Development Engineering

CSEP 590 B

Engineering the Immunization Cold Chain

Richard Anderson

Today

- Announcements
- Some general themes
- Mapping the immunization cold chain
- Discussion of Uganda deployment

Announcements

- Discussion Sections Zoom Attend one
 - Wednesday: 3:00-4:00 pm
 - Wednesday: 5:00-6:00 pm
- Homework 1, Due April 13.
 - Submit by email
 - Course grade based on 7 of 9 assignments
 - Defer questions on HW1 until end of class
- Reading: Global Goods Software for the Immunization Cold Chain, W. Brunette, R. Anderson, et al., Under submission.

Course Schedule

Date	Торіс	Lead
April 6	Engineering the Vaccine Cold Chain	
April 13	Community Cellular Networks	Kurtis Heimerl
April 20	Remote Temperature Monitoring	Martin Lukac, Nexleaf
April 27	Election Monitoring	James Long
May 4	Voice Based Social Networks	Aditya Vashistha
May 11	TBD	
May 18	Fintech for Rural Networks	Jenny Aker
May 26	TBD	
June 1	Open Data Kit	Waylon Brunette

Development Engineering

Technological interventions to improve human and economic conditions in low-resource settings

An engineering discipline aimed at addressing global inequity

Develop principles for design, introduction, scaling, and sustainability of Global Good technology

Engineering

• Domain Understanding

• General Principles

Case study approach

• Engage with individual examples

• Extract transferable knowledge

Today – The immunization cold chain



General Issues

- Top down management of global development
- Global Goods software
- Designing for users

Global Development

• Global organizations set policy







THE GLOBAL ALLIANCE FOR VACCINES & IMMUNIZATION

• Donors



• Country ministries







Global Goods Software



- Software systems for global development
 - Health data reporting, medical records, human resource management, health insurance, logistics
- Goal of Global Goods software is to have a positive impact
- Generally, Open Source, but different models
 - Many projects depend on donor support
- Projects often have a fairly long history
 - Barriers to entry









Designing for the user

- Common conflict between "purchaser of system" and user of the system
- Information systems may make overall system more efficient, but the actual users do more work
- In development setting, Global Organizations and Country Ministries set policy and are the "customers"







Mapping the Global Immunization Cold Chain





Richard Anderson University of Washington



Problem: How do we count every vaccine refrigerator in the world?

- Mapping the global immunization cold chain
- Construct an accurate cold chain equipment inventory for all lowand medium-income countries

Why is this an interesting Development Engineering problem?

- Address the problem of taking DevEngr interventions to scale
 - How does the field have impact
 - Difference between pilots and sustainability
 - Examples: 99 Dots, Digital Green, DHIS2
- Understanding "Global Good" Software
 - Creating, deploying, and sustaining low-cost software platforms
 - Open source software in global health eco-system



Why this is important: Immunization

- One of the world's most effective health intervention
 - Wide coverage of basic vaccines
 - Diphtheria, Pertussis, Tetanus: 77% in poorest countries
 - Tremendous reduction in deaths
 - Some diseases close to elimination







Why this is important: Immunization Logistics

- Vaccines need to be kept in a given temperature range
 - Spoil if vaccines freeze
 - Spoil if above 8 degrees for extended period of time
- Facilities must store between 1 to 3 months of stock



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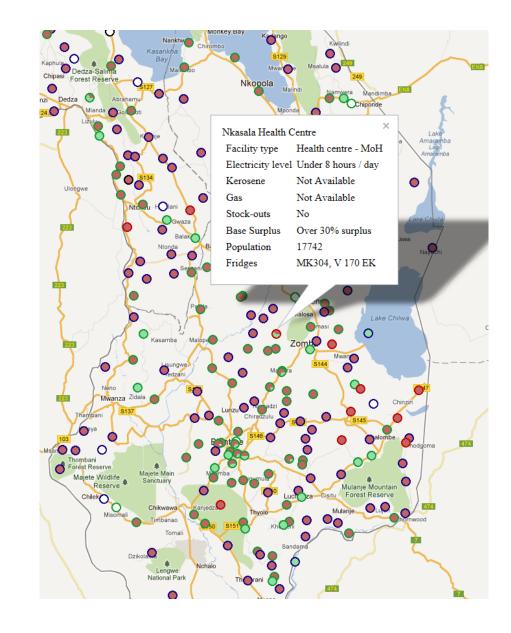




Why this is important

• This information is critical for decision making for managing the global immunization cold chain



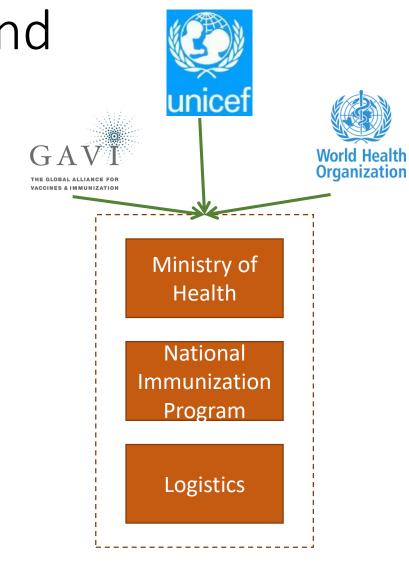


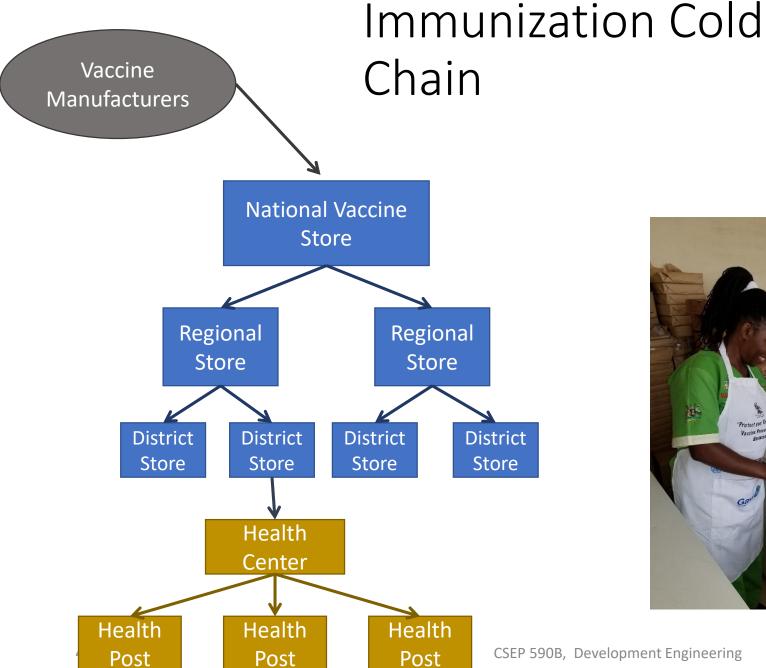
Immunization Domain Background

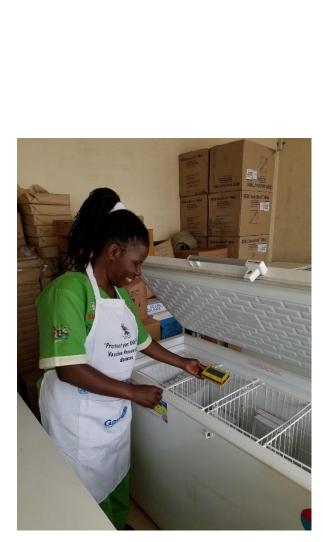
- Vaccines are the same around the world
- For many countries immunization is managed and funded globally

















Immunization Cold Chain Challenges

- Ensure that all countries have high quality vaccine cold chains
 - Working equipment at all points in vaccine supply chain
 - Sufficient capacity for vaccines
- Refrigerators need power
 - Grid power, Solar power, Gas, Kerosene
 - Many areas suffer from regular power outages
 - Desire to replace Kerosene / Gas equipment with Solar
- Equipment upgrades
 - Identify needs and determine order size
 - Remove obsolete equipment
 - Ensure proper installation
 - Establish repair infrastructure
 - Monitoring of equipment condition





My background in immunization logistics

- Sabbatical with PATH (2008-2009)
- CCEM Project
- Country projects: Nicaragua, Kenya, Zimbabwe, Malawi, Nigeria, Ghana, Uganda, India, Pakistan, Laos
- Multiple projects on cold chain information systems
 - DHIS2 for Cold Chain Inventories
 - SMS Temperature Reporting
- Promoted Cold Chain Equipment Inventory Data Standards



		Name	Туре	Comments	Req.
Manu A	1.	Unique ID	String	Unique ID for the application. (This ID should be unique across all asset types)	Y
frog at the most desarrate no 1.4	2.	Model ID	String	Key into an official catalog. Information about the model is derived from this.	Y
04/20/2014	3.	Equipment tracking ID	String	Ideally, the real serial number. However, this is not always available or maintained at the facility.	N
A State State	4.	Bar Code	String	If a barcode is used, the information can be stored here	N
	5.	Year	Numeric	Year of acquisition (manufacture). Often not accurate (but may not need to be.)	N
	6.	Source	String	Where the equipment came from	N
	7.	Working status	Enumeration	Functioning, AwaitingRepair, Unservicable	Y
bas(dhs-web-dashbaard-integration/index.action Warwarris device Profi	8.	Reason not	Enumeration	NeedsSpareParts, NoFinance, NoFuel, Surplus, Dead, NotApplicable	N
Write feedback • Share interpretation Groups Feech for users, charts, maps, reports and resources	ak .		Enumeration	InUse, NotInUse, InStoreForAllocation	Y
Control for the second			Enumeration	For electric equipment, is it connected to a voltage regulator. Yes, No, Unknown, or NotApplicable. NA for non-electric	N
	yan ^{tha} yan th ct Health Office P chang	ne the second se	Enumeration	Electricity, Gas, Kerosene, Solar, Unknown	N



Refrigerator

Problem Statement

- Count every refrigerator
- Global data base of refrigerator and health facility info
- Analytics to make this information useful
- Caveats
 - Focus on low and middle income countries
 - Multiple levels of dashboards and distinction between global and country

data bases

2010 data

Kenya: 5306 facilities, 4946 refrigerators, Population 41 M Malawi: 827 facilities, 1426 refrigerators, Population 15 M Uganda: 2846 facilities, 3153 refrigerators, Population 35 M Zimbabwe: 1605 facilities, 3080 refrigerators, Population 14 M





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Cold Chain Equipment Inventories

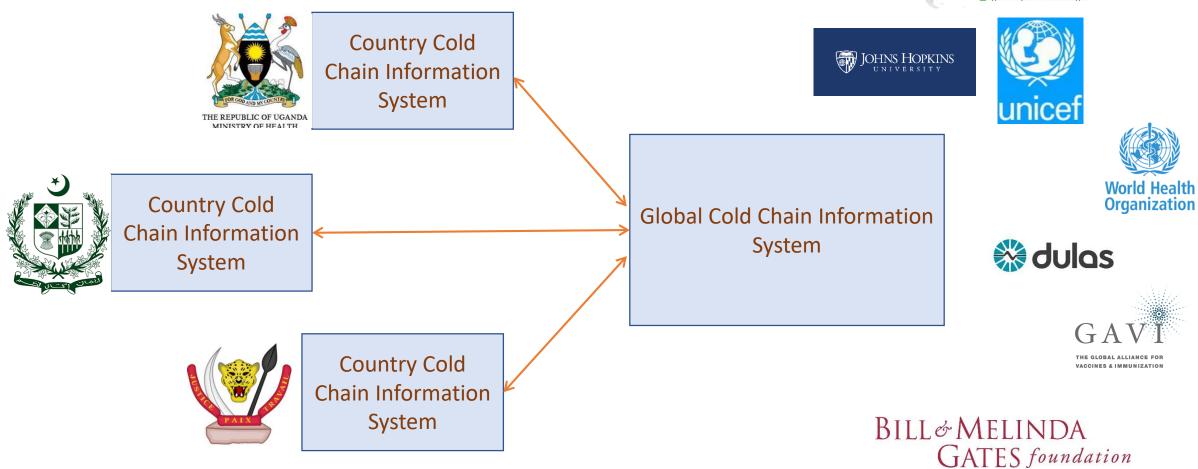
- No accurate global equipment inventories
- Inconsistent at the country level
 - Inventories often become out of date
 - Not updated for equipment changes
 - Health facility information is also a challenge
- Periodic efforts to collect inventory information for reporting
 - Often restricted to sampling
- Fragmented data sources
- Different health systems inside a country
 - Public, Private, NGO, Faith-based

dhis2	CCEM Nigeria	Maintenand							
	Equipment in Bakori A War	d Full divisio	n details						
•	Facilities Filter								
Federal Government	Administrative region	Health fa	cility name Cli	mate Zone Location	n Facility Type				
R Katsina State	Katsina State/Bakori Local Government Area/B	Katsina StatelBakori Local Government Area/Bakori A Ward/ Bakori LGA Cold Store Details							
B-Bakpri Local Government Area	Katsina State/Bakori Local Government Area/B	Katsina State/Bakori Local Government Area/Bakori A Wardi Maarrabar Danja Health Clinic Detailis							
Bakori A Ward									
Bakori LGA Cold Store	Refrigerators/Freezers	 Filter 							
Advantation Danji Harahin Cri Ji Balano II Wardi Hi Balano Kiwardi Naral Hi Casan Wardi Hi Jang Kabawa Mardi Hi Jang Kabawa Wardi Hi Kabama Wardi Hi Kabama Wardi Hi Kabawa Wardi	# Administrative region	Health facility name	g Name	CCEM equipment ID	Serial number	Year of Supply	Working sta		
	, Katsina State/Bakori Local Government	Bakori LGA MF 114- Cold Store MF 114-	Vestfrost		200040	1999	Working well		
		Bakori LGA MF 114- Cold Store MF 114-	Vestfrost		20080887257	2008	Working well		
			c fridge without freezer- c manufacturer		1736057	2009	Not working		
			c fridge without freezer- c manufacturer		A2R20770888	2011	Working well		
		Bakori LGA MK 074- Cold Store MK 074-	Vestirost		20013405613	1992	Working well		
		Bakori LGA MK 204- Cold Store	Vesthost		20071238077	2007	Working well		
		Bakori LGA MK304- Cold Store MK304-	Vestfrost		20062866112	2008	Working well		
		Bakori LGA MK 204- Cold Store	Vesthost		20071560830	2007	Not working		

1 - HEALT	H FAC	WCCEI Lass			
1. Facility code:					
Administrative levels and facility information 2. Province:		of health facility: only ONE box			
3. District: 4.Name of health facility:	National vaccine store Province vaccine store District vaccine store				
5. English name of health facility:	Provincial hospital Referral hospital Health centre A Health centre B				
Health facility immunisation activities					
7. Total population in area served by facility	r:	8. Facility coverage (per cent of population receiving immunization services from facility);			
9. Number of villages reached by facility (Or Health centre):	nly for				
10, Vaccine storage type: Mark only ONE box Depot Delivery Ocept and delivery No storage		11, Vaccine delivery type: Mark only ONE box Static Outreach Istatic and outreach No delivery			
Health facility energy sources available to power	r cold chail	n equipment			
11. Electricity source: Mark only OME box Grid Generator Grid and Generator None		12. Grid electricity availability per day: Mark only OME box More than 16 hours 8 to 16 hours 4 tot hours Less than 4 hours None			
13. Gas :Mark only ONE box Available Irregular Not available Unknown		14. Kerosene:Menk only ONE box Available Birregular Okt available Unknown Unknown			
Cold chain logistics information					
15: Vaccine supply interval (weeks):		16: Vaccine reserve stock requirement (weeks):			
17: Mode of vaccine supply: Mark only ONE box Delivered Collected Both delivered and collected None		18: One way road distance to closest supply point (in KM):			
19: Main supply point:		20: Secondary supply point:			

Vision

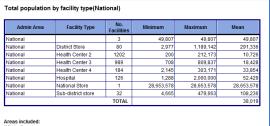


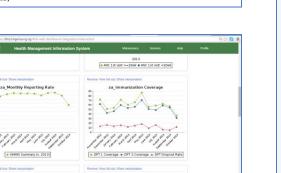


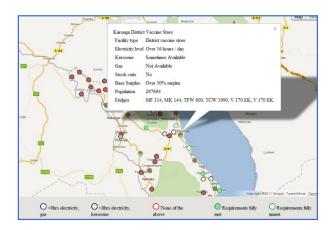
Part I: Visualizing the Cold Chain

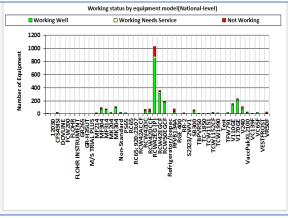
- Map based visualization
 - GIS Coords
 - Regions
- Global Management Questions
 - Country summaries
 - Equipment trends
 - Integrated analysis tools and models
- Country Cold Chain Management
 - Equipment management
 - Allocation
 - Reporting











Part II: Data Management

- Cold Chain Equipment Inventory
 - Basic equipment and facility information
 - Tracking of performance and maintenance
- Remote data updates
 - Keeping data up to date is the critical challenge
 - District cold chain supervisor responsible for managing equipment
 - Mobile App is feasible for district supervisors
- Integrate with other Health Information Systems
- Ownership by the country



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ODK-X

- Mobile data collection on Android Phones. Project started at University of Washington by Professor Gaetano Borriello
- Open Data Kit 1.0 aka ODK
 - Submission of forms
- Open Data Kit 2.0 aka ODK-X
 - Synchronization with a database
- Open source tools. Strong commitment to contributing to global good software

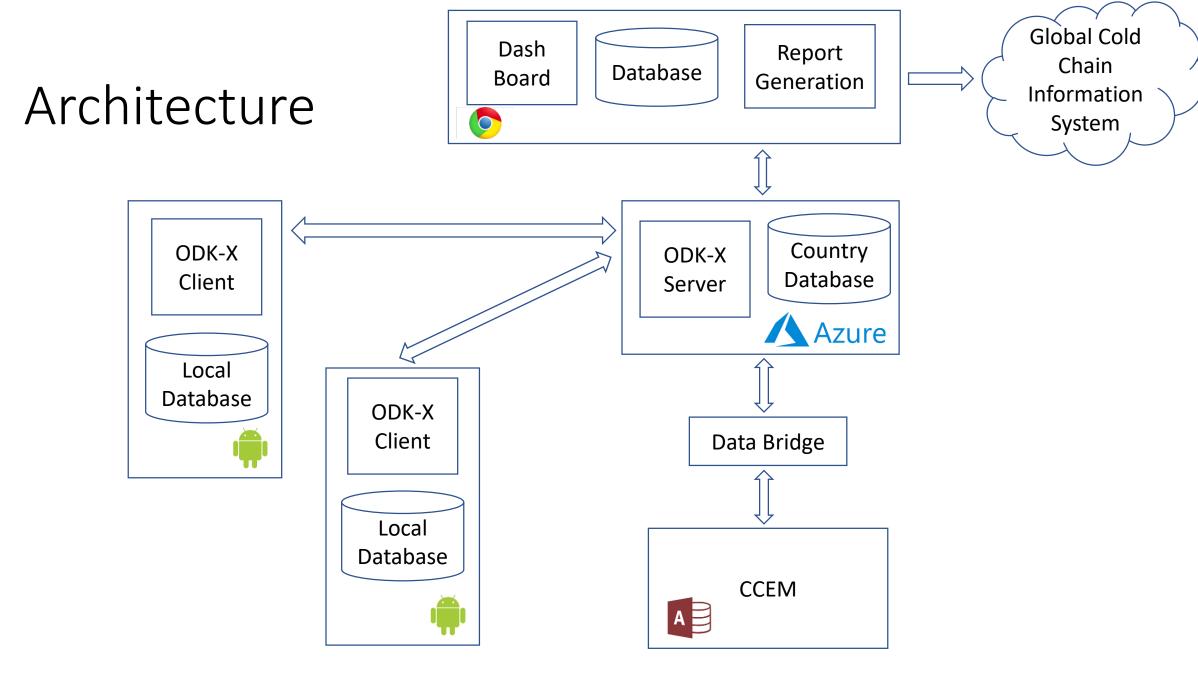




Cold Chain App

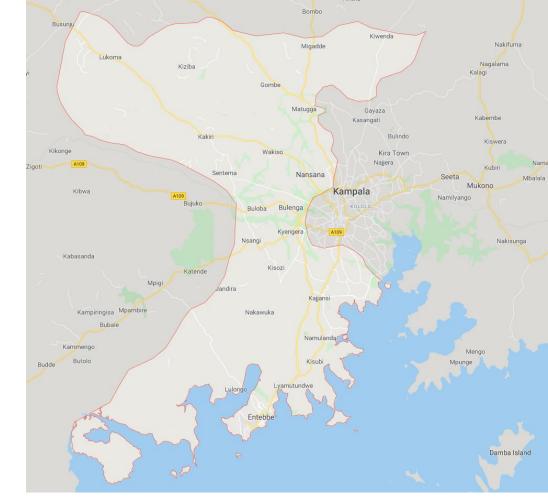
- App built on top of the ODK-X platform
 - Combination of ODK Survey and ODK Tables
 - Written in Java Script
- Manage a database of health facilities and refrigerators associated with facilities

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South	South East	Chisitu Dispensary	Chisitu Dispensary	Stock Information	Refrigerators Search	Refrigerator 941077	View Facility Information
South East	Belaka	Chinyama Health Centre	Basic Facility Information	Distance To Supply Vaccine Reserve Stock Point: 10 km Reg: 1	Prev 10 • Strowing 12 Of 2 Next Refrigerator: 32951031	Basic Refrigerator Information	Add Maintenance Record
South West	Machinga	Facility ID: 1019-0021	Health Facility ID: 1019- 0025 Facility Type: Health	Vaccine Supply Vaccine Supply Mode: Interval: 4 Delivered	Catalog ID: E3108m Health Facility: Chisitu Dispensary	Facility: Chistru Model ID: E3911M Dispensary Refrigerator ID: R898	
	Mangochi	Phloribe	Center Admin Region: Mulanje Ownership: Public	Refrigerator Inventory (2)	Refrigerator: 941077	Status: Awaiting Repair Voltage Regulator? Reason Not Working: Date Serviced: 2017-05- 05	View All Maintenance Records
1 Alexandre	Mulanje	Robrid Mulanye Mountain Forest Reserve	Power Information	Add Refrigerator	Health Facility: Chisitu Dispensary	Service Priority: High	Edit Refrigerator Status
	Phalombe	Luchenza Marge 1 Karge	Electricity Source: Grid Grid Availability: More Than 16 Solar Suitable Climate?	Edit Facility		View Model Information	Edit Refrigerator
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Project Status

- Cold Chain Visualization project
- Cold Chain App prototype
- WHO Deployment
 - Haiti, Pakistan, DRC, Bangladesh
 - Sentinel Surveillance officers
- GAVI Deployment Uganda
 - Two regions Kampala and Wakiso (13 Districts)
 - Possible expansion to national scale



Challenges

- Data Challenges
 - Initial collection and cleaning
 - Name resolution
 - Country administrative regions
- Mobile App
 - Data connection, on-line/off-line
 - Usability
 - Android Phones
- Country Deployment
 - IT support and training

- Project Scoping
 - Software can do anything . . .
 - Boundaries with other health information systems
- Hosting and Data Ownership
- Country specific versus general
- Sustainability
 - Planning for partnership with Makerere



Can this be made global scale?

- Technologically, yes
- Architectural choices are straight forward
- This is not big data
 - Estimate 200,000 Health Facilities and 300,000 Refrigerators
- Data management
 - Administrative and geographic data across 70 countries will be a significant challenge
- App deployment
 - Diverse deployment settings
 - Challenge of producing multiple versions of App on per country basis
- Split global and country management
 - Determination of global verses country data

Does it provide sufficient value to cover the cost

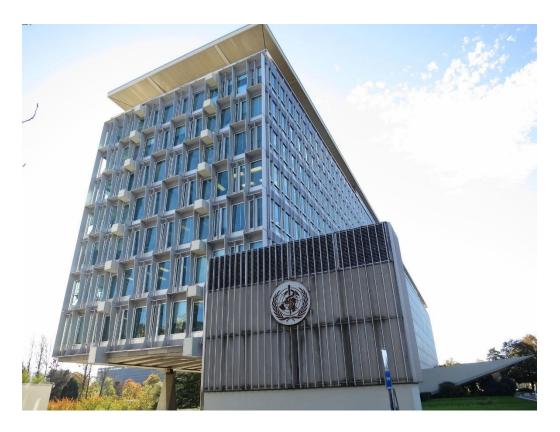
- Global immunization has substantial resources
- Cost of developing and maintaining this is modest
- But this only makes sense if has quantifiable benefits





Value at the Global Level

- Ensure adequate immunization cold chain
- Equipment purchase and distribution
- Implementation and management of equipment
- Market shaping



Value at the Country Level

- Immunization System Management
- Equipment Allocation
- Equipment Management
- Strategic decisions
- Reporting
- Interactions with Global Level



Research Questions

- Multiple country deployments underway
 - Thirteen Districts in Uganda
- Potential long term deployment in Uganda
- What can we learn at this stage of the project?



Technical questions

- Performance and usability of ODK-X application
- Global administrative data pipeline
- Data cleaning pipeline for country data
- Multi country App and system deployment



Country Questions



- Does the project yield a usable and up to date cold chain equipment inventory
- Updating inventory last good inventory in Uganda was 2011 with a partial update in 2014
 - Can Uganda's cold chain equipment be inventoried by district cold chain technicians using the mobile application
- Does the system help or hinder district cold chain workers
- In which processes is the data used
- What is the country costs of maintaining and managing the system

Global Questions

- How do country and global level systems interact
- How does the global cold chain mapper fit with other systems and information sources
- How can more accurate and complete country data be used for improved global support for immunization





Taking the project live

- Training January 28-30
 - 4 UW people + 2 PATH
 - 15 cold chain technicians
 - 15 other people from ministry
- Methodology
 - Powerpoint presentation
 - Instruction
 - Walk through
 - Exercises
 - Hands on training with the application

Training

- 14 of 15 technicians were already familiar with Android phones
- MoH Android phones were distributed to all
- Quick understanding of the cold chain application
- Hard parts of training were
 - Configuring the application
 - Managing synchronization and the possibility of data conflicts

ODK-X

- Behind the scenes concerns
- App installation a slow process as the entire database is installed
- 30 users simultaneously hitting the server on a unknown networking environment
- Stress test on conflict resolution
- Necessary to collect and reconfigure all devices each night
- Move from a test server to the live server the last day
- Technology worked very well throughout
 - Good performance and few issues

User reactions

- Surprise at list of health facilities for each district
 - Differences between national view and district view
- Discussions on user permissions for operations
 - Handling of dangerous operation
 - Some workflow issues
 - Who has permission to delete, move refrigerators
 - Who handles administrative updates (e.g., adding health facilities)

Training summary

- Capacity development for Development Engineering interventions is critically important
- A practice run with training materials in Seattle was very helpful
- Carefully constructed time schedules had to be discarded
- Last minute changes in the application added to the stress of implementing training
- Lots of work for trainers outside of training sessions
- Considered to have been successful

Deployment: Feb 1 to April 30

- Scale: Approx 400 health facilities and 600 refrigerators
- Data update (through March 15): Approx 80%
- Information collected on need for refrigerator maintenance and temperature alarms
 - Leading to various actions on refrigerator repair / replacement
 - Existing system where additional information allows new actions
 - Demonstrates feasibility of collecting performance data
- A small number of erroneous entries
 - Usability / training issue
- One escalated issue on synchronization

Questions and Discussion







