan Parikh, Gaetano Borriello, and Neal Lesh. |
| | PIH | PIH-PHII AMIA Poster | | |
| | PIH | AMIA | | |
| OASIS Core | JEMBI | IDRC Vancouver eHealth EA Workshop | Rwanda Health Enterprise Architecture | R Gakuba (Ministry of Health, Rwanda); C Seebregts and C Fourie (Jembi Health Systems, South Africa); B Leão (Leão Informatica); E Peloso(Deloitte, Canada); M Walker (Northrup Gruman, USA); P Biondich (Regenstrief Institute) and C Bailey (World health organization) |
| OASIS Core | JEMBI | IDRC Vancouver eHealth EA Workshop | Health Enterprise Architecture Framework (HEAF) Project | C Seebregts (Jembi health Systems); R Gakuba(Ministry of Health, Rwanda), B Leão (Leão Informatica), E Peloso(Deloitte, Canada), M Walker (Northrup Gruman, USA), P Biondich (Regenstrief Institute) |

| Reports | | | | |
|-------------------|-------------------|--|---|--|
| Project(s) | Partner(s) | Title | Author(s) | Description |
| OASIS Core | | OASIS II Evaluation Report | Heather Zornetzer, Melissa Loudon, Justine Esquivel | OASIS II Evaluation Report |
| OASIS Core | | Final report of the OASIS II evaluation | MVG-Net | Final report of the OASIS II evaluation |
| OASIS Core | | OASIS II Evaluation Plan | | OASIS II Evaluation Plan |
| MVG-Net | MVP | OASIS Research Project at Baseline | Dr. Patricia Mechael, Roxana Coscmaciuc, Nadi Nina Kaonga, Bennett Nemser, Heather Cole-Lewis, Dr. Andrew S. Kanter | OASIS Research Project at Baseline |
| MVG-Net | MVP | OASIS Research Project First Follow Up 3 months | Dr. Patricia Mechael, Roxana Coscmaciuc, Nadi Nina Kaonga, Bennett Nemser, Heather Cole-Lewis, Dr. Andrew S. Kanter | OASIS Research Project First Follow Up 3 months |
| MVG-Net | MVP | OASIS Research Project Second Follow Up 9 months | Roxana Coscmaciuc, Nadi Nina Kaonga, Bennett Nemser, Heather Cole-Lewis, Dr. Andrew S. Kanter | OASIS Research Project Second Follow Up 9 months |
| MVG-Net | MVP | OASIS Research Project Final Report 15 months | Roxana Coscmaciuc, Nadi Nina Kaonga, Bennett Nemser, Heather Cole-Lewis, Dr. Andrew S. Kanter | OASIS Research Project Final Report 15 months |

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| MVG-Net | MVP | JHC_Final Submission OASISII | Patricia Mechael Co-authors: Bennett Nemser , Roxana Cosmaciuc2, Heather Cole-Lewis2, Seth Ohemeng-Dapaah , Schadrack Dusabe , Nadi Nina Kaonga2, Patricia Namakula , Muhadili Shemsanga , Ryan Burbach2 and Andrew S. Kanter | Capitalizing on the Characteristics of mHealth to Evaluate Its Impact |
| OpenROSA | D-Tree | Dodoma Final Report | Ken Bayona | Report on CommCare and related activities in Dodoma, Tanzania |
| OASIS Core | JEMBI | OpenMRS Enterprise Business Plan | | |
| OASIS Core | JEMBI | OIP-2010 Final Report | Harsha Halgaswatta, Darius Jazayeri, Sy Haas | New UI Prototypes for OpenMRS 2.0 |
| OASIS Core | JEMBI | M-OASIS Report 1April- 30Sept- OASIS | I.Pinto, A.Campione | Mozambique OASIS Node Report for period April to September 2011 |
| OASIS Core | JEMBI | M-OASIS Report 1Oct- 30Dec- OASIS | I.Pinto, A.Campione | Mozambique OASIS Node Report for period October to December 2011 |
| OASIS Core | JEMBI | MOASIS Activity Report, April to December 2010 | I.Pinto, A.Campione | Mozambique OASIS Node Report for period April to December 2010 |
| OASIS Core | JEMBI | OASISZimbabweTechnicalRe portSept2010 | T.Simbini | Zimbabwe OASIS Node Report |
| OASIS Core | JEMBI | OASISZimbabweTechnicalRe portMarch 2011 | T.Simbini | Zimbabwe OASIS Node Report |

| PROJECTS | | | | |
|-------------------|---------------------------|--|--------------------|---|
| Project(s) | Partner(s) | Project Name | Partners | Description |
| OpenROSA | D-tree, Dimagi, UW | OpenROSA Xform specification and documentation | D-tree, Dimagi, UW | Standardization among mHealth projects, improved links to other eHealth systems. Accomplished by documenting OpenROSA XForms specification, creating robust link between JavaROSA and OpenMRS, and software development on OpenROSA API. |
| OpenROSA | D-tree, Dimagi, UW | OpenROSA OpenMRS Integration | D-tree, Dimagi, UW | Supported OpenMRS-jr (pronounced OpenMRS junior) is a mobile application developed using the JavaRosa platform. In |
| OpenROSA | D-tree, Dimagi, UW | OpenROSA App Software Development | D-tree, Dimagi, UW | Extensive work done on the core CommCare platform by Dimagi, including the ability to include multimedia (audio clips and images) to improve client experience. |
| OpenROSA | D-tree, Dimagi, UW, ITIDO | CommCare research site in Dodoma, Tanzania | D-tree, Dimagi, UW | Supported research site in Dodoma, Tanzania for about 2 years. This was a collaborative effort between Dimagi, The University of Washington's computer science department and later on came The Invention and Technological Ideas Development Organization (ITIDO). A total of 50 Community Health Volunteers (CHVs) each serving about 100 clients in the areas of Chamwino, Miyuji and Ipagala were trained on the use of CommCare. |
| OpenROSA | D-tree, Dimagi, UW | SMS Reminder study with CommCare in Tanzania | D-tree, Dimagi, UW | Evaluated the impact of SMS reminders to improve the promptness of routine CHW visits. |
| OpenROSA | D-tree, Dimagi, UW | Coded in Country Internships | D-tree, Dimagi, UW | Supported 3 mature organizations to mentor junior development shops to build mHealth/eHealth software |

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| OASIS core | JEMBI | HIS-Integration | Cell-Life | Jembi led the integration of several health information system components, including OpenMRS, the District Health information System (DHIS), an HIV dispensary management application (iDart) and an HIV drug resistance prediction application (RegaDB). |
| OASIS core | JEMBI | SDMX-Integration | WHO | Partnered with World Health Organization (WHO) to develop the core Java libraries for SDMX-HD (Statistical Data and Metadata Exchange – Health Domain), an open standard for aggregated data, and used this to integrate data between OpenMRS and TracNET, an application used for compiling aggregate data in Rwanda. |
| OASIS core | JEMBI | Tshwane District Hospital | WHO | Design and development of an OpenMRS based implementation for the Tshwane (Pretoria) District Hospital HIV/VCT clinic. The work in this project produced the proof of concept HL7 based Pharmacy interoperability module used to connect OpenMRS and iDart (an Open Source Pharmacy Solution). The project played a valuable role in the introduction of the Jembi Health Systems technical team to the constraints of working within a medical environment and in a low resource setting. The team was exposed to the challenges of training end users and the real world practicalities of installing an electronic solution in a clinic. |
| OASIS core | JEMBI | OCC-Open Concept Collaborative | WHO | Completing development of the OCC server and module (with particular WHO work items) to allow OpenMRS to export and import concepts from the OCC server. The server should act as a repository for large stable concept dictionaries to allow for easier concept sharing between sites. |

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| OASIS core | JEMBI | PIH Pharmacy Module | Partners In Health | Development of an OpenMRS Dispensing Module that enables pharmacy dispensing transactions to be recorded and exported via an HL7 stream to any external pharmacy system. This project was seen as an opportunity to build capacity and extend our developer network in Zimbabwe. Wayne Naidoo travelled to Harare in January 2011 where he spent 5 days training six developers in and initiating the project work. Most of the coding work was carried out by the CEPHI team in Zimbabwe and was managed and mentored remotely by the technical lead. |
| OASIS core | JEMBI | SDMX-Integration | OpenMRS | Development of a OpenMRS module that allow the OpenMRS reporting module to export reports in a standardised format: SDMX-HD |
| OASIS core | JEMBI | JCMG-IPA | | The Johannesburg City Medical Group Independent Practice Association (JCMG-IPA) project was Jembi's first non-donor project for a local South African group. The project focused on the implementation of a centralized OpenMRS solution allowing practitioners to access a particular patient virtually and monitor them in accordance to the program they were enrolled in (typically: Vaccinations or VCT). |
| OASIS core | JEMBI | PIH Malawi Reporting | PIH | Jembi was contracted by the Partners In Health team to assist and develop data quality reports for the PIH Malawi implementation. |
| OASIS core | JEMBI | MSF Pilot Showcase | Medecins Sans Frontiers | Developed a rapid OpenMRS pilot application to showcase the possibility of OpenMRS meeting the needs of the MSF future planned implementations. |

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| OASIS core | JEMBI | eKapa Review | | The eKapa solution is a local (South African) software application designed to manage ART in South Africa. Jembi was requested to perform a system and software review with particular focus at proposing and its viability that included the replacement of the existing Oracle based database in eKapa with an OpenMRS based solution. |
| OASIS core | JEMBI | REACH MedInfo Demonstration | Mohawk College | The Research Enterprise Architecture for Health Care Laboratory (REACH) project is one of the foundational projects within Jembi Health Systems technical team. The team translated an implementation of an EA design, housed at Mohawk College, to meet the use cases of a low resource setting. |
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| Open Architecture | JEMBI | RHEA (Rwanda Health Enterprise Architecture) | PEPFAR (HI-PPP), Rockefeller Foundation, IDRC | The Rwandan Health Enterprise Architecture project is a large research and technical implementation project focused at the design and implementation of Enterprise Architecture based solution for Maternal and Antenatal Care in Rwanda. The Jembi team has been involved in the scoping, design, technology review and implementation of the project. |
| OASIS core | JEMBI | Technical Assistance & Mentoring | InSTEDD, Safe Blood for Africa, MVP | Jembi has been invited to provide technical assistance and staff mentoring and or training on a range of occasions:- Cameroon Implementation Technical Assistance in the implementation of OpenMRS; InSTEDD iLAB Cambodia introduction and training of staff on OpenMRS; Blood-Bank System Review: a review of the Malawian Blood Bank Software system for a NGO Safe Blood For Africa in the light of scoping a larger open source blood bank software project; Jembi mentored an MVP developer in Rwanda as they became familiar with OpenMRS. |

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| Open Architecture | JEMBI | HEAF (Health Enterprise Architecture Framework) | Rockefeller Foundation, IDRC | To design a health enterprise architecture framework (HEAF) that aims to use an enterprise architecture (EA) approach to document and model the artefacts from the implementation projects to improve representation and reuse of the artefacts and also to generalize in a way that extracts general principles and improves reuse. |
| Open Architecture | JEMBI | HEART (Health Enterprise Architecture Repository of Tools) | OHT | HEART is a health IT asset registry and repository to facilitate and accelerate affordable and sustainable health information implementations by making them more discoverable, more accessible, and more useful than they are today. |
| OASIS core | JEMBI | OpenAMS (Athlete Monitoring System) | Sports Science Institute of South Arica | Development of a system to improve SSISA-High Performance Centre's athlete training information management services |
| OASIS Core | JEMBI | HEAL - Masters Project | IDRC, UKZN | Design and research an architecture for interoperability of many disparate health systems in a National Health Information System. The end result should be a software product and a thesis on how the design took places and what considerations were made to support the design. |
| OASIS Core | JEMBI | HEAL - Masters Project | IDRC, UKZN | This project aims to develop a general framework for a Decision Support System (DSS) component within a Health Enterprise Architecture for low-resource settings. The efficacy of the framework will be demonstrated by developing a DSS for HIV treatment failure. This case study will be prototyped, field tested and evaluated. |
| OASIS Core | JEMBI | Mobile Data Collection | KIRT & NICD | To develop a solution for the collection of aggregated data (aggregated prior to entry into system) via a mobile phone for a project based in the Bushbuck Ridge |

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| | | | | area of Mpumalanga. |
| OASIS Core | JEMBI | Birth to Twenty | UWC & UCT | A research team has been following a group of individuals from birth (1990) to the age of 20 / 21 and over the past 2 decades has collected a large dataset. This project aims to find a solution to upload the data and combine it into a single database which could be used for research and querying. |
| Open Architecture | JEMBI | Zimbabwe EA | CDC | To support HITRAC with the technical skills, tools and implementation expertise needed to develop and enhance health information systems and to support the development of the Enterprise Architecture Data Model for HRIS and Health Information System integration. |
| OASIS core | JEMBI-MOASIS | MOVE_IT, national mortality system SIS-ROH 1.0/2.0 | HMN,WHO | The project's overall goal is to improve the coverage and the quality of the national mortality system of Mozambique, and support the national vital statistic. |
| OASIS core | JEMBI-MOASIS | SESP | CDC, OASIS | The aim of SESP is to define National policy, rules and procedures for individual patient record systems and develop Mozambique MOH's own SESP application/system. |
| OASIS core | JEMBI-MOASIS | Maintenance and development of the MODULO-BASICO (MB) | CDC, OASIS | The main aim is to execute any necessary emergency maintenance and corrections including automated integration of some forms resulted from the current review of SIS in the official application. |
| OASIS core | JEMBI-MOASIS | NEW MODULO-BASICO: SIS-MA | CDC, OASIS | Management of the development of the new Modulo-Basico |

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| OASIS core | JEMBI-MOASIS | EA | CDC, OASIS | The overall aim is to provide the MOH with an contextualized Health Enterprise Architecture |
| OASIS core | JEMBI-MOASIS | SIS-H | CDC, OASIS | SIS-H consists of Implementation of a Hospital Information System (System of Hospitalization Data Aggregation), and the aim of the project is to develop and implement a system for data aggregation on hospital admissions. |
| OASIS core | JEMBI-MOASIS | SIS-HCM: Phase I | CDC, OASIS | SIS-HCM is the new information system for the Maputo Central Hospital. The Phase I includes the conception and design of detailed Terms of Reference. |
| OASIS core | JEMBI-MOASIS | IIESS (Inventory of Infrastructure of Health Services) | CDC, OASIS | IIESS refers to Maintenance and Dissemination of the Register of Infrastructure, Equipment and Health Services (formerly known as SAM). The system provides data of Infrastructure, Equipment and Services in the NHS through, a new module incorporate in the Modulo-Basico. |
| OASIS core | JEMBI-MOASIS | National Health Repository (Data Warehouse) | CDC, OASIS | The project aims at developing a National Health Repository (Data warehouse). Moasis' role was to support the MOH on the design, implementation, maintenance and management of a health data registry (National Repository/Data warehouse) integrated into the overall project design of overall architecture of e-Health. |

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| OASIS core | JEMBI-MOASIS | Database of NGO Reports | CDC, OASIS | Project that provides support from MOH to MOASIS, on answer the technical questions with the company (MzBusiness) responsible for developing and implementing a technological solution (Database) for registration and management of activities undertaken by their partners in cooperation with the Health Sector across the country replacing the mechanism for submission of reports on paper so far used |
| OASIS core | JEMBI-MOASIS | Moasis Web page | CDC, OASIS | Project's aim is to improve, renovate and maintain MOASIS web page, which will be used as an instrument for disseminating MOASIS activities, sharing experiences and successful results. |
| OASIS core | JEMBI-MOASIS | SIS-COLERA | CDC, OASIS | SIS-COLERA consists of Development and implementation of epidemiological surveillance system for cholera outbreaks. The project's aim is to develop and implement an easy to use application for cholera outbreak epidemiological surveillance in Mozambique providing daily data. |
| OASIS core | JEMBI-MOASIS | Maintenance and management of the Mozambican MOH Website | CDC, OASIS | Rehabilitation project for maintenance and emergency management of MOH website, and preparation of project proposal for its revision and modernization |
| OASIS core | JEMBI-MOASIS | Review of SIS instruments, tools and manuals | CDC, OASIS | Aim of the project is to provide technical grants to the MOH to revise and update the Manual and Guides containing rule and update forms for HIS |
| OASIS core | JEMBI-MOASIS | Arquitectura do SIS | Mozambique MoH | DESENVOLVIMENMTO DO QUADRO GERAL DO PROJECTO (ex e-Health ARQUITECTURE) (SIS-Enterprise Architecture PROJECT FRAMEWORK DEVELOPMENT) [ex e-HEALTH ARCHITECTURE] |
| OASIS core | CEPHI | HRH system for | | The Zimbabwe Team (CEPHI) have developed and |

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| | | health care workers | | deployed a "Human Resources for Health" (HRH) system for health care workers in various health facilities in Zimbabwe. |
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| COMMUNICATION | | | |
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| Project(s) | Partner(s) | Output | Description |
| OASIS Core | JEMBI | OASIS website | http://sites.google.com/site/oasisopenarch/ |
| OASIS Core | JEMBI | OASIS newsletter | OASIS newsletter - |
| OASIS Core | JEMBI, MVP, CEPHI, | OASIS Communication Strategy draft document | OASIS Communication Strategy draft document |

| GRANTS | | | | | | | | |
|-------------------|-------------------|---|---------------------------------|--------------|-------------|------------------------|----------------------|---------------|
| Project(s) | Partner(s) | Name | Type | Prime | Role | Contractor | Country | Status |
| Open Architecture | JEMBI | OpenArchitectures | Research Grant | JEMBI | Prime | Rockefeller Foundation | South Africa, Rwanda | Completed |
| OASIS core | JEMBI-MOASIS | Strengthening Health information Systems Implementation, Capacity and Infrastructure in the Republic of | Cooperative Agreement: PS002815 | JEMBI-MOASIS | Prime | CDC | Mozambique | In Progress |

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| | | Mozambique under the President's Emergency Plan for AiDS relief (PEPFAR) | | | | | | |
| OASIS core | JEMBI-MOASIS | MoVE-IT | Contract | JEMBI-MOASIS | Prime | WHO-HMN | Mozambique | In Progress |
| Open Architecture | JEMBI | HI-PPP | Subcontract | CDC | Partner | PEPFAR, CDC, Cardno | South Africa, Rwanda, Mozambique, Zimbabwe | In Progress |
| Open Architecture | JEMBI | Research into Enterprise Architecture for Coordinating Healthcare | Research Grant | ecGroup | Contract or | IDRC | South Africa | Completed |
| | | Health Enterprise Architecture Laboratory (HEAL) | | UKZN | Partner | Rockefeller Foundation, IDRC | South Africa | In Progress |
| Open Architecture | JEMBI, Rwanda | Health Enterprise Architecture Repository of Tools (HEART) | Subcontract | OHT | Contract or | Rockefeller Foundation | South Africa, Rwanda | In Progress |
| OASIS core | JEMBI-MOASIS | Operations Research (Implementation Science) for Strengthening Program Implementation | Research Grant | JEMBI-MOASIS | Prime | CDC | Mozambique | Applied |

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| | | through the President's Emergency Plan for AIDS Relief (PEPFAR) | | | | | | |
| OASIS core | JEMBI-MOASIS | | | JEMBI-MOASIS | Prime | USAID | Mozambique | Applied |
| MVG-Net | MVP | Columbia Global eHealth Program/Columbia International eHealth Lab | Research Grant | DBMI | Prime | Rockefeller Foundation | USA | In Progress |
| MVG-Net | MVP | Ethiopia mHealth Roadmap | Contract | DBMI | Prime | BMGF | USA | In Progress |
| core | JEMBI | General Support Grant | Grant | | Prime | Rockefeller Foundation | South Africa | In Progress |
| | | Organisational Development | Grant | | Prime | IDRC, Twinning Centre | South Africa | In Progress |
| OpenROSA | D-tree, UW, Dimagi | Phone-based tools for Community health workers | Research Grant | UW | | Microsoft Reseach | Tanzania | completed. |
| OpenROSA | D-tree, UW, Dimagi | internal funding from Dimagi | Grant to support Dodoma | Dimagi | | Dimagi | Tanzania | completed (and not sure exactly fits--feel free to ignore) |

10.2 Appendix Two. OASIS II Utilization-Focused Evaluation - Extended Executive Summary

H. Zornetzer¹⁸ and A.M. Loudon¹⁹

April 15, 2012

10.2.1 Introduction and Background: OASIS II Projects and Rationale for UFE

The OASIS II collaboration is unique and challenging in the breadth of the work in different countries in Africa and across different health focus and disease areas, and in the depth of the work supporting health care systems in limited resource settings - from high level national plans (EA) through EMR systems and other tools at health centers and smaller hospitals to mobile phone based tools in small communities. The primary groups involved engaged in a Utilization-Focused Evaluation (UFE) process to help answer their question of, "How well are we leveraging this unique range of expertise?"

The 5 main OASIS II project activities and the 4 main partner roles included:

1. OASIS Core (implemented by Jembi Health Systems, lead by Dr. Chris Seebregts) which has mainly investigated the development of a sustainable model for health systems strengthening by in-country capacity building support for Ministries of Health (MoH). Ongoing research looks at ways of creating and supporting OASIS nodes in multiple countries in Africa (South Africa, Rwanda, Mozambique, and Zimbabwe) with a particular focus on how health information systems are managed at country level;
2. Open Architectures (also implemented by Jembi Health Systems and lead by Dr. Chris Seebregts) which has investigated the concept of using open enterprise architecture to guide the technical Health Information System (HIS) strengthening activities of OASIS, applied in low and middle-income countries;
3. The Millennium Villages Project MVG-Net (implemented by the Millennium Villages Global Network, lead by Dr. Andrew Kanter at Columbia University) which supported the development of MVG-Net and the interoperable multinational, multilingual eHealth infrastructure and research tools. Research is focused on comparing of methods of supporting eHealth interventions across a multinational enterprise, assessment of whether ICT for Health systems have an impact on the Millennium Development Goals (MDGs) and how much compared to other interventions, and assessment of what components are required to operate a common enterprise-wide health information system across multiple countries in multiple languages;
4. OpenROSA / JavaROSA project (implemented by D-Tree International and lead by Dr. Neal Lesh) which focuses on the promotion of a "Coded in Country" (CIC) approach, and identifying what kinds of in-country capacity building efforts related to open source mobile technologies (mHealth) for health work best in different contexts. Likewise, the ROSA project research also looks at how the standardization among mHealth projects can improve links to other eHealth systems. Related to health outcomes directly, the ROSA project has focused efforts on a rigorous assessment of whether CommCare - a specific open source

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mobile technology software for community health worker decision support – can improve community health worker and client behavior;

5. the Rwanda OpenMRS and Informatics Training Program (implemented by Partners in Health, lead by Dr. Hamish Fraser) which seeks to develop and support the longer term institutionalization of a Health Informatics and OpenMRS training programs in Rwanda, graduating students as well as integrating the course into the Kigali Institute of Science and Technology's (KIST) curriculum.

The Utilization-Focused Evaluation (UFE) process was applied in this project, working off of the premise that evaluations should give careful consideration to selecting the most appropriate content and methods for the primary stakeholders and their intended uses of the evaluation findings. For this evaluation, intended uses by the primary project leads were prioritized and all project phases included input and feedback from major stakeholders. Evaluation methods that promoted and facilitated the involvement of the primary project leads - Drs. Chris Seebregts of Jembi, Andrew Kanter of the Millennium Villages Project, Hamish Fraser of Partners in Health, and Neal Lesh of OpenROSA - were applied in order to support the application of the evaluation findings to their work 1) within the respective OASIS II projects, and 2) to identify direction setting steps for possible future collaborative work.

10.2.2 Focus Areas

The goal of the UFE was to engage the primary stakeholders in the evaluation of the OASIS II initiatives to investigate, synthesize, and assess progress and outcomes in 2 primary focus areas related to the collective contribution of the 4 groups during the project period to 1) support eHealth Workforce Strengthening in Africa, and 2) to promote and facilitate interoperability of eHealth technologies. The evaluation also sought to help define the nature of the unique collaboration between the 4 primary groups that gave rise to these contributions.

The general goals related to the eHealth workforce strength focus area were to clearly articulate the greater objectives of OASIS II in building local capacity for eHealth technology development and implementation in Africa and to understand to what end the work through the OASIS II projects reached or approached these objectives. The intended uses of these findings are to motivate and inform capacity building efforts within the larger eHealth community by providing relevant policy-brief format information regarding: 1) "upstream" inputs and activities internal to each group (as well as with important boundary partners for each project) that led to successful local capacity building for developers, implementers and decision makers, and 2) to identify lessons learned during OASIS II projects around both successful and less successful capacity building efforts.

The general goals related to the interoperability focus area were to highlight collaborative efforts that emerged between members for promoting interoperability – from social and professional networking to coordination between groups on data concept exchange to collaboration on the definition and application of open architecture approaches. Two new substantial and complementary efforts included in this evaluation are the Maternal Concept Lab (MCL) project and the general OASIS landscape collaboration in Rwanda. The intended uses of these findings are to inform current and future interoperability efforts in low-resource settings, both led by network members and more generally, and to make a case for continuation of interoperability efforts as projects/systems move towards local ownership, and for the development of new initiatives in under-examined areas.

10.2.3 Methodology: Evaluating action research related to intended uses of results

A team of 2 evaluators and a field research assistant collected both quantitative and qualitative data and synthesize findings to respond to the identified intended uses by the

4 primary project groups over the course of 6 months of research activities. These activities included: in-depth interviews with the 4 primary OASIS II project leads - Drs. Chris Seebregts of Jembi, Andrew Kanter of the Millennium Villages Project, Hamish Fraser of Partners in Health, and Neal Lesh of OpenROSA; interviews and web-based surveys with other key project personnel, relevant stakeholders and project target beneficiaries; field-based observations and focus groups at several key project sites in 4 countries (Rwanda, Mozambique, South Africa and Tanzania); revision of documents and other outputs of the individual projects; and review of online discussions relevant to the OASIS II activities.

The development of descriptive and explanatory case studies was a major research activity of the evaluation. Case studies outlined the context of the projects studied and the importance of contextual factors. Case study write-ups also allowed the application of diverse methods (documentary sources, interviews and web surveys) and diverse informants (training program students, trainers, employers, developers, implementers and funders of interoperability projects) to contribute to a unified set of findings. Given the emphasis in UFE on research products that will be used directly, the use of case studies also helped present the findings in a coherent and applicable way. Data for the case studies was collected primarily during semi-structured interviews. Topic guides for the interviews were developed by the evaluation team, then reviewed and edited by the PIs.

For the eHealth Workforce Strengthening focus area, primary stakeholder input was included from a total of 53 individuals with relatively equal representation across the 4 primary OASIS II projects in Rwanda (MVP, Jembi and PIH stakeholders), Tanzania (MVP and OpenROSA stakeholders), Mozambique and South Africa (Jembi stakeholders). 38 interviews were conducted, including stakeholders representing various roles across the eHealth workforce. In addition, 13 responses to the PIH program trainee web-survey were received (of the 22 trainees invited to participate in the online anonymous questionnaire). A strength of the study is the large number of African interviewees (25 of the 38) for this focus area as well as the wide range of types of stakeholders "captured" with the mixed methods interview process applied here - including funders/donors, researchers, program staff, trainers, trainees, community health workers, representatives of Ministries of Health, and OASIS project partners and collaborators.

For the interoperability focus area, 24 interviews were conducted. Interviewees included people who had been involved in MCL - either as direct contractors or volunteers, or through particular projects where MCL was used - as well as key informants in organizations that might adopt MCL or promote adoption in future. For the case study of OASIS II in Rwanda, a smaller group of interviewees included people who had been involved in specific interoperability projects (SDMX-HD and two dictionary mapping projects, one between the PIH and MVP dictionaries and other mapping Rwanda's maternal health forms to MCL) or who had worked extensively in Rwanda (primarily the PIs). A general weakness of the study is the small number of African interviewees for the interoperability focus area. For the OASIS-Rwanda landscape case study in particular, direct interviews with representatives of Ministry of Health were determined inappropriate for the scope of this evaluation in order not to risk the perception of a conflict of interest for ongoing OASIS II projects.

To comply with international ethical human subjects research standards (and specifically with IDRC's requirements for ethical conduct of human subject research), verbal consent was obtained at the beginning of each interview and interviewees were informed of the purpose of the study and anonymity provisions and given the opportunity to comment off the record if they felt more comfortable doing so. Interview data (recordings, notes and

transcripts) is stored securely using SpiderOak²⁰, a zero-knowledge online backup system, and Dedoose²¹, a HIPAA-compliant online research tool. Only the evaluation team had access to the primary interview data, as many of the interviewees are direct ongoing project partners (or participants in ongoing projects) within the OASIS II project portfolio. All efforts were made by the evaluation team to fairly and accurately represent interviewees' opinions while protecting their identity from other stakeholders in the preparation and publication of this report.

10.2.4 Focus Area I: Interoperability Findings

10.2.4.1 MCL Case Study: work to date and next steps

The Maternal Concept Lab project (MCL) was launched formally in November 2010. The idea was to focus efforts on sharing existing and pipeline tools that were being built for the same clinical protocols (around maternal and child health, specifically obstetric, neonatal and infant health) and with some of the same software components (particularly OpenMRS). "MCL:Core," the maternal health core concepts was an initial component, and additional components were incorporated at later stages since 2010. So far, progress on MCL components includes 1) **MCL:Core** has been established based on the MVP/CIEL dictionary. MVP and PIH have worked together to map the PIH concept dictionary - used in all PIH sites except Malawi - to the MVP dictionary. MoTeCH's tools for health promotion messaging and decision support have been mapped to the MCL:Core concepts, as have several of D-tree's m-Health protocols and, as part of Jembi's work in Rwanda, the Rwandan government's maternal health forms; 2) **MCL:Search** has gone through several development iterations, and was widely recognized in interviews as the best available tool for searching standard concept dictionaries. In addition to searching the MCL core concept list, the search allows users to select results from standard dictionaries (from MVP/CIEL, PIH and AMPATH as well as the OpenMRS default dictionary) and terminology standards (SNOMED, ICD, HL-7 CVX, LOINC etc); 3) **MCL:Mapper** exists as Excel spreadsheets to record the mappings so far. The process and the spreadsheet format are the basis for what this tool set will include eventually; and 4) **MCL:Repository** currently includes a subset of tools - notably D-tree's Android-based maternal health protocols and the forms, the Rwandan MoH maternal health forms and reports and notification messaging settings associated with MoTeCH's planned implementation for CARE in Bihar, have been mapped to the core dictionary.

In addition to material achievements, MCL has provided valuable learning about the process of mapping tools to a common concept dictionary, as well as general lessons about shared concepts as a way to collaborate for reusability. To date, this has been done without dedicated funding and without a formal structure. MCL is actively evolving, and to that end, the results of this evaluation continue to inform that discussion, particularly around issues with the collaborative approach to developing and sustaining MCL (and potential similar efforts in the future), and the fact that there was actually a wide range of interpretations about exactly what MCL is and what its value proposition could be defined as.

The UFE process brought helped to focus a range of issues around concept mapping issues, collaboration issues, models for interoperability and reusability, and roles for funders and decision makers. Seven "next steps" filtered out of the interviews and analysis process, including: 1) **Publicly launch MCL**, probably through a panel at a high-profile conference, 2) Reinforce the concept lab model by **expanding to another health domain**/community of practice, 3) **Get best practices/health standards mapped into the dictionary**, 4) Do **an implementation that proves applicability to**

²⁰ <https://spideroak.com/>

²¹ <http://www.dedoose.com/>

a system other than OpenMRS, 5) Get to a stage where a specific MCL-enabled tool being used by several groups in the field, 6) Develop a comparison tool which allows you to map a tool in to the dictionary, and produce and automated comparison to (for example) WHO guidelines, and 7) **Develop a concept mapping tool** with a lower barrier to entry than the current process.

In addition to tools - a significant contribution in their own right - MCL should consider providing formal guidance on the concept mapping process. Concept mapping is non-trivial, and part of the 'infrastructure' for reusability may be providing knowledge services, including advice (on a mailing list for public conversations, or over Skype) as well as documentation and/or training. Finally, the value proposition of MCL is highly dependent on a critical mass of adoption - it needs to "gain traction", as one interviewee said. Without this, it is considerably less attractive both groups developing new systems and those who might switch existing systems to use MCL. Next steps should be decided with this in mind.

10.2.4.2 OASIS II Rwanda Case Study: a unique example of interoperability work

PIH, MVP and Jembi have distinct eHealth projects in Rwanda, between them covering roughly 10% of the country's approximately 450 primary care facilities. In addition, but not included in this evaluation, the MoH is currently rolling out their own version of OpenMRS for primary care, based on the PIH version with some additional modules. Many of the MoH developers have been through PIH's 11-month postgraduate program, and have gained hands-on experience developing OpenMRS modules as a result. The MoH rollout intends to reach between 120 and 150 additional sites over the next two years.

Despite differences in approach, maturity and scale, all three groups have basic components in common - specifically all three groups are working actively with the OpenMRS platform, as well as with RapidSMS (also being rolled out by the Rwandan MoH), and all three groups have plans to use the SDMX-HD OpenMRS module. In addition, all three have taken steps towards semantic interoperability for their maternal health data. PIH has mapped their concept dictionary to the MVP/CIEL dictionary, which forms the basis of the Maternal Concept Lab, MCL, and Jembi has done the same with the Rwanda MoH maternal health forms prior to their implementation. The table below summarizes the PIH, MVP and Jembi eHealth implementations in Rwanda under the OASIS, OASIS II and other projects.

| | PIH | MVP | Jembi |
|----------------|--|---|--|
| Context | PIH has been working in Rwanda since 2005. Their focus is on health systems strengthening in partnership with the MoH. There are currently 25 PIH-supported health facility sites in operation, with plans to have around 30 by the end of 2011. | MVP has one village site in Rwanda, out of a total of 14 sites in several African countries. The overarching goal of the program is "the coordinated delivery of a package of scientifically-proven health and development interventions which are aimed at accelerating progress towards | Jembi's implementation of RHEA, the Rwanda Health Enterprise Architecture, will begin in late 2011. The pilot implementation focuses on maternal health in 12 health facility sites within a single district |

| | | | |
|-------------------------|---|---|--|
| | | achieving MDG targets” | |
| Systems | PIH’s primary system is a customized OpenMRS distribution with additional modules, some of which the Rwanda version has in common with PIH sites in other countries. | The full MVP system ‘stack’ includes: <ul style="list-style-type: none"> - Childcount+, a RapidSMS-based data collection application for community health workers or CommCare, a J2ME or Android-based community health worker application - Customized OpenMRS for clinic-based data collection - Aggregate reporting to MVIS for project-wide statistics - ODK for Verbal Autopsy and vital event recording - Data warehousing using I2B2 and Pentaho (open source application suites) | Jembi’s implementation is intended as a pilot of a multi-level enterprise architecture, including OpenMRS at clinic level and communication with provider, client and facility registries and shared health record provided by ezVida, the enterprise system chosen by the Rwanda MoH. |
| Interoperability | PIH is in the process of implementing the OpenMRS SDMX-HD module to provide reporting of aggregate statistics from OpenMRS to TracNet, Voxiva’s HIV statistics system | MVP is planning to use SDMX-HD to connect to DHIS2, the District Health Information system. MVP also takes advantage of reference terminology maps to provide comprehensive reporting to MOH and international entities. | Jembi’s work on enterprise architectures defines standards for diverse systems to communicate and provides infrastructure to facilitate this. Jembi also developed the SDMX-HD module for OpenMRS on contract to PIH. |
| Status | PIH’s OpenMRS implementations are well established. SDMX-HD integration is nearly complete, pending Voxiva implementing data | OpenMRS, MVIS and Pentaho (basic ETL) are implemented; SDMX-HD link to DHIS is not. Childcount+ in Rwanda is interoperable with OpenMRS, but needs | Initial integration between OpenMRS and ezVida is beginning, with the intent to implement on the ground by late 2011. |

| | | | |
|--|------------------------|-----------------------------------|--|
| | consumption in TracNet | migration to MOH-approved system. | |
|--|------------------------|-----------------------------------|--|

Several major early lessons captured in this UFE are notable, summarized here from the analysis of interview data: 1) **Interoperability takes time, a significant proportion of which goes to building relationships and negotiating roles**; 2) **Communities of practice provide a foundation for interoperability** - whether organized around tools (e.g. OpenMRS), or research questions and implementation goals (OASIS, OASIS II, RHEIN, RHEA), communities of practice build relationships and support the development of best practices that can be codified into common standards; 3) **Standards and architecture processes must be locally led** by people that are willing and able to take projects on, and try and grow in small steps; 4) **Standards aren't prioritized without incentives and enforcement** - the PIH SDMx-HD link to TracNet is not yet implemented in part because of lack of prioritization by Voxiva. The MoH has begun to provide enforcement, but their needs to be more thinking about incentives for interoperability work by private companies. MCL, on the other hand, has no enforcement but clear reusability incentives, at least for OpenMRS users; 5) **For interoperability to be prioritized, other parts of the implementation need to be working well**, and 6) **Design for unreliable Internet connectivity** - Enterprise architectures that use a web services model need to be modified to deal with low connectivity environments.

One major conclusion articulated in this case study, although seemingly obvious, is that interoperability can and must be approached at many levels, from data sharing between systems to standards setting and architecture provisions for national health systems. In Rwanda, the MoH has largely been able to sustain conversations between different projects, and has bridged the different levels by communicating an emerging blueprint for eHealth in the country. Structures such as the weekly eHealth meetings and the publication of an eHealth strategy are critical to continue to support, and these could be usefully adopted by other countries wanting to promote interoperability.

Second, support for communities of practice - both within and between countries - can create a conducive environment for interoperability. By developing relationships and awareness of the history of implementations and lessons learned, communities of practice overcome some of the organizational barriers to interoperability. Shared, reusable tools can similarly contribute to overcoming technical barriers. Nevertheless, additional incentives may be required to convert ideas into implementation. Both donors and governments can provide incentives by requiring compliance with standards and reuse where feasible, and by being willing to pay for dedicated work on interoperability.

10.2.5 Focus Area II: eHealth Workforce Strengthening Critical Factors

All 4 principal groups involved in the implementation of OASIS II projects are committed to and have worked on the issue of local capacity building and eHealth workforce strengthening in East Africa. Each group has a different focus, approach and scope to operationalizing capacity building efforts. Primary stakeholder input was included from a total of 53 individuals with relatively equal representation across the 4 primary OASIS II projects in 4 countries: Rwanda (MVP, Jembi and PIH stakeholders), Tanzania (MVP and OpenROSA stakeholders), Mozambique and South Africa (Jembi stakeholders). 38 in depth interviews were conducted, including stakeholders representing various roles across the eHealth workforce. 3 separate focus group interviews were carried out in person, 1 with CHWs in the Dodoma, Tanzania DTree/OpenROSA project site, 1 with MVP data clerks at the Nyamata, Rwanda MVP site, and 1 with MOASIS developers in the Jembi project site in Maputo, Mozambique.

10.2.5.1 PIH

PIH focused on developing and institutionalizing **a formal training program in software development** for the OpenMRS platform in Kigali, Rwanda that included a heavy emphasis on classroom and hand-on programming skills curricula, and a basic introduction to health informatics. The formal part of PIH's OASIS II eHealth workforce strengthening project work is focused on a training program, *E-Health: Software Development and Implementation* (EHSDI), in Kigali, Rwanda, for Rwandan programmers to learn advanced Web and Java programming techniques, OpenMRS programming and the basics of medical informatics. 2011/2012 was the 3rd year of the course being offered in a collaboration with the eHealth Center at the Kigali Institute of Science and Technology (KIST). The training program curriculum, developed and refined by a collaborative team at PIH, Harvard, and with input from the OpenMRS core developer community around the world, is divided into two stages – functionally an instruction/training stage (7 months), followed by a hands-on production stage (2 months). The training stage goals are 2-fold, 1) to teach junior-level programmers the required technologies for OpenMRS development, and 2) provide a basic introduction to medical informatics. The production stage requires the students to develop “production quality” modules for OpenMRS per the needs of the Rwandan MoH (and other partners). For developer skills training, both stages include several weeks of teaching, followed by a written exam and a relevant student project component. Background in medical informatics is taught throughout the course based on weekly lectures or presentations on a range of topics. Full curriculum information and course content materials can be found on the OpenMRS wiki²². The informal part of PIH's OASIS II eHealth workforce strengthening project work is the collaboration with other OASIS II members around capacity building in general and training in particular for data managers and users, as well as supporting technical areas like data management and reporting. For example, PIH led the OpenMRS trainings at the OpenMRS meeting in Cape Town (2010) where participants from all over the continent (and other regions) were able to benefit from the OASIS II funded training program process, results and products. In addition to intensive workshops and short term trainings and capacity building efforts, an important outcome of the EHSDI program is the employment of a graduate from the course by Jembi and MVP in 2011. This represents a success in terms of contributing to the size and quality of the eHealth workforce available in Rwanda.

At this point, 34 African trainees have gone through the PIH EHSDI OpenMRS-focused program. Critical factors identified in the UFE related to the content and impact of the training program include the fact that of the 5 content areas included in the curriculum, the programming focus was the initial priority and was the only one that the trainees felt was addressed in depth. **All trainee respondents to the web survey and all related interviewees commented on how helpful and relevant the OpenMRS programming component is, however that that more time and emphasis was needed on the other 4 areas** - Data Management, Project Management, Basics of Health Informatics, and other Professional Development skills. This was impressive to the evaluation team in its consistency, however not surprising based on the evolution of transition to more fully developed local capacity within the MoH and local collaborators around OpenMRS planning and implementation at the national level. The evaluation team's specific recommendation for PIH and/or KIST partners going forward is to reevaluate the curriculum to focus on either 1) adding a “level II” course that addresses the context issues related to OpenMRS implementation (addressing the other 4 content areas), and/or 2) shift the balance of the current curriculum to include more equal attention to those other components. Based on feedback about format, scope and necessary resources for the program, it may be unrealistic to assume that one course

²² <https://wiki.openmrs.org/display/RES/EHSDI+Training+Course>

can address all 5 necessary context and content information to prepare OpenMRS programmers *and* implementation support personnel (which by default is a combination trainee profile to some extent at present).

As the program itself is being transferred to the KIST entity in order to be more formally institutionalized into the Rwandan university system, the expectation is that this will help more clearly anchor the program at a local level. **The lack of a recognizable, respected form of accreditation was cited by almost all trainees and interview respondents as a significant barrier to more formal institutionalization of the training program.** Converting to a fee based degree program will raise the bar on university education and computer science and will significantly contribute to strengthening the health informatics sector as it's own unique interdisciplinary field within Rwanda's rapidly growing health and informatics communities.

10.2.5.2 MVP

MGV-Net is designed as a comprehensive open source electronic health service delivery platform to function at MVP sites where health services are provided. MVP currently has nearly 180,000 patients (46,000 under 5 year olds, 87,000 15-49 year olds) and nearly 320,000 encounters recorded in the four OASIS databases. The MGV-Net also ideally generates data that can be used to track progress and inform decision-making and management throughout MVPs health intervention strategies. While leveraging both computer and mobile technology based applications that provide support at the point-of-care for community health workers (CHWs) and facility-based staff, MGV-Net ideally enables facility-based data capture of individual-level information, community-based data capture of individual-level information, data storage of individual patient health records, and provides an automated mechanism for aggregating data and generating reports and feedback to healthcare providers and managers.

Related to the capacity building focus area, the MVP / MGV-Net group met this challenge in this project period via **semi-formal workshops and on-the-job training** for the various primary users of the version of OpenMRS being implemented in the MVP sites (in addition to other tools, including the mobile tool Child Count+ which interfaces with OpenMRS). In addition to intensive training for a few individual programmers and data managers through the PIH training program in Rwanda (mentioned above), various degrees of continuing capacity building trainings for data entry staff as well as clinical care providers were designed as part of the MVP workforce strengthening approach in several sites in East Africa (although only Tanzania and Rwanda sites were included in this evaluation).

The evaluation team was able to visit the MVP sites in both Mbola, Tanzania and Myange, Rwanda and interview data is included in the analysis from a wide range of stakeholders – from data clerks to data managers, eHealth specialists with data management and technical support responsibilities, and site coordinators. **A major strength mentioned by the data clerks and eHealth specialists interviewed was related to the perceived increase in job and continuing education opportunities available to them to engage at a local level with an international community** (both through OpenMRS and MVP's networks themselves).

There were some common challenges and gaps identified across the interview responses. To summarize, **more human resources are needed to help cover the large implementations rolling out.** The few specialists that exist related to specific tools (OpenMRS and ChildCount+ are stretched very thin in terms of their work responsibilities. **In addition, nurses and clinicians who were envisioned to be primary users of eHealth and mHealth tools were not adequately trained in their use or incentivized to do so reliably in both sites.** This has resulted in the perception by the interviewees of patchy use of the systems by the appropriate end users and a disproportionate responsibility falling on the technical support staff to both promote the use of OpenMRS and mobile tools as well as actually engage the users for

data entry and data management. Compounding this, a simultaneous strength and weakness of the job training approach by MVP was to recruit, support and hire recent computer science university graduates to be primary OpenMRS and IT support personnel. This was a benefit as these individuals tended to be young, actively interested in learning about new technologies and their application in the field of health, and excited to take on new responsibilities within the MVP projects. However in some cases proved a liability in terms of hiring a cohort that had little (if any) project management experience and very little (if any) health sector training. **This finding reinforced the lesson learned mentioned above in the PIH training program section that topics beyond programming are critical to include in preparing an eHealth workforce that, at least for now, must be able to cover a range of support issues related to health services work flow and information flow.**

Additional critical factors to challenges identified at a MVP-wide level had to do with the perceived compartmentalization of eHealth tools as only part of the MVP and Columbia research projects and not really “owned” by MoH or local clinic staff in any way (in both Tanzania and Rwanda sites at least). **At the clinic level, nurses had been treating the eHealth program, especially OpenMRS, as a threat, and not as something that could/should facilitate their work flow.** This had to do with major hurdles in the first few years of the MVP eHealth platform implementations where the MoH and MVP in Rwanda were essentially duplicating efforts in terms of data collection and reporting. Nurses have the historical experience of being tasked with a double workload when it came to information collection and management since they were required to continue to manage paper form systems for the MoH while at the same time transitioning to OpenMRS. There was very little buy in early on (or incentives) by the nurses to support the eHealth implementation. Over the course of the OASIS II project period some of these problems were solved at the political level between the MVP project teams and the MoH in terms of harmonizing reporting tools, however there was a general consensus among interview respondents at the local level that nurses were still not adequately trained in OpenMRS use or maintenance and perhaps more importantly, the nurses – potential primary users of OpenMRS system outputs – were not really able to articulate if and how the eHealth tool implementations could improve information use, access, etc. **In short, buy-in was still somewhat minimal on the part of several important primary user groups and high-level management and long term sustainability of the MVG-Net was doubted by several key interviewees because of this.**

10.2.5.3 OpenROSA

The OpenROSA/D-Tree project was unique in the mix of the 4 OASIS II project partners in that it focused on **field-based primary eHealth tool user training** (rather than MoH centralized human resource training) in one implementation site in Dodoma, Tanzania where CHWs and their supervisors and site directors were trained in the implementation of CommCare – an application for use on mobile phones to support work performance for CHWs - for community based work in maternal and child health. OpenROSA also employed the **“Coded In Country” (CIC) model of using local software developers in Tanzania to work on the site-specific version** of CommCare being used in Dodoma. These two complementary approaches were intended to cover the process of implementing an mHealth project in Dodoma throughout the design-development-modification-implementation-monitoring-maintenance lifecycle.

Key interviews were conducted with developers and project staff at D-Tree and Dimagi (the group on the back end of the core CommCare application development). In addition, a focus group was conducted with CHWs and their supervisors in Dodoma by the evaluation team. The summary results indicate that focusing on community level end users (and the support staff at several levels necessary to manage the overall project) was incredibly empowering for the CHWs themselves as well as their supervisors, in terms of initiating local interest in and ability to maintain community focused health projects, which in this case happen to have an “mHealth” component. The complement to

the community based capacity building on project management, information collection and basically critical thinking skills around project problem solving was complemented by a more directed technology capacity building focus with ITIDO, a Tanzanian NGO, that was supported in part by the OpenROSA OASIS II project. Via directed trainings on CommCare module development and adaptation and via remote support from Dimagi and other JAVARosa community computer programmers, ITIDO was reasonably able to provide the local technology support necessary for the Dodoma implementation.

Several critical elements were identified across the interviews and focus group results, including the importance of individual “champions” of maintaining momentum around local ownership over the CommCare CHW project. In addition, the flexibility that the OpenROSA group afforded “slow down” and allow real local empowerment to be a primary focus of the project (when not necessarily linked to health outcomes or technology development goals) was key to leaving local partners feeling like they were engaged, involved and leading project directions by the end of the OASIS II project period.

10.2.5.4 Jembi

Jembi Health Systems has focused their efforts on **developing and supporting in-country eHealth specialist ‘nodes’ in several countries in collaboration with a local university partner to directly support the Ministry of Health (MoH)**. Four nodes have been developed to date – 1) Jembi Health Systems and the School of Computer Science at the University of KwaZulu-Natal (UKZN-SCS) in South Africa, 2) The Rwanda Health Enterprise Architecture (RHEA) project, 3) The Mozambique Open Architectures, Standards and Information Systems (MOASIS) project and the University of Eduardo Mondlane (UEM) in Mozambique, and 4) The Center for Public Health Interventions (CEPHI) and the University of Zimbabwe. Full implementation is underway in Mozambique (MOASIS) and South Africa. The goal is that this model will strengthen the eHealth capacity of the MoH and by extension the national eHealth landscape. The MoH in both countries have generally struggled to retain skilled computer and information systems staff. Related, Jembi also focuses on the Health Enterprise Architecture Framework (HEAF) model to consolidate implementation experiences and ‘patterns’ into a methodology and set of artifacts that can be used to assist in generating country-specific architectures and promote reuse.

Jembi’s approach is unique both its’ scope (national level from the get go) and its’ niche in many ways. Rather than try to support MoH internal capacity building or establish temporary completely external outside support from a non-national entity (international business, contractor or NGO), Jembi works with local partners (universities and local research groups) to establish a specialized provider for MoH eHealth development and implementation services. Several key interviews shed light on the critical upstream factors that have led to Jembi’s success so far in both providing implementation support to the respective MoH while at the same time attracting significant project and system level donor funding for eHealth system strengthening. **Strong relationships** with experts in the health information system space in each country (whether nationals or expatriates), **strong interest on the part of the MoH counterparts** with clear definitions of roles of collaborating partners (who does what and with what funding/support), and **political agreements that document those relationships and protect developing programs and projects** through personnel changes in the MoH. The later was specifically identified by respondents as a key factor in maintaining forward momentum and proving for institutional memory of advances made in MoH eHealth systems progress milestones, even when MoH personnel changed one or several times over the course of a project phase. Finally, several interviewees, both internal and external to the Jembi team, mentioned that the “back to basics” approach by the OASIS node teams in both South Africa and Mozambique was a critical success factor so far.

This is to say that when identifying capacity building and training targets within the OASIS node teams and MoH partners, often beginning with an orientation of the most basic health system work flows, basic information system management principals (including data management fundamentals) etc. for teams of technology implementers and their MoH end user counterparts was key. The comment was echoed several times by respondents that in part Jembi's success with their increasing capacity at the local nodes to meet the MoH eHealth system support needs is based on not being afraid to tackle the simple problems well, even when donors are pushing for certain eHealth or mHealth elements "of the moment."

10.2.6 Gaps: Suggested future training and capacity building focus topics

1. **More content focus (formally and informally) on the interdisciplinary nature of health informatics.** Essentially technical experts and developers need to understand more about health care services, work flows and information flows (including data management and decision making contexts) in order to be able to fully engage in a support capacity for improving health service provision. Likewise, health care services providers – from MoH decision makers to doctors, nurses and community health workers – need to have a basic understanding of what the ICT tools and eHealth solutions landscape looks like (and where it's headed) in order to more fully engage as informed end-users of these tools throughout the design, development, adaptation and modification processes of eHealth system introduction and use in Africa;
2. **More project management, professional development skills and agile problem solving approaches to eHealth tool / system use and maintenance.** Respondents to interviews across all four projects consistently referred to a lack of codified focus on problem solving skills in local East and Southern African education systems (and universities and computer science programs in particular). Several key interviewees directly referred to how most of the eHealth and mHealth efforts (theirs respectively included) don't put enough time into capacity building in general and in specifically promoting and cultivating critical thinking on the parts of their trainees or project participants. Resources are not necessarily the bottleneck at this point in most projects - there are enough computers and cell phones available in all 4 project contexts that health informatics training programs as well as less formal capacity building efforts should focus more on shifting mentalities towards more adaptive, agile problem solving in basic eHealth intervention design, development and maintenance.
3. **Target both top down and bottom up capacity building efforts to include decision makers, implementers and programmers at upstream and end-user points.** Without all three kinds of stakeholders involved in actual implementations at scale (both as indirect support teams and at the clinic or field worker level), there is limited sustainability, regardless of funding available and local health priorities.

10.2.7 Output Utilization Plan

In addition to the UFE findings hopefully being useful for 1) each core project group to reflect on relative to their particular next steps with ongoing initiatives, and 2) to share with local collaborators and partners, one of the specific intended uses of this UFE's findings was to generate data, analysis methodologies and results for discreet peer reviewed publications in the ICT4D, eHealth, and health system strengthening literature.

In identifying unique and concrete components of the OASIS projects to target for publications, it is important to keep in mind that the OASIS projects for the most part are action research and reporting on action research is different than more traditional health intervention research and information systems research. Three points are important to keep in mind:

- This kind of research does not lend itself to hypothesis testing because the shape the research takes is emergent rather than prearranged form (start with outcomes and work backwards to tease out key factors).
- The majority of the extant ICT4D and eHealth sector papers are single case studies. With the OASIS projects, there is a unique opportunity to compare across multiple countries and 2 focus areas (in this UFE).
- In addition, in most extant publications, building local capacity and creating interoperability frameworks are two elements that, if mentioned at all, are almost always done as “next steps” or “future directions” rather than being the subject of existing interventions – the OASIS projects are innovative in this way alone.

Following a facilitated brainstorming session with the 4 PIs mid-evaluation (June 2011), the following 3 publications were identified as initial targets for UFE findings utilization, always with the goal of sharing lessons learned with the wider eHealth and ICT4D communities.

1. “Concept paper on the MCL: A new approach to collaborative development of [well architected] maternal health information systems in developing countries”. This paper will focus in large part on policy issues around the processes and methodologies for adopting shared concept dictionaries as an approach to any health domain area where there’s currently a duplication of efforts. Initial journal target for this publication is the *Journal of the American Medical Informatics Association*.
2. “Rwanda Health Enterprise Architecture (RHEA): Lessons learned in the eHealth interoperability landscape in Rwanda”. Telling the Rwanda OASIS interoperability landscape development story, capturing the experiences of the 3 OASIS partners involved there (PIH, MVP and Jembi) and identifying critical factors that may help inform similar national-level eHealth system interoperability decisions and initiatives in other countries. Initial journal target for this publication could be the journal of *Health Affairs* and or the *International Journal of Medical Informatics*.
3. “eHealth workforce strengthening in limited resource settings: approaches across OASIS projects in East and Southern Africa”. Comparing approaches across projects and identifying unique elements as well as common themes, challenges and opportunities. Target journal could be *Health Affairs* or *PLoS Medicine*.

10.3 Appendix Three. System Architectural Framework for Health in Low Resource Settings Summary

The purpose of the Health Enterprise Architecture Framework (HEAF) project is to elaborate approaches that are relevant to the design of health information systems in low resource settings. Our premise is that a system and architectural framework can serve to compile useful tools, methodologies and artifacts into a single format to guide future efforts and promote reuse. This will, in turn, further the use of design techniques to support the design of health information systems in low resource environment. Many health information system projects are underway but few follow a coherent design approach.

10.3.1 Goals

The goals of this project are:

- **To Improve the Use of Design** - We aim to introduce an element of systems analysis and design into the process of building systems that goes beyond narrow, product-centered views and takes into account the wider health system. The result is HIS that are designed to achieve more than just the immediate functional result, e.g. goals such as reuse and interoperability.

- **To Improve Reuse and Reusability** - We aim to improve reusability in order to rescue the wasteful cycle of re-inventing the wheel and also to encourage reflection on design principles that will improve the overall design and application.
- **To Enable Country Ownership** - The design approach will promote country ownership and the ability of countries to influence the systems that are implemented. Developing countries often are characterized by software development efforts servicing narrow needs. There is no incentive and often no infrastructure with which to harmonize these systems. Harmonizing these systems with a national architecture would result in a significant improvement in utility of the systems and improve their overall cost effectiveness.

10.3.2 Architectural Model

It was agreed to use the architectural model proposed in ISO 14639 (currently being detailed in Part 2 of the ISO TR) as the basis for this document. According to the model, an eHealth architecture is composed by different components that are aggregated in key-categories:

- Foundation components – ICT infrastructure which encompasses the core IT technologies as networking, servers, software and IT human resources. In general this is the easiest category to find in any country.
- “Infostructure” – Standards are a key component of the ehealth infostructure and their proper utilization will define how robust and scalable the final application will be.
- Health Process Domain Components – this category contains the different health domains that should be present in a national eHealth strategy.
- Governance and National Ownership – this is the most important category of the eHealth architecture model since it represents the organizational and governance aspects of the project including the finance and the development of local capability and capacity in Health Informatics.

1.1.1.3 Review of Applicable Health Informatics Standards

This chapter contains a review of those health informatics standards categorised as follows:

- *ISO/TS* Standards relevant for the construction of national registries of persons, health care providers and health care professionals
- Adaptations of these standards for LMIC (Low to Middle Income Countries)
- Clinical Classifications and Terminologies
- Standards for security
- Standards for interoperability

1.1.1.4 Review of Relevant Architectural Frameworks and Approaches to Interoperability

This chapter contains:

- A review of various published Enterprise Architecture Frameworks in use
- How these EA frameworks have been applied to National Health Information Systems
- The modelling process and the various tools and methodologies used
- A summary and definition of types of Interoperability and Integration
- The use of middleware strategies for Health Systems Integration
- The role of the Health Information Exchange (HIE) in an EA

An overview of encompassing aspects such as non-technical best practices, patient identification, vital registration, EHR and the HIE, privacy and security, and the role of data and infrastructure standards and application certification in ensuring success in large-scale initiative interoperability.

1.1.1.5 Review of Developed/Mature Country Architectures

The following countries were reviewed from four different viewpoints (Enterprise, Information, Computation, Technology)

- Australia
- Canada
- Singapore
- Israel
- Denmark
- Sweden
- Spain

1.1.1.6 Review of HIS in Selected Countries in Sub-Saharan Africa

This section reports on a review of eHealth and health information systems in Africa in order to identify architecture assets in these countries. The review collected information about eHealth and health information systems from the following sources:

1. Published literature
2. Grey literature
3. Web-sites of country ministries of health.
4. Communication from individuals exposed to health information systems in the countries.

The initial scan included 48 African countries with information collected in English, French and Portuguese. An overview of this information indicated that the countries could be grouped into three broad groups:

- Countries where there was no evidence of eHealth planning or implementation.
- Countries where there was some evidence of eHealth planning but no evidence of significant implementation.
- Countries where there was evidence of eHealth planning as well as some significant implementation.

The following ten countries were reviewed in detail based on the ISO architectural model:

- Angola
- Botswana
- Ethiopia
- Ghana
- Kenya
- Nigeria
- Tanzania
- Uganda
- Zambia
- Zimbabwe

10.3.3 Detailed Architectural Description of Rwanda HIS

This chapter includes an detailed architectural description of Rwanda from the three architectural viewpoints included in the HISA standard:

- Why Rwanda as a choice?
- Enterprise Viewpoint
 - Governance
 - eHealth leadership
 - MoH
 - Donor harmonization
 - Strategic plan
 - Alignment to health sector strategic plans
 - Financing
 - Functional Decomposition of NHIS in Rwanda
- Information Perspective
 - Information flows in Rwanda
- Computation Viewpoint
 - Systems and applications implemented in Rwanda
 - HMIS
 - TRAC
 - OpenMRS
 - Rwanda Health Information exchange
 - Facility Registry
 - Other components of the HIX etc

10.3.4HEAF – Health Enterprise Architecture Framework

The purpose of this chapter is to generalize the architectural descriptions from previous chapters into a general architectural framework and patterns. It describes:

- Methodology used
- Health sector building blocks
- Enterprise Viewpoint
- Information viewpoint
- Computation viewpoint
- Enterprise Repository
- Patterns
- Examples of Application of HEAF in Ghana and the Philippines

10.3.51.4.8 Discussion, Conclusions and Analysis

The purpose of this chapter is to analyze and discuss the contents of the other chapters within the context of a general health enterprise architecture framework.

10.3.6HEAF web site and Wiki

An overview and description of the overall aims of the HEAF project can be found on the project website at www.heafproject.org. The general approach is to post working material to the collaborative Wiki (<http://heaf.jembi.org>) and from there, generalize to the emerging framework. In future, the material and assets will be registered in the Health Enterprise Architecture Registry and Tools, a project that Jembi is working on with Open Health Tools.

Authors and Reviewers

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10.4 Appendix Four. MVG-Net Evaluation