Design and impact of health information systems in developing countries

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Overview

• Global health informatics (eHealth)
• The PIH-EMR system in Peru
• The OpenMRS platform
• OpenMRS in Rwanda
• Other ehealth projects
• Lessons learned
Original problem:

- Can HIV and MDR-TB care be delivered
  1. In settings with limited or absent infrastructure?
  2. To thousands or tens of thousands of patients?
  3. Over long periods of time?
  4. With outcomes equivalent to treatment in the US?
  5. At a “manageable” cost?
Status of Global Health Informatics

• Rapid development over the last 2 years
  – Bellagio meeting on e-Health in July 2008

• Driven by the coincidence of:
  – need for better Global Health Delivery
  – increased resources for health system strengthening such as the Global Fund
  – more effective, robust, low-cost technologies
Partners In Health Model of Care

- Access to health care for all people
- Creation of long-term development by partnering with local people and communities
- Use of community health workers to grow a local and sustainable work force
- Addressing the effects of poverty including poor nutrition, water, and housing
- Drawing on the resources of the world’s elite medical and academic institutions and on the lived experience of the world’s poorest and sickest communities
Directly observed therapy in Haiti – PIH photo

Courtesy of Partners in Health. Used with permission.
Chronic disease management

1. Identifying patients requiring treatment
2. Starting patients on the correct medication
3. Ensuring stable and economical supply of medication
4. Ensuring compliance with treatment
5. Monitoring treatment progress and outcomes and addressing adverse events promptly
Core Functions of e-Health Systems

• Clinical care and quality improvement

• Monitoring and reporting

• Drug supply management

• Research
Example: MDR-TB in Lima, Peru

- Highest incidence of TB in South America
- 40,000 patients treated with DOTS per year
- > 3% have MDR-TB
- Require up to 9 drugs to treat MDR-TB

DOTS = directly observed therapy

PIH photo

Courtesy of Partners in Health. Used with permission.
PIH-EMR System in Peru

- Secure web-based EMR
- Operational since 2001
- Usable with low-speed dialup connections
- Bilingual (Spanish/English)
- 100,000+ patients tracked
- 13,000 patients treated for MDR-TB
- Now the national system for MDR-TB Rx

Smears
Cultures
Drug sensitivity (DST)

Biochem.
Hematology

Registration form
History/exam
Previous Rx
Previous Dx
Contacts

Follow up
Chest X-ray

Drug regimens
Pharmacy

 Courtesy of Partners in Health. Used with permission.
PDA Data Management
Collecting lab data in sites without internet

Processing & Verification
Sync through local PC

PIH-EMR

Courtesy of Partners in Health. Used with permission.
Palm Project: Study Design

Controlled study

• (A) Prospective

• (B) Historical
## Palm Project: Study Results

### Median processing time

<table>
<thead>
<tr>
<th></th>
<th>Intervention Districts days (n)</th>
<th>Control Districts days (n)</th>
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<tbody>
<tr>
<td>Pre-Palm</td>
<td>30.5 (4876)*</td>
<td>30.8 (5954)</td>
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<tr>
<td>Post-Palm</td>
<td>7.7 (2890)**†</td>
<td>22.7 (3263)**†</td>
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* p<0.001  
† p<0.001

### Frequency of Errors

<table>
<thead>
<tr>
<th>Type of Discrepancy</th>
<th>Intervention districts before</th>
<th>Control districts after</th>
<th>Intervention districts after</th>
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* p < 0.001  
‡ p = 0.055

Drug Sensitivity Lab Data Flow

Baseline problems with DST data

- 10% of results took > 60 days to arrive at clinic

- 16% of patients waited > 100 days to start treatment

- 17% of DSTs were duplicates

Laboratory Reporting System

1. Connects laboratories to health centers
   - Email notifications to health center personnel

2. Tools to improve data quality

3. Reporting functions for laboratory personnel

*cluster randomized controlled trial of 1760 patients*

eChasqui study results: error rates

- Intervention HCs showed:
  - 82% less errors compared to controls for DST results (2.1 vs. 11.9%, p<0.001)
  - 87% fewer errors compared to controls for cultures (2.0 vs. 15.1%, p<0.001)
- eChasqui allowed missing results to be viewed online - 72% of all errors
- 66% of control and 55% of intervention HC users responded they were missing at least 10% of paper results

eChasqui study results

• Intervention health centers took significantly less time to:
  – receive both DST (median 11 vs. 17 days, p<0.001)
  – Receive cultures (5 vs. 8 days, p<0.001)

• Patients in intervention health centers had 20% lower time to culture conversion (p=0.047).
OpenMRS
Requirements for general purpose medical record system

- Simple to setup
- Multiple computing platforms
- Local users can create EMR forms and reports
- Web based (but can also be run locally)
- Open standards - HL7, LOINC, SNOMED, ICD10
- Fully open source
  - supported by a community of programmers
  - using best ideas and software from many projects

- Able to be setup, modified and owned by the countries where we work, not just a “present from the US” but a full transfer of technology, skills and ownership
OpenMRS: a modular, open source, EMR platform

• Developed as a collaboration of PIH, the Regenstrief Institute and South African MRC
• Uses concept dictionary for data storage
• Modular design simplifies adding new functions and linking to other systems
• Supports multiple languages
• Released with open source license (April 2007)
• Core of paid programmers with growing community support
• www.openmrs.org
### Concept Form

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Courtesy of OpenMRS. Used with permission.
Community: OpenMRS Wiki

OpenMRS® is a community-developed, open-source, enterprise electronic medical record system framework. We've come together to specifically respond to those actively building and managing health systems in the developing world, where AIDS, tuberculosis, and malaria afflict the lives of millions. Our mission is to foster self-sustaining health information technology implementations in these environments through peer mentorship, proactive collaboration, and a code base that equals or surpasses proprietary equivalents. You are welcome to come participate in our community, whether by implementing our software, or contributing your efforts to our mission!

Discuss
Join community conversations via our forums, mailing lists, and online chats.

Recent Posts:
- 24-May OpenMRS Forum: Installation of Latest Stable Release 1.4.2
- 24-May OpenMRS Forum: Re: Problem list, Rx/SIH - how stored?

Community
Get project updates through our blog aggregator or join a working group.

Recent Blog Updates:
- 23-May Omar Yardiaga: Finally, running 500k observations in my alpha module.

Develop
Suggest changes and view project timelines via our development site (trac) or learn how to contribute code!

Recent Submissions:
- 23-May OpenMRS Changeset: Changeset [8008]: groovy module: groupify the controller w/CStrings

Looking for Google Summer of Code Projects?

Courtesy of OpenMRS. Used with permission.
Disease-specific EMR (MDR-TB)

### Find Patient(s)

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<th>Identifier</th>
<th>First</th>
<th>Middle</th>
<th>Last</th>
<th>Age</th>
<th>Gender</th>
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### Create Patient

To create a new person, enter the person's name and other information below. It is good practice to first verify that this person is not already in the database using the search box above.

- **Name**: 
- **Birthdate** (Format mm/dd/yyyy): 
- **Gender**: Male, Female

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MDR-TB treatment history flowsheet

Charles Virunga
35 yrs (~01-Jan-1975) Health Center: Cange

BMI: 24.7 (Weight: 67.5 kg, Height: 165.0 cm)
Regimen: Ethionamide (Eto), Ciprofloxacin (Cfx), Pyrazinamide (Z), Cycloserine (Cs), P-aminosalicylic acid (PAS), Capre (Cm), Moxifloxacin (Mfx)

Last encounter: Specimen Collection @ Cange | 19-Aug-2010 | Louise Allen
MDR-TB program start date: 05-Apr-2007 Treatment start date: 05-Apr-2007
Culture Status: Unconverted

Overview | Visits | Specimens | Regimen | Status

Find Patient(s):

Patient Overview
Patient Enrollment Date: 05/04/2007

View Main Patient Dashboard | Edit Patient Information (Short Form) | Edit Patient Information (Long Form)

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OpenMRS-Google Maps–SMS-Integration, Karachi

Credit: Owais Ahmed, Aamir Khan

Map image © Google. Rest of image courtesy of Aamir Khan. Used with permission.
OpenMRS sites - fall 2010
Rwanda health indicators

• A small central African country:
  – Population 9 M people
  – Highest population density in Africa, 85% rural

• Achieved rapid economic growth since genocide in 1994, but still has very poor health outcomes:
  – Life expectancy 38-44 years
  – Infant mortality 152/1000
  – Maternal mortality 1071/100K
  – Medium income $230
  – HIV prevalence 3%
  – Malaria prevalence 46%
OpenMRS at PIH sites in Rwanda

- Currently used for 21 PIH – supported health centers
- Data for patients with HIV, TB and now heart failure
- Over 16,000 patients tracked (Dec. 2010)
- Team of Rwandan data officers trained to enter data, ensure quality & produce reports
- Many sites have their own server and maintain a synchronized copy of the entire database

Courtesy of Partners in Health. Used with permission.

H Fraser, PIH photo
### Clinical Alerts (Rwinkwavu, Rwanda)

**Consultation, 04 Nov 2006**

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<th>e</th>
<th>Age</th>
<th>Attend?</th>
<th>Weight</th>
<th>New weight</th>
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</table>
We evaluated whether the ID physicians had access to the latest CD4 count for their patients in Rwinkwavu, Rwanda. The physicians record the result they have on the follow-up form based on paper lab result forms. We checked if they were up to date before and after a new lab component was added to the EMR to ensure up to date results.
Results – Access to CD4 counts

- The proportion of CD4 counts conducted within the past 60 days but unknown to the clinician at the time of consultation was:
  - 24.7% in the pre-intervention period
  - 16.7% in the post intervention period
  - This is a 32.4% reduction in CD4 loss (p=.002)
- We are now extending direct clinician access to the EMR

*Amoroso et al, Stud Health Technol Inform. 2010;160:337-41*
Physician looking up ARV patients

Photo Rockefeller Foundation

Courtesy of the Rockefeller Foundation. Used with permission.
Physician looking up ARV patients

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<tr>
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<th>Start Date</th>
<th>Stop Date</th>
<th>Dose</th>
<th>Comments</th>
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<th>AST</th>
<th>ALT</th>
<th>Cr</th>
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<td>225.0</td>
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<td>225.0</td>
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Weigh

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<th>CD4 COUNT</th>
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<tr>
<td>250</td>
</tr>
<tr>
<td>200</td>
</tr>
<tr>
<td>150</td>
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</table>

Courtesy of the Rockefeller Foundation. Used with permission.
Impact of OpenMRS patient summaries at AMPATH

- The OpenMRS EMR system at AMPATH in Western Kenya was used to generate printed patient summaries including reminders for ordering repeat CD4 counts.
- The computerized reminder system identified 717 encounters (21%) with overdue CD4 tests.
- In the intervention clinic with computer-generated reminders, CD4 order rates were significantly higher compared to the control clinic: 53% vs 38%, OR = 1.80, CI 1.34 to 2.42, p<0.0001.
- When comparison was restricted to encounters where summaries with reminders were actually printed, order rates in intervention clinic were even higher (63%).

Potential components of integrated national eHealth architecture in Rwanda

Supply chain systems
*Camerwa*

National reporting system
*TRACNet*

National registries e.g.
patients, providers

Pharmacy system

EMR System
*OpenMRS*

Mobile health systems
*SANA, ODK, OpenXdata*

Registration and insurance

Laboratory System

Radiology / telemedicine system

SDMX-HD

HL7

Dicom

HL7

HL7

HL7
Initial Rwanda ehealth architecture

First stage represented in red:

Ministry of Health
- Central Messaging Service (Broadcast messages)
  - Client Registry
  - Provider Registry
  - Facility Registry (NAMIS)
  - Terminology Service
- Patient Flow Management
- Shared Health Record
- Death Registry
- Birth Registry
- National ID Database

Interoperability Layer
- Health Information Access Layer - HIAL (Mbirth/Mule/OpenESB ??)

External Systems
- CHW (mUbuzima)
  - Add SDMX-HD Indicators
  - Update the Provider (CHW) registry
  - Query facility registry
- CHW (RadidSMS)
  - Add client request
  - Update the SHR
  - Update the Provider (CHW) registry
  - Query facility registry
- OpenMRS
  - Submit SDMX-HD Indicators
  - Add client request
- TracNET
  - Add SDMX-HD Indicators
  - Query facility registry
- HIS
  - Add SDMX-HD Indicators
  - Add client request
  - Update the SHR
  - Update the Provider registry
  - Query facility registry
  - Query Terminology

Courtesy of the Rwanda Ministry of Health. Used with permission.
The Government of Rwanda has announced that OpenMRS will be used for the national roll out to health centers and small hospitals.

MoH wants a non-disease specific system which:
- Can assist in the management of all outpatients
- Will also continue to be used for HIV management
- Is integrated into the national ehealth architecture

First new government site started 2 weeks ago
Developer training, Rwanda

- We are running a training program in Kigali for computer science graduates
- One year, mentored training course
  - Web development
  - Java programming
  - OpenMRS programming
  - Medical informatics
- 10 graduates year 1, 12 in year 2
- They support OpenMRS rollout as well as building software development capacity in Rwanda

Courtesy of Partners in Health. Used with permission.
Testing touch screen patient registration in Rwinkwavu, Rwanda

Photo courtesy Rockefeller Foundation

Courtesy of the Rockefeller Foundation. Used with permission.

Photo courtesy Rockefeller Foundation
Other information system projects
Malawi Patient Management System (Baobab)

- Touch screen data entry system
- Low cost, robust flat screen terminals
- Large numbers of patients registered (>300,000)
- May be best example of direct data entry system in a developing country

Report CDC Malawi, presented at PHIN2009
Evaluation of PDA system for Home Based Care at AMPATH in Kenya

• Developed a Palm Pilot PDA application, very similar technology to Peru TB study

• Data collected:
  – patient registration, HIV testing, TB screening, maternal care, vaccinations

• Reported data on 14,648 households, 40,111 patients, mean of 12 new patient records per day

• 899 (45%) pregnant women not receiving AN care

• 693/1131 (61.3%) HIV+ patients never been tested

• User satisfaction was high, technical issues rare

• Cost to cover 2 million patients, $0.15/patient

District Health Information System (DHIS) in rural South Africa

- DHIS is a web based information system for aggregate data
- Used in multiple African countries and India to collect and analyze data
- Health facilities submit reporting data on paper for entry at district level
DHIS study

• PMTCT data in South Africa has been very poor in several studies.
• Surveyed the completeness and accuracy of data reported for six key PMTCT data elements between January and December.
• Reconstructed reports for the same six PMTCT data elements from clinic registers and assessed accuracy of the monthly reports previously submitted to the DHIS.
• Data elements were reported only 50.3% of the time and were ‘‘accurate’’ (i.e. within 10% of reconstructed values) 12.8% of the time.

Mate et al. Plos One, May 2009 | Volume 4 | Issue 5 | e5483
DHIS evaluation continued

- There was **no computerisation of data collection** and no facility for electronic submission of data in any clinic.
- Clinic staff and supervisors reported that even if the data did not look correct, **checking it was rarely done** due to lack of time.
- **Little analysis of data occurred at the clinic** or by clinic supervisors.
- **Data were not discussed in staff meetings** nor analysed by them.
HIV treatment reminders, Kenya

• 538 patients randomized to weekly SMS reminder (n=273) or standard care (n=265).
• Adherence to ART was reported in 168 of 273 (61.5%) patients receiving the SMS intervention compared with 132 of 265 (48.8%) in the control group (relative risk [RR] for non-adherence 0.81, 95% CI 0.69-0.94; p=0.006).
• Suppressed viral loads were reported in 156 of 273 patients in the SMS group and 128 of 265 in the control group, (RR for virologic failure 0.84, 95% CI 0.71-0.99; p=0.04).

Pharmacy and supply chain
## Pharmacy data

### Stock Card - Amox-Clav (500 mg Tablet)

[View stock by lots]  
[Enter physical inventory]

Displaying transactions from 1 d Dec 2008 to 28 d Feb 2009  
[Changer]  
[Earlier]  
[Later]  
[Jump to latest transaction]

---

### Amox-Clav 500 mg Tablet

**Cange PTJW**

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<td>Israel Esther</td>
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Pharmacy and Warehouse Stock Tracking

Reduction in product-days of stocked out medication (daily report – *a method of triangulation*)

System was set up in 2005 but scaled in 2006.

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<th>Q4 2006</th>
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<td>634 (P&lt;0.001)</td>
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<tr>
<td>Prod. Days</td>
<td>60,608</td>
<td>58,576</td>
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<tr>
<td></td>
<td>2.6%</td>
<td>1.1%</td>
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“Stop the Stock-outs”, Kenya

- Led by Health Action International, Oxfam and local civil society organizations
- “Stop the Stock-outs” used a system developed by Frontline SMS
- Patients to send text messages to a server if the drug they had been prescribed was stocked out at the clinic’s pharmacy
- Data is linked to mapping software

“Stop the Stock-outs”

- The group was able to map the levels of stockouts of essential medications in more than 100 clinics in Kenya
- **Stockouts rates of 50-60% were documented for essential medications**
- This data was publicized and led to the Kenya parliament voting for increased funding for drug supply
  - The system is also being used in Malawi, Zimbabwe and Uganda
Some lessons learned
The importance of local leadership

- Prioritizing the most important information requirements and focus on nailing them!
- Avoid “fishing expeditions” and “nice to haves”
- Explain what is possible and what isn’t and manage expectations
- Make sure you agree who is responsible for power, IT, data management and user supervision

Formal informatics training needed for leaders
The importance of individual patient records

- The public health approach to clinical data management in developing countries has focused on aggregate data at national level.
- Studies show that data quality is very poor if there are no tools for managing and analyzing the data locally.[1]
- Local data use makes the system valuable for clinical care and staff.

Design systems with outputs as the primary focus

<table>
<thead>
<tr>
<th>Forms</th>
<th>Infrastructure</th>
<th>Software</th>
<th>Data Collection &amp; Quality</th>
<th>Analysis, Reports, Quality of Care?</th>
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Avoid the form vortex

<table>
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<tr>
<th>Forms, data Collection &amp; Quality</th>
<th>Infrastructure</th>
<th>Software</th>
<th>Core Data set</th>
<th>Analysis, Reports, Quality of Care</th>
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The importance of local data use
The importance of local data use

Avoid systems that just suck!
Defending the core data set

- The route to success is a core data set that supports the key outputs
- Then forms can be created to enter that data
- Maternal Concept Library is a collaboration to identify the essential data to reduce maternal deaths and work from this core.
- Changes to the core should require a formal process

Image courtesy of Feral78 on Flickr.
Data management tools and training

• Data quality and completeness is a critical success factor
• Data quality tools needed to carry out regular checks
• Many organizations in Rwanda doing training but do not cooperate

Courtesy of Partners in Health. Used with permission.
One successful system beats 10 nearly there…

• Prioritize requests by what is feasible
• Get success with low hanging fruit live
  access to lab data, confirmed in evaluation
  studies
  – Access to TB lab data in Peru
  – Access to CD4 data in Rwanda
• *Don’t have 10 things on the go before one
has succeeded!*
Power supply, backups and protection

• Must invest in adequate power infrastructure especially with local server
• Low power devices make solar and backup systems more viable
• Laptop servers are a big win in many sites
Data backups

Haiti post earthquake

- I-Sante EMR system backs up data in Port au Prince and US, able to restore system in General Hospital from the backup system
- MSF – OpenMRS system for surgical care was lost with collapse of La Trinite hospital. Able to recreate the system within 1-2 weeks from backups.
- Data synchronization can address this issue as well as usability and data access

Photo GHESKIO

Courtesy of GHESKIO. Used with permission.
Confidentiality and data ownership

• Technical solutions exist to ensure security and encryption of medical data
• We encrypt data transfers with SSL
• Staff receive training in patient data and security management
• All logins and page views can be audited
• Lack of national policies and laws is a major concern in most developing countries including Haiti
Mobile devices for network and power independence

“277 Million Chinese people were accessing the Internet through mobile devices June 2010 up from 43 Million in December 2009!”

MIT Technology Review

Courtesy of Larry Nathanson. Used with permission.

Larry Nathanson, BIDMC Boston
Linked initiatives to address maternal mortality

• Big push to address maternal mortality in developing countries –finally!
• Initiatives in training, surgical facilities, blood banking, patient tracking and monitoring outcomes
• Collaboration between WHO, Gates, PIH, MVP, Dtree, AMPATH, IDRC, PEPFAR
• Pilot projects in Ghana, Bihar -India, soon Rwanda, Haiti and others
Maternal Concept Lab

• Identify the key requirements to improve maternal health and the information that is needed
• Agree to a small set of outputs: reports, summaries, etc.
• Agree the core data set that will allow you to create those outputs
• Share the data set and tools and designs with the larger collaboration
• Document all the details and evidence on a public site

Jonathan Payne, PIH and DTree
What has been invested in eHealth?

• Recent world bank study showed that over $480M has been awarded to ehealth projects by World Bank for *current projects*

• At least 3 other major development agencies also funding at high levels:
  – USAID
  – PEPFAR
  – GFATM

• Little if any evaluation has been carried out on those projects
Collaborators and Funders

• Partners In Health
• Regenstrief institute
• Medical Research Council, South Africa
• World Health Organization
• US Centers for Disease Control
• Brigham and Women hospital
• Harvard Medical School
• University of KwaZulu-Natal
• Millennium Villages Project
• International Development Research Centre, Ottawa
• Rockefeller Foundation
• Fogarty International Center, NIH
• Google Inc
Studies of mobile phone interventions

• Use of SMS reminders for pharmacists reduced stockout rates for malaria medications (Tanzania)

• Use of SMS in Kenya (Frontline SMS and Ushahidi) by patients led to measurement of drug stockout rates and better supply chain management
Evaluation of the District Health Information System (DHIS) in rural South Africa

- **Focus on PMTCT**
- **Outcomes:** assessed data quality, the utilisation for facility management, perceptions of work burden, and usefulness of the system to clinic staff.
- **Results.** A high perceived work burden associated with data collection and collation
- Some data collation tools were not used as intended.
- There was good understanding of the data collection and collation process but little analysis, interpretation or utilisation of data
- Feedback to clinics occurred rarely

Challenges for information system deployments

• Reliability and support for equipment, power supplies and software
• Connectivity
• Training (IT, data entry, users, analysis)
• Data management and quality control
• Evaluation
Open standards

• The current history of the field is vertical systems customized to one purpose
• Little interoperability between systems and lab, pharmacy, national reporting tools and mobile devices
• Use of SNOMED-CT, ICD10, LOINC