

# Computing and Global Health

CSE 482b

ICTD Capstone, April 17, 2023

Richard Anderson



# Today

- Global Health Overview
  - Burden of Disease
  - Health Care Systems
  - Global Organizations and Funding
- Computing and Global Health Projects
  - Mobile Wellness Toolkit Project
  - Mobile Midwife Platform
  - Projecting Health
  - mPneumonia
  - Cold Chain Equipment Inventories
  - mWach
  - Uganda CCIS



# Global Burden of Disease

- We are all human – so subject to the same frailties
- However, the burdens of disease vary dramatically
- IHME Global Burden of Disease
  - GBD Compare

Single | Explore | Compare ▾

**Settings** [Use advanced settings](#)

Display: Cause (selected) | Risk

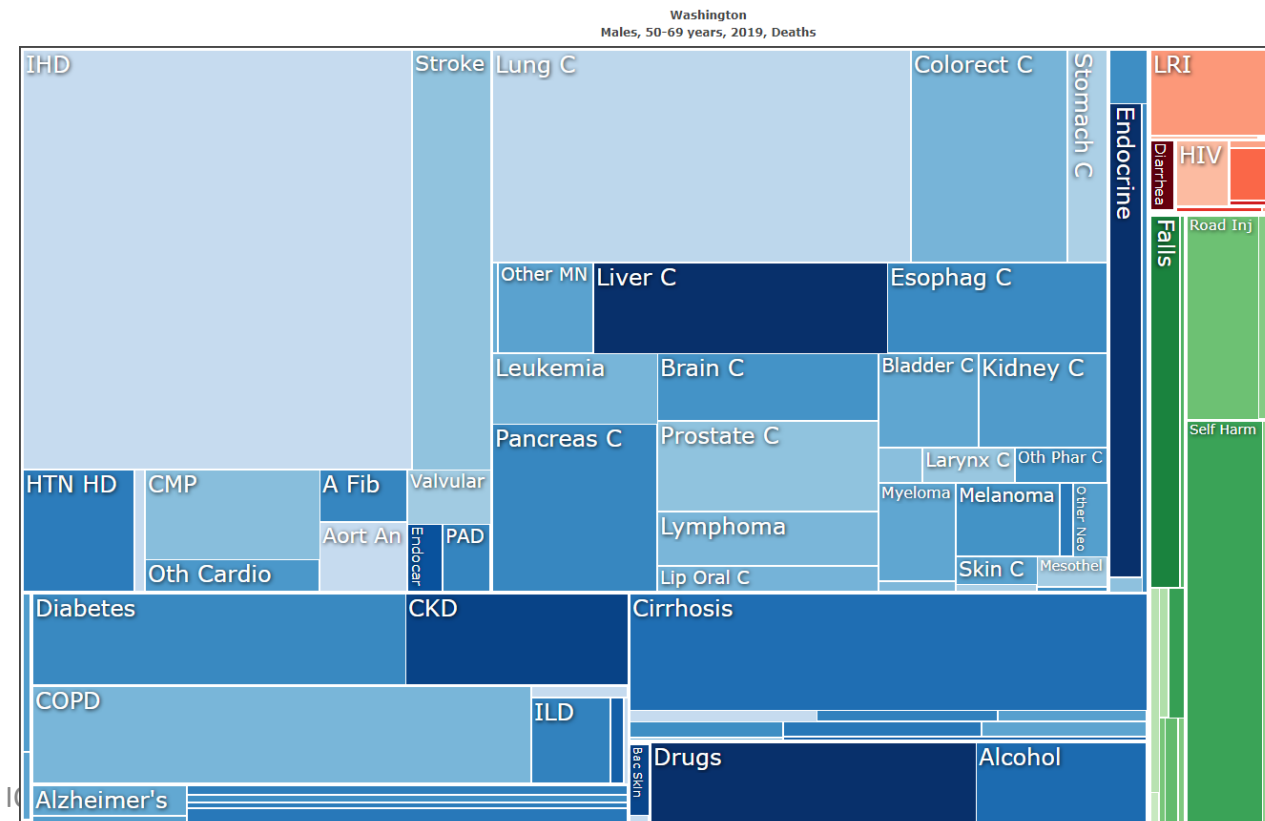
Measure: Deaths (selected) | YLDs | DALYs

Location: Washington ▾

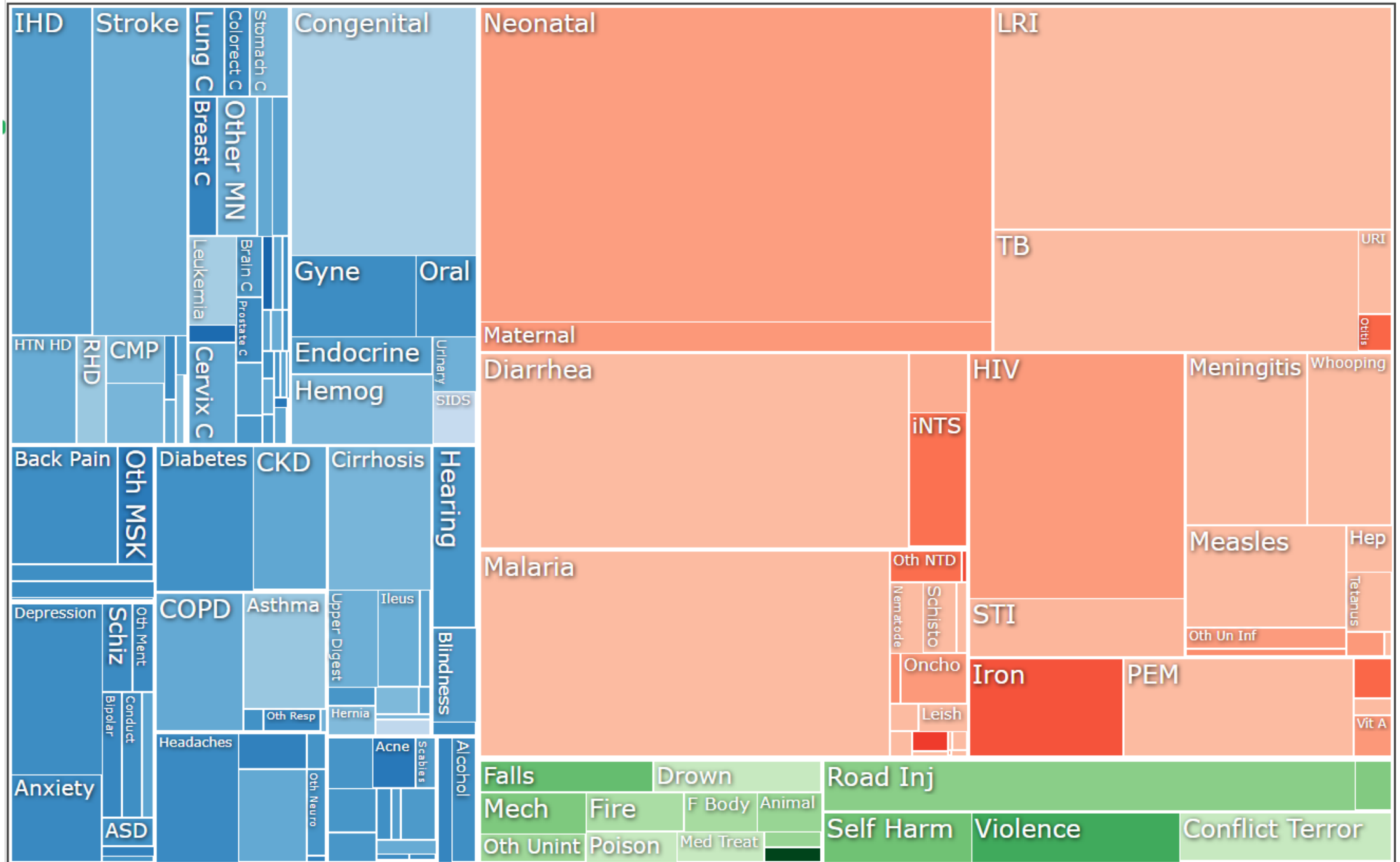
Year: 2019

Age: All | <5 | 5-14 | 15-49 | 50-69 (selected) | 70+

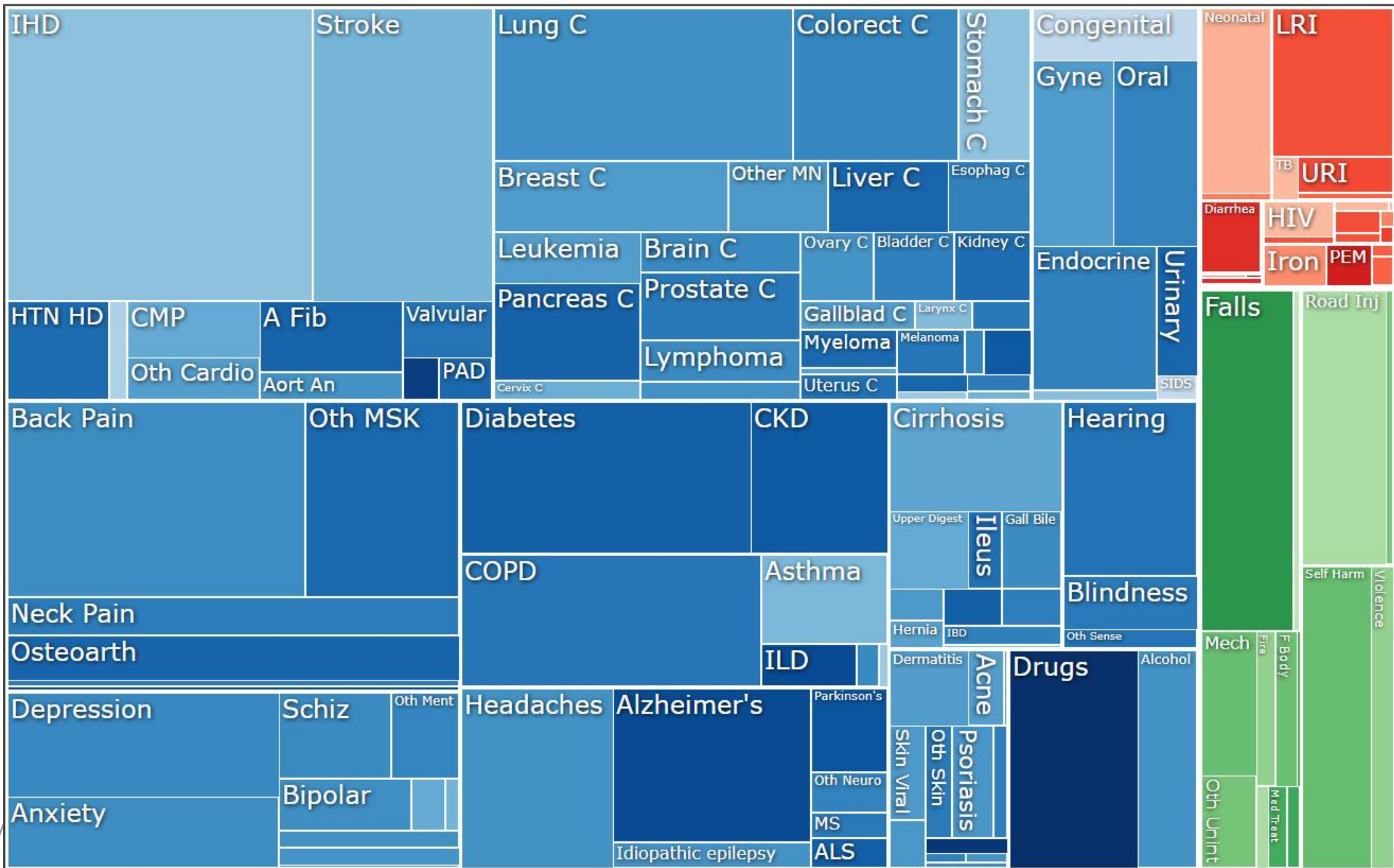
Sex: Male (selected) | Female | Both



World Bank Low Income  
Both sexes, All ages, 2019, DALYs



World Bank High Income  
Both sexes, All ages, 2019, DALYs



# Health Care Systems in LMICs

- Public and Private Health Care
- Hierarchy of facilities
  - Major Hospitals, District Hospitals, Health Centers, Health Posts
- Under resourced
  - Limited equipment and supplies
  - Lack of trained people in rural areas
- Limited governmental financial support
- Ministry of Health controls policy



# Global Organizations and Funding

- Global stake holders
  - Unicef, GAVI, WHO
- National Donors
  - USAID, PEPFAR, CDC, GDZ, DFID, Norad, JICA, . . .
- Private Donors
  - BMGF, Clinton Foundation, . . .
- Broad mix of implementing organization
- Funding streams determine priorities
  - Focus on particular diseases

# UW ICTD Lab Projects



- Research group founded by Richard Anderson and Gaetano Borriello
  - Kurtis Heimerl joined in 2015, June Lukuyu in ECE is an Affiliate

## Graduate Students

Esther Jang



Matt Johnson



Samia Ibtasam [Razaq]



Naveena Karusala



Philip Garrison



Matt Ziegler



Sudheesh Singanamalla



Emmanuel Azuh Mensah



Ananditha Raghunath



Pat Kosakanchit



Nick Durand



Lisa Orii



Nussara (Firn) Tieanklin



Innocent Obi Jr





# Digital StudyHall



- Video based education using Tutored Video Instruction model
  - Idea was to use mediated video presentation
  - Benefit of expert content, mediation, and peer discussion
- Project was conceived by Randy Wang, a Princeton University professor who left the university to establish the project in Lucknow India
- Goal was to provide educational content to rural Indian schools which often lacked qualified teachers
  - Model – teachers in the schools would “co-teach” with a video lesson filled in a different school
- UW Faculty involvement: Richard Anderson, Tom Anderson, Arvind Krishnamurthy, and Kurtis Heimerl (as a student)



# Digital StudyHall



- Project was initially technology focused
  - Viewed as a networking project for distributing content
  - Secondary project was developing low cost display mechanisms
  - Education was viewed as the “Application Domain” for the technology
- Randy Wang was employed at Microsoft Research India
  - Spin off project (by Rikin Gandhi) on agricultural education: Digital Green



CSEP 482B, ICTD Capstone



# Digital Public Health -> Projecting Health

- Application of Digital StudyHall/Digital Green ideas to Public Health
- Led by University of Washington and PATH in Uttar Pradesh India
- Most similar to Digital Green in technology approach
- Video topics had standard messaging based on official guidelines
  - Far more concerns about getting messaging correct
  - Implemented community advisory board
- Deployment approach
  - Use by ASHAs (Community Health Workers) leading Mothers' groups
  - Local NGO to manage deployment
- Social media technology has changed since project wrapped up



# Open Data Kit

- Problem: Digital data collection in poorly connected environments
- 2007 Technologies:
  - Personal Digital Assistants (PDAs)
  - Feature Phones
- Forms based data collection
  - Enter data based on individual forms
  - Forms end up as records in a database
  - Example: tracking Malaria outbreak in remote villages
- Initially University of Washington project, now a widely used system under a number of different brandings



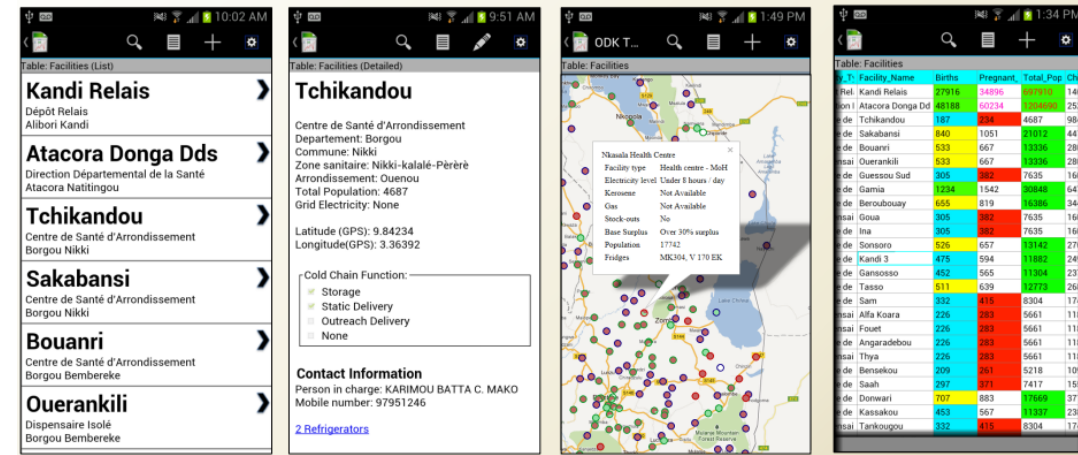
# Open Data Kit History

- Brainchild of Gaetano Borriello
- “Let’s do data collection with Smart Phones in developing countries”
- Use of Android Platform
- In 2008-2010 there was great skepticism that smart phones would be a feasible device for global work
- Initial development by UW PhD students
- Open Data Kit: Suite of tools for data collection
- Spun out from UW as independent projects



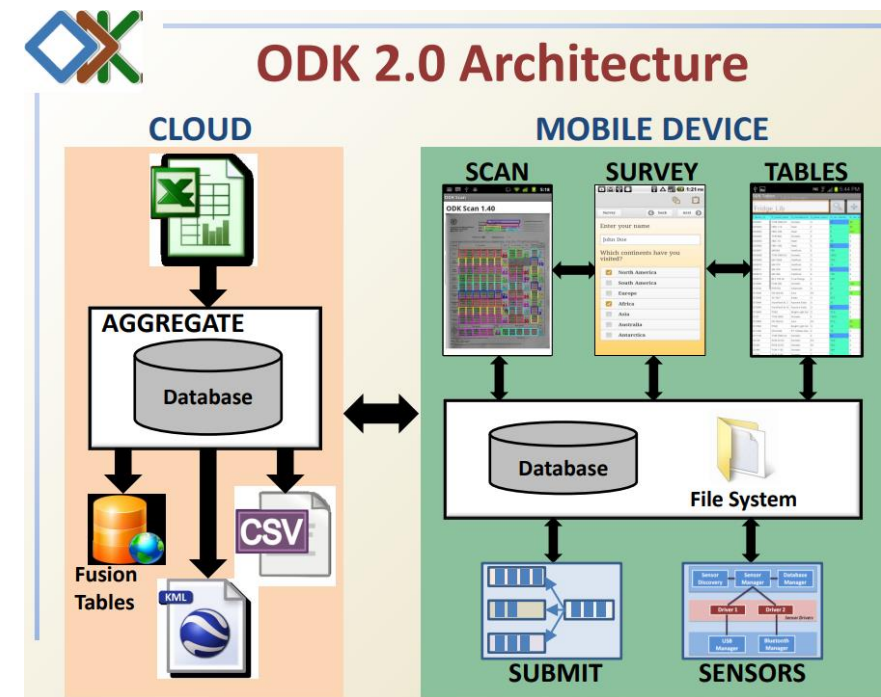
# ODK Lessons

- Successful bet on future technologies
- Reliance on consumer technology
- “Market fit” – addressed an important global development use case
- Identified different roles in the digital data collection
  - Deployment architect – manage data collection and forms design, but not systems programming
- Enabled organizations with “moderate” technical capacity to manage data collection
- Open source allowed multiple organizations to build on platform including commercial organizations



# ODK 2 aka ODK-X

- ODK 1 – Submission of forms based information from Android Device to Server
- ODK 2 – Data management platform with database on both Android Device and Server
  - Row based synchronization in online/offline environment
  - Substantial generalization of ODK 1
  - Platform for research projects



**ODK 2.0: Tables** interface showing four views:

- List View:** A list of facilities including Kandi Relais, Atacora Donga Dds, Tchikandou, Sakabansi, Bouanri, and Ouerrankili.
- Detailed View:** A detailed view of the Tchikandou facility, showing its location, population, and contact information.
- Map View:** A map showing the location of the Tchikandou facility and surrounding areas.
- Spreadsheet:** A spreadsheet view of the facility data, with columns for Name, Status, Program, and Total Pop.

# Mobile Wellness Toolkit Project

- National Science Foundation project
- Partnership between University of Washington and PATH
- University of Washington
  - Richard Anderson, CSE
  - Gaetano Borriello, CSE
  - Beth Kolko, HCDE
  - PostDocs: Brian DeRenzi, Neha Kumar
- PATH
  - David Lubinski, Kiersten Israel-Ballard, Noah Perin



How do we make low cost consumer technologies available to organizations who implement health and wellness programs?






# ODK Sensors

- Framework for integrating sensors into an ODK2 Application
- FoneAstra – sensor bridge for mobile phones
  - Initially basic phones, but later android phones
- Temperature Monitoring for Vaccine Refrigerators
- Temperature Monitoring for low cost breast milk pasteurization




# mPneumonia

- Pulse Oximetry for detection of childhood pneumonia

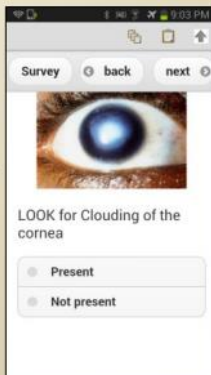


## ODK 2.0 Example


- **Pneumonia Detection** (Ghana & India)
- Digitize complex WHO-IMCI workflows
- Guide and assist user obtaining proper patient measurements
- Display treatment based on IMCI guidelines




Survey back next  
Look for chest indrawing.  
CHILD MUST BE CALM  
 Present  
 Not present




Survey back next  
LOOK for Clouding of the cornea  
 Present  
 Not present



Does the child have fever?

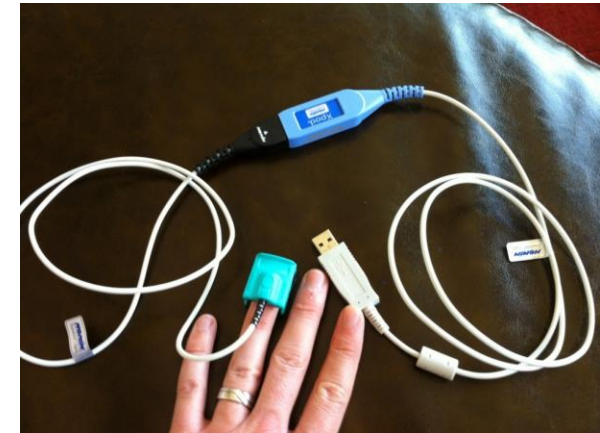


Breaths per Minute: 45  
Reset Counter  
Record Count

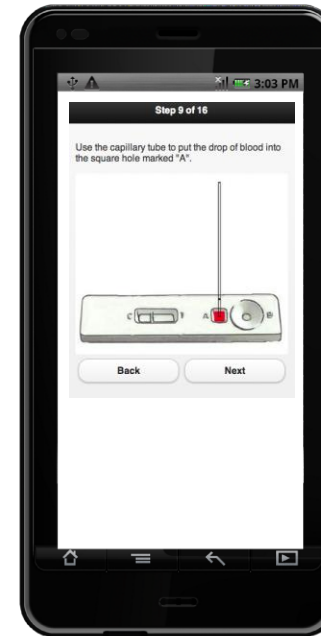
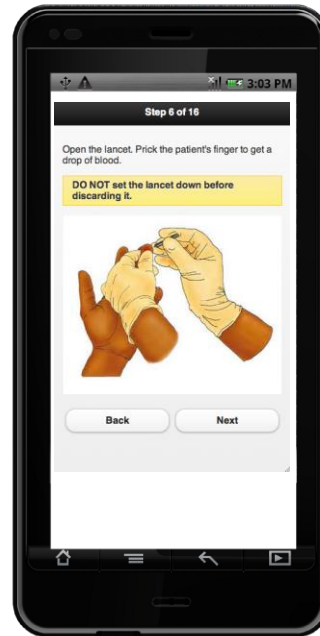
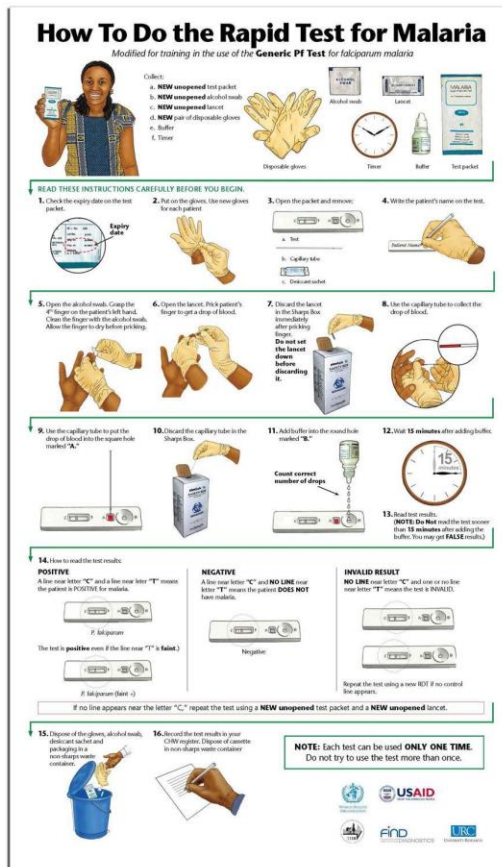


Pulse Oximetry

IMCI      Respiratory Rate Counter      Pulse Oximetry

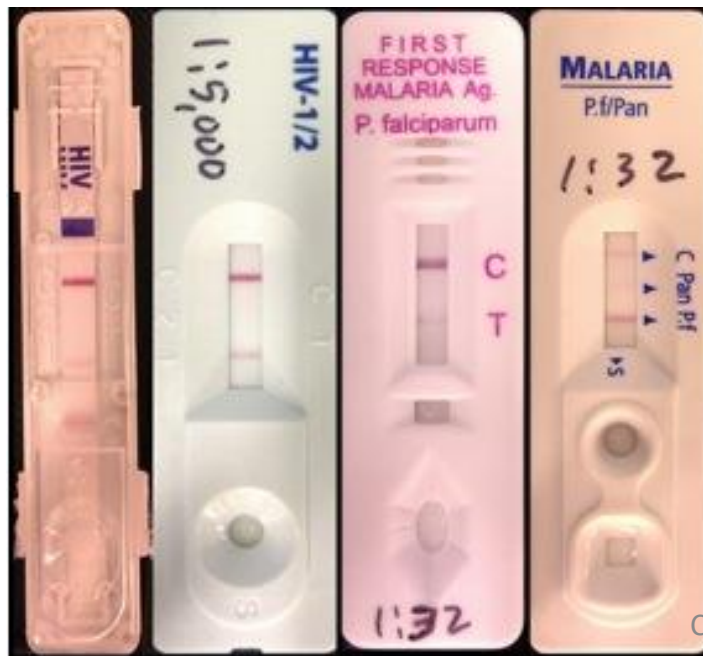


# Job Aids: Smartphone Apps for health workers



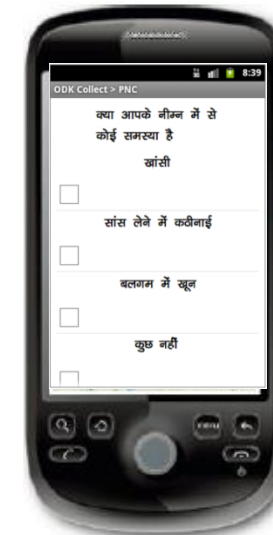
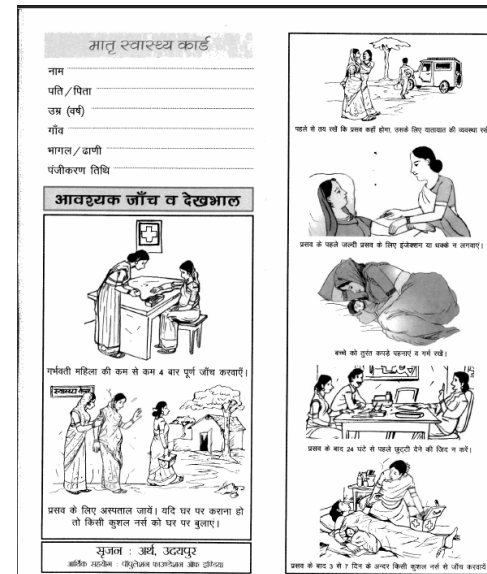
# Point of care diagnostics

- Rapid diagnostic tests (RDTs) quickly test for conditions based on blood/urine sample
- Supportive tools to aid health workers with the administration and interpretation of these tests.



# Mobile Midwife Platform

- Mobile data collection to support PNC visits
  - Data collection
  - Protocol support
- Open Data Kit application
- Android phones deployed with nurse midwives



# Mobile Videos in MMP

- The use of video is feasible in PNC visits
- The PNC environment is complicated
  - Patient education occurs throughout visits with various levels of effort
  - Multiple settings and participants
- Authority and trust
  - Nurses viewed video as being authoritative and enhancing their communication



# mWACH

- Study with Dept of Global Health
- SMS Reminders to Pregnant Women in Kenya
- Target basic mobile phone users
- Innovation was two-way SMS

## Control Group

No intervention.

## One-way SMS

Pregnant woman receives twice-weekly SMS with health information relevant to her health and her stage of pregnancy.

## Two-way SMS

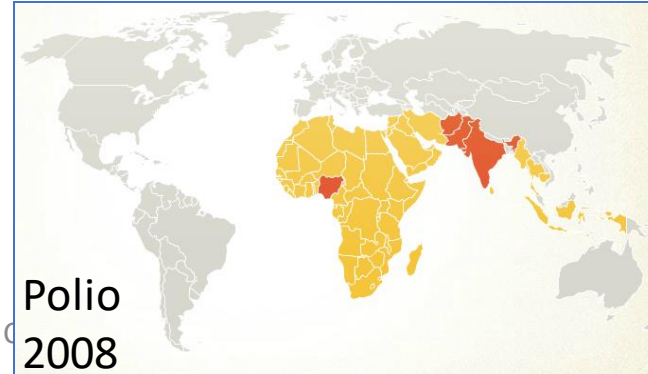
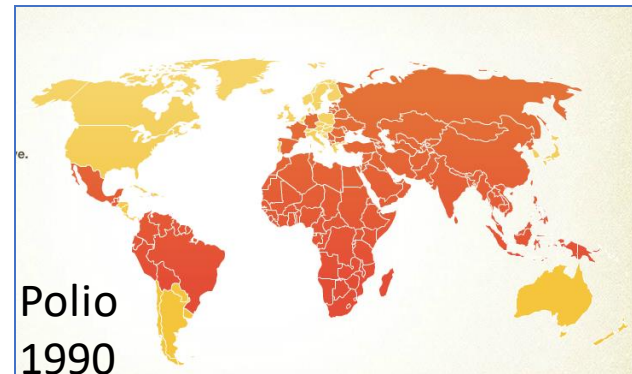
Pregnant woman receives twice-weekly SMS requesting a reply.

Hypothesis that woman's reply can be a proxy for engagement and uptake of health services.

The screenshot displays the 'ENCOURAGEMENT SYSTEM' interface. On the left is a 'Patient List' with entries for Mukami Adoyo, Hamisi Omondi, Murugi Onyango, Elinah Atieno, Adila Michieka, Eucabeth Owiti, Adla Otieno, and Eucabeth Adoyo. The main area shows a message composition screen for 'Abuya Abasi' with a 'TO: ABUYA' field and a 'SEND' button. Below this is a 'Communication History' section showing a message from 'YOU' at 12 mins ago and two replies from 'Abuya' at 30 and 36 mins ago. The right sidebar contains 'Patient Information' for Abuya Abasi, including client number #08372923, phone number +254 722 002100, problem list 'Anemia', birthday 10-30-1988, status 'Pregnant', EDD 8-20-2012, education completed 8 years, language English, message frequency 5 days, and time 8-10 p.m.

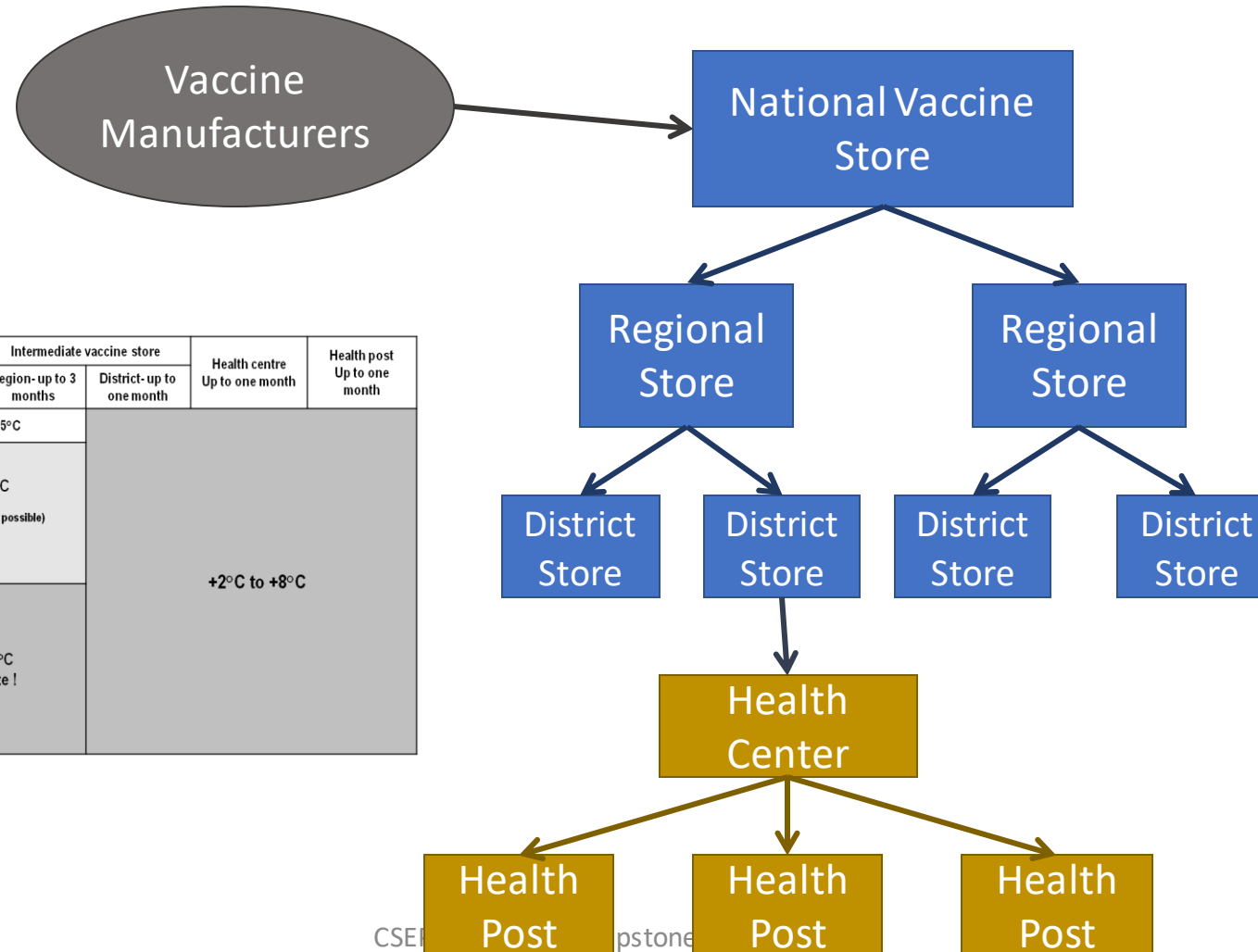
# Cold Chain Equipment Inventories

- Vaccine Cold Chain: National Storage of Vaccines from import to delivery
- Critical for management of national vaccine programs
- Expanded Program of Immunization had dramatic impact on reducing childhood deaths





# Vaccine Cold Chain Structure



	Primary vaccine store Up to 6 Months	Intermediate vaccine store		Health centre Up to one month	Health post Up to one month
		Region- up to 3 months	District- up to one month		
OPV	-15°C to -25°C				
BCG					
Measles, MR, MMR					
YF					
Hib freeze-dried					
Meningococcal A&C					
HepB					
IPV					
DT, DTP, DTP Hep B					
Hib liquid					
Td	+2°C to +8°C Never Freeze !				
TT					

# Cold Chain



# Cold Chain



# Cold chain equipment



# Cold Chain Equipment Manager (CCEM) Software

The screenshot displays several key components of the CCEM software interface:

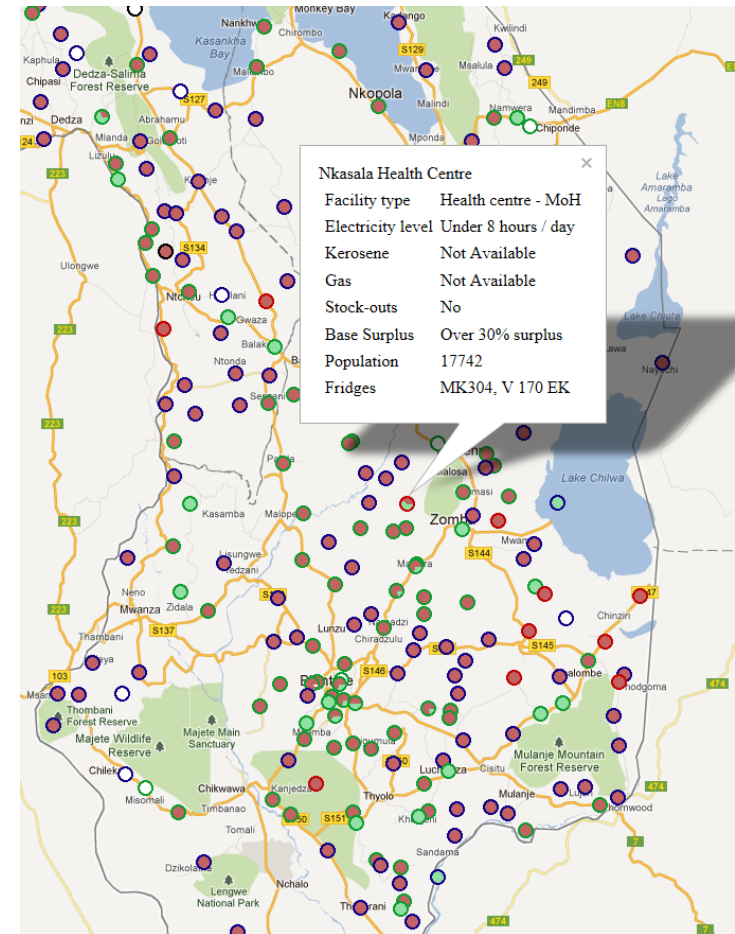
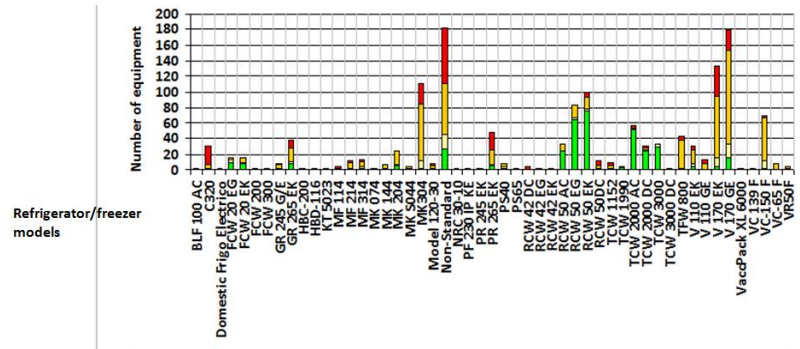
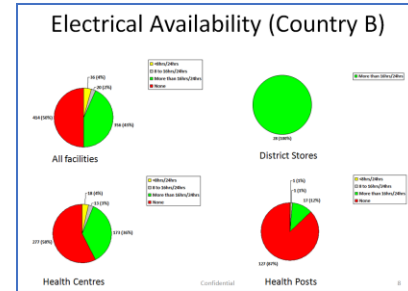
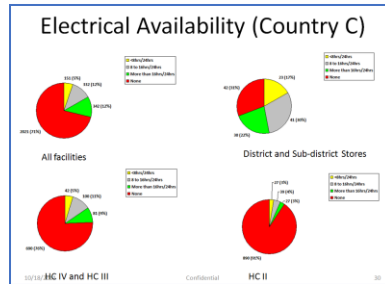
- Inventory Data Reports >> Standard CCEM Reports >> Summary Reports:** A menu for selecting reports such as 'Total population by facility type', 'Electricity availability by facility type', and 'Working status by refrigerators/freezers model'.
- CCEM Setup >> View/Edit Catalogues >> Refrigerators/Freezers:** A configuration screen for equipment model 'E3100M', including fields for 'In PQS?', 'Type', 'Model name', 'Manufacturer', 'Power source', and 'Refrigerant gas type'. It also shows calculated storage volumes and energy consumption.
- Working status by equipment model(National-level):** A bar chart showing the number of equipment units in three states: Working Well (green), Working Needs Service (yellow), and Not Working (red) across various facility types.
- Forecast Equipment for Multiyear Plans >> Forecast Results >> Generate/Review Forecast Results >> Compare refrigeration:** A table titled 'Storage capacity summary(2011): MyForecastParam2' comparing facilities with +2C to +8C storage and -20C storage. The table includes columns for Surplus, Match, and Shortage for different storage capacity ranges.
- Enter/Edit Inventory Data >> Health Facilities and Inventory >> Enter New Data:** A detailed form for entering equipment data, including 'Equipment ID', 'Catalog ID', 'Model name', 'Serial number', 'Internal storage dimensions', and 'Calculated internal storage volume'. It also includes a 'Temperature reading' section.
- Working status by facility type(National):** A summary table showing the number of facilities and their working status across different facility types.

Admin Area/Facility Type	Total	No. facilities with +2C to +8C storage			No. facilities with -20C storage		
		>30%	10-30%	<=10%	>30%	10-30%	<=10%
District Store	80	14	3	0	0	0	0
National Store	1	0	1	0	0	0	0
NGO HCL1	241	147	1	1	111	241	0
NGO HCL2	201	152	0	4	42	201	0
NGO HCL3	16	10	0	1	0	0	0
NGO HCL4	43	24	0	0	22	43	0
Private HCL	54	37	0	0	16	54	0

The screenshot shows the main menu and navigation options of the CCEM software:

- Facilities - Cold Chain Equipment Management 2.1 (Version 2.1.6.4)**
- File** menu
- Navigation Options:**
  - Refrigerators/Freezers
  - Cold Boxes and Vaccine Carriers
  - Voltage Regulators
  - Vaccines
  - Health Facility Type
  - Administrative Levels and Data
  - Fuel Cost and Demographic Info
  - Current Vaccine Schedule
  - Language Settings
- View/Edit Catalogues** and **Country Data** options.
- Enter/Edit Inventory Data >> Health Facilities and Inventory >> Enter New Data** (selected)
- Facilities** (selected) and other options: Refrigerators/Freezers, Cold boxes and vaccine carriers, Ice packs, Cold rooms, Voltage regulators, Generators, Transport.

# Reports



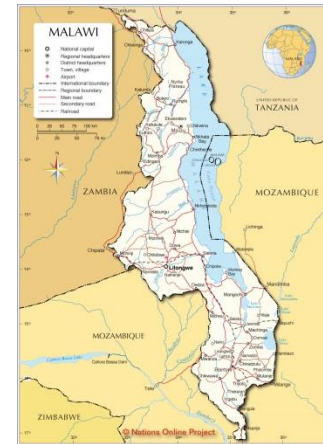
# CCEI Data Standards



- Goal: Agree on standards to allow tools to interoperate
- Wide range of tools available
- Data integration problem is central
- Need for multiple software tools

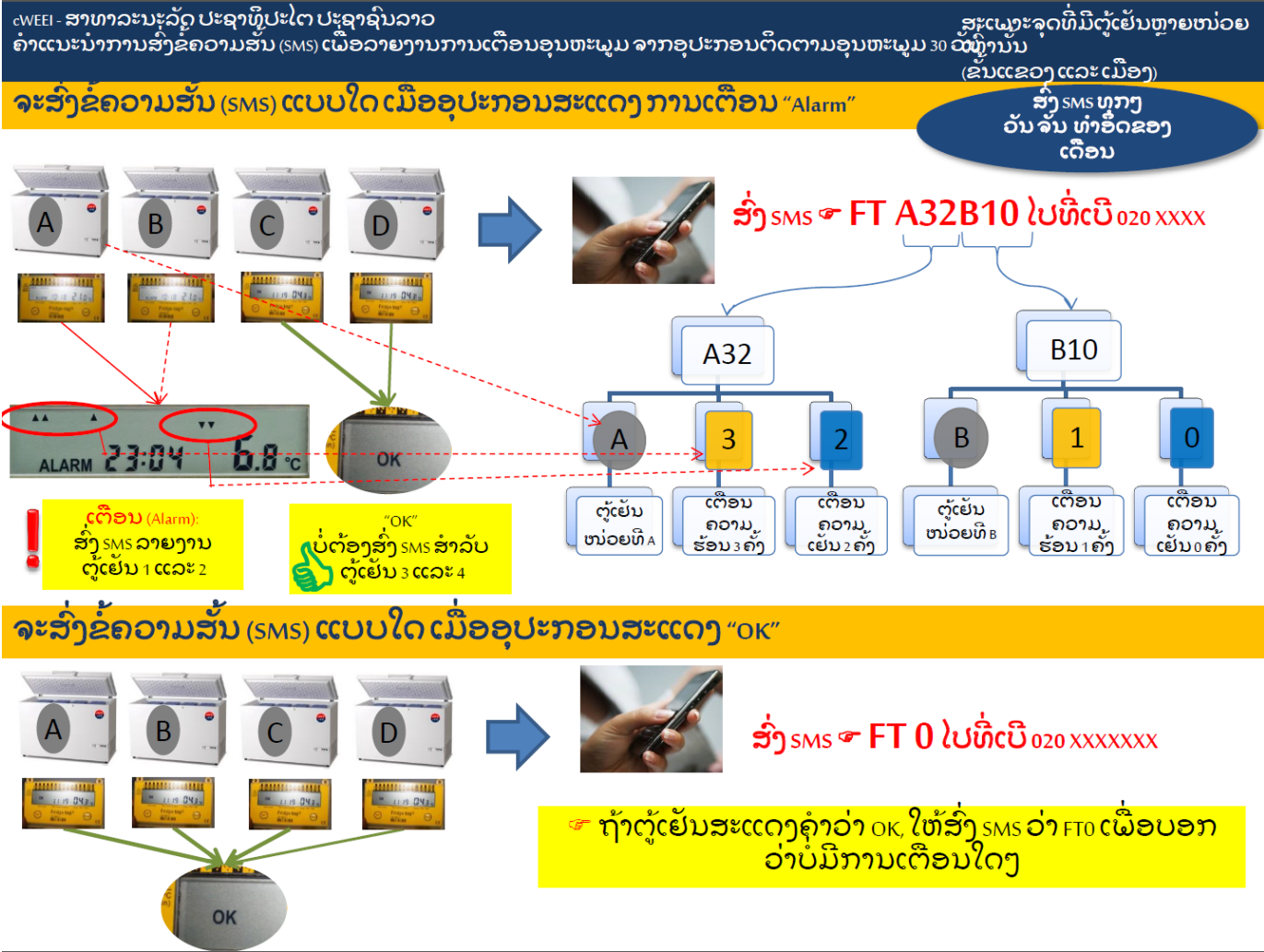
1 - HEALTH FACILITY QUESTIONNAIRE		wCCEI Laos
1. Facility code:		
<b>Administrative levels and facility information</b>		
2. Province:	6. Type of health facility: <i>Mark only ONE box</i>	
3. District:	<input type="checkbox"/> National vaccine store <input type="checkbox"/> Province vaccine store <input type="checkbox"/> District vaccine store <input type="checkbox"/> Provincial hospital <input type="checkbox"/> Referral hospital <input type="checkbox"/> Health centre A <input type="checkbox"/> Health centre B	
4. Name of health facility:		
5. English name of health facility:		
<b>Health facility immunisation activities</b>		
7. Total population in area served by facility:	8. Facility coverage (per cent of population receiving immunization services from facility):	
9. Number of villages reached by facility (Only for Health centre):		
10. Vaccine storage type: <i>Mark only ONE box</i>	11. Vaccine delivery type: <i>Mark only ONE box</i>	
<input type="checkbox"/> Depot <input type="checkbox"/> Delivery <input type="checkbox"/> Depot and delivery <input type="checkbox"/> No storage	<input type="checkbox"/> Static <input type="checkbox"/> Outreach <input type="checkbox"/> Static and outreach <input type="checkbox"/> No delivery	
<b>Health facility energy sources available to power cold chain equipment</b>		
11. Electricity source: <i>Mark only ONE box</i>	12. Grid electricity availability per day: <i>Mark only ONE box</i>	
<input type="checkbox"/> Grid <input type="checkbox"/> Grid and Generator <input type="checkbox"/> Generator <input type="checkbox"/> None	<input type="checkbox"/> More than 16 hours <input type="checkbox"/> 8 to 16 hours <input type="checkbox"/> 4 to 8 hours <input type="checkbox"/> None <input type="checkbox"/> Less than 4 hours	
13. Gas: <i>Mark only ONE box</i>	14. Kerosene: <i>Mark only ONE box</i>	
<input type="checkbox"/> Available <input type="checkbox"/> Irregular <input type="checkbox"/> Not available <input type="checkbox"/> Unknown	<input type="checkbox"/> Available <input type="checkbox"/> Irregular <input type="checkbox"/> Not available <input type="checkbox"/> Unknown	
<b>Cold chain logistics information</b>		
15. Vaccine supply interval (weeks):	16. Vaccine reserve stock requirement (weeks):	
17. Mode of vaccine supply: <i>Mark only ONE box</i>	18. One way road distance to closest supply point (in KM):	
<input type="checkbox"/> Delivered <input type="checkbox"/> Collected <input type="checkbox"/> Both delivered and collected <input type="checkbox"/> None		
19. Main supply point:	20. Secondary supply point:	

# Countries

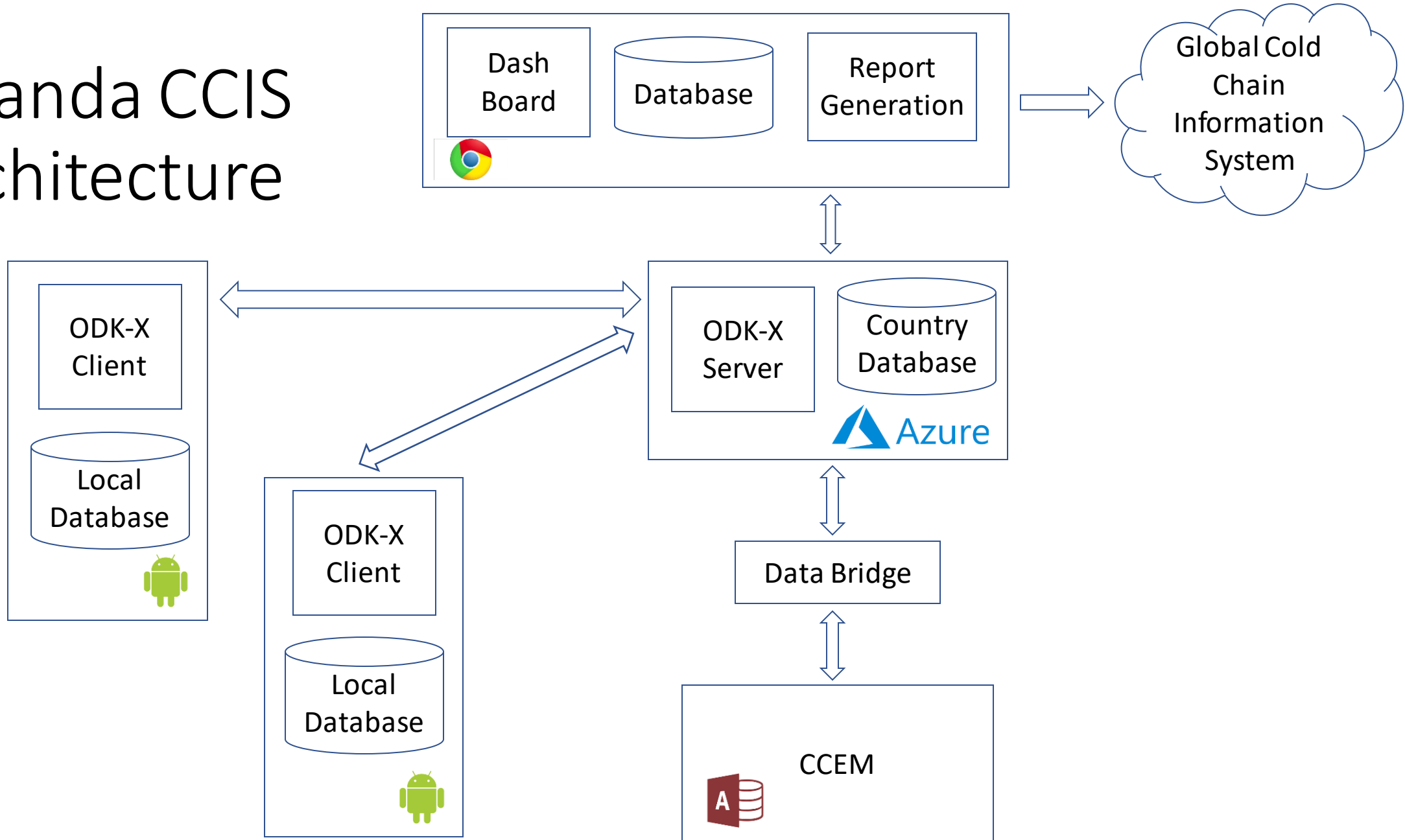




# Laos – Integration with SMS reporting

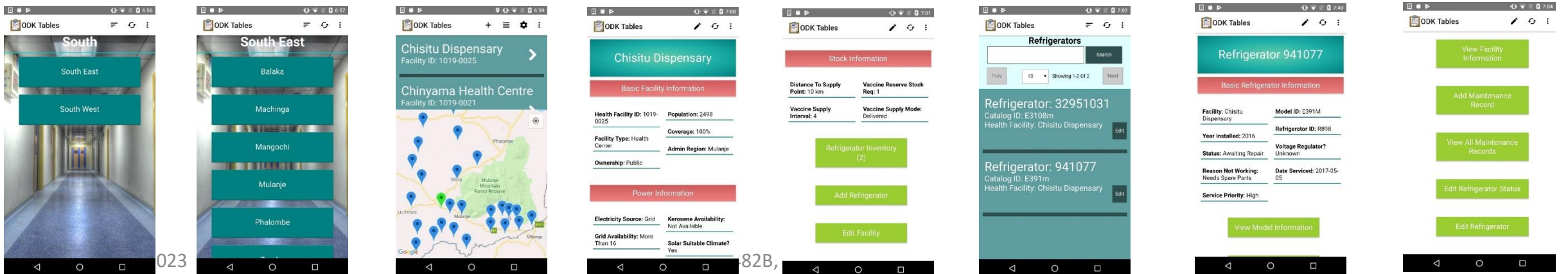


# Uganda CCIS Architecture



# Uganda Cold Chain Mobile Application

- App built on top of the ODK-X platform
  - Combination of ODK Survey and ODK Tables
  - Written in Java Script
- Manage a database of health facilities and refrigerators associated with facilities

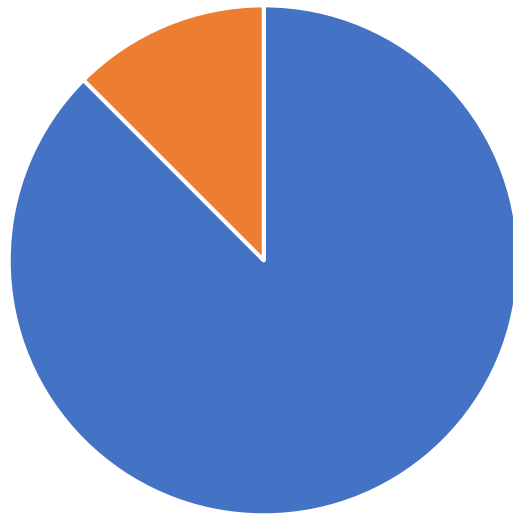


# Results: Functionality

## Updating CCEI

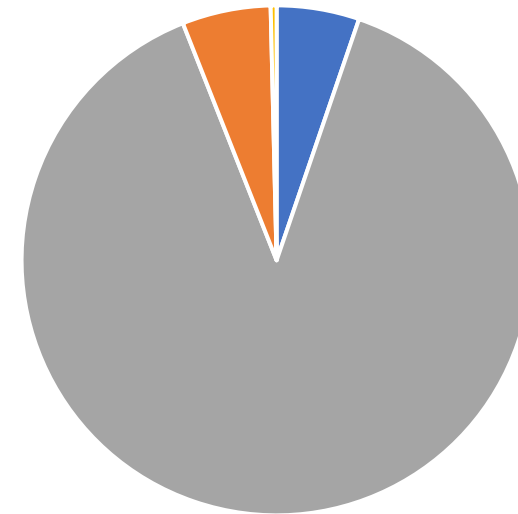
- Data reported from 80.15% of the 394 HCFs in the study districts
- Data reported from 80.77% of the 486 CCE in the study districts
- Frequency of temperature excursion:

Analysis: CCE functionality



■ Functional ■ Non-functional

Analysis: CCE temperature performance



■ Freeze alarm ■ Temperature between 2-8C ■ High alarm ■ Blanks

**Analysis:**  
60 non-functional CCE out of 489 in study as of July 10, 2020

**Prioritizing repair:**  
**129** Out of 795 entries showed CCE with either freeze (35) or high alarm (94) data

# Questions and Discussion

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