EMORY UNIVERSITY | CGSW Center for Global Safe WASH | Leading and Learning in WASH

The Sustainability of Water Treatment Systems in Healthcare Facilities in Ghana and the Water Infrastructure and Water Quality Which Contribute to Sustainability

Compiled by:
Mia Gallegos, MDP, Public Health Program Associate, Emory University

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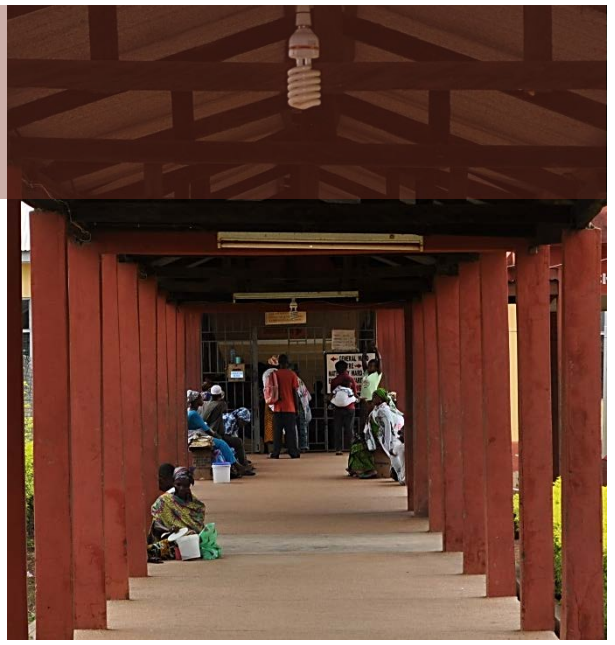
GE Foundation

Hospitals in Ghana are….

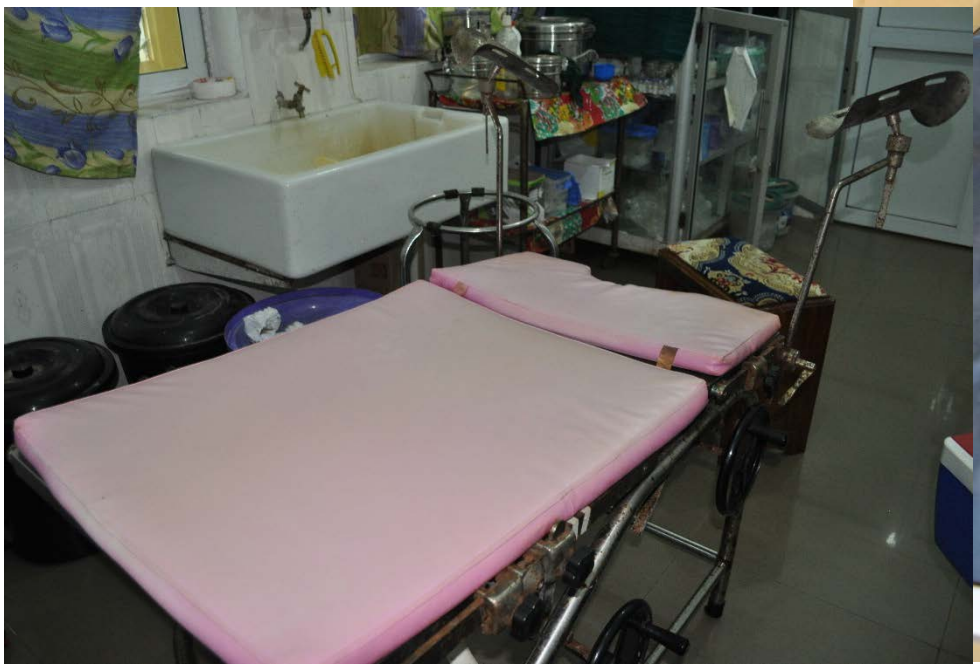
… Busy

…Crowded



… Chaotic

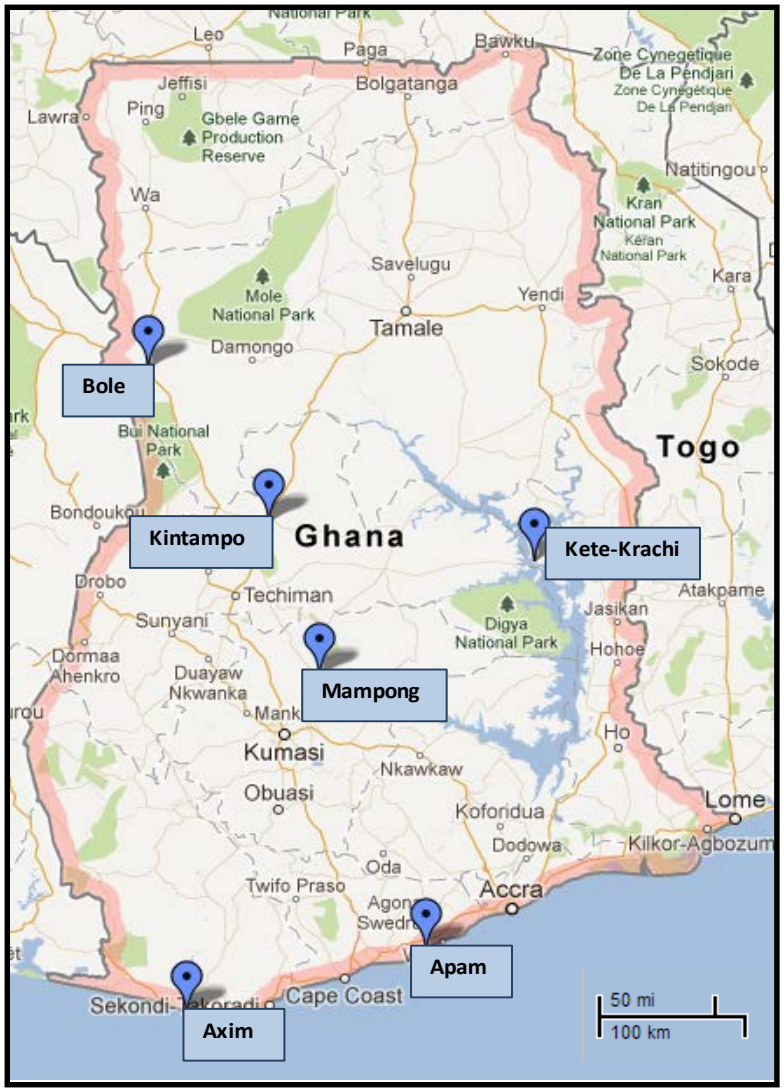
… unclean floors and surfaces



… poor infrastructure

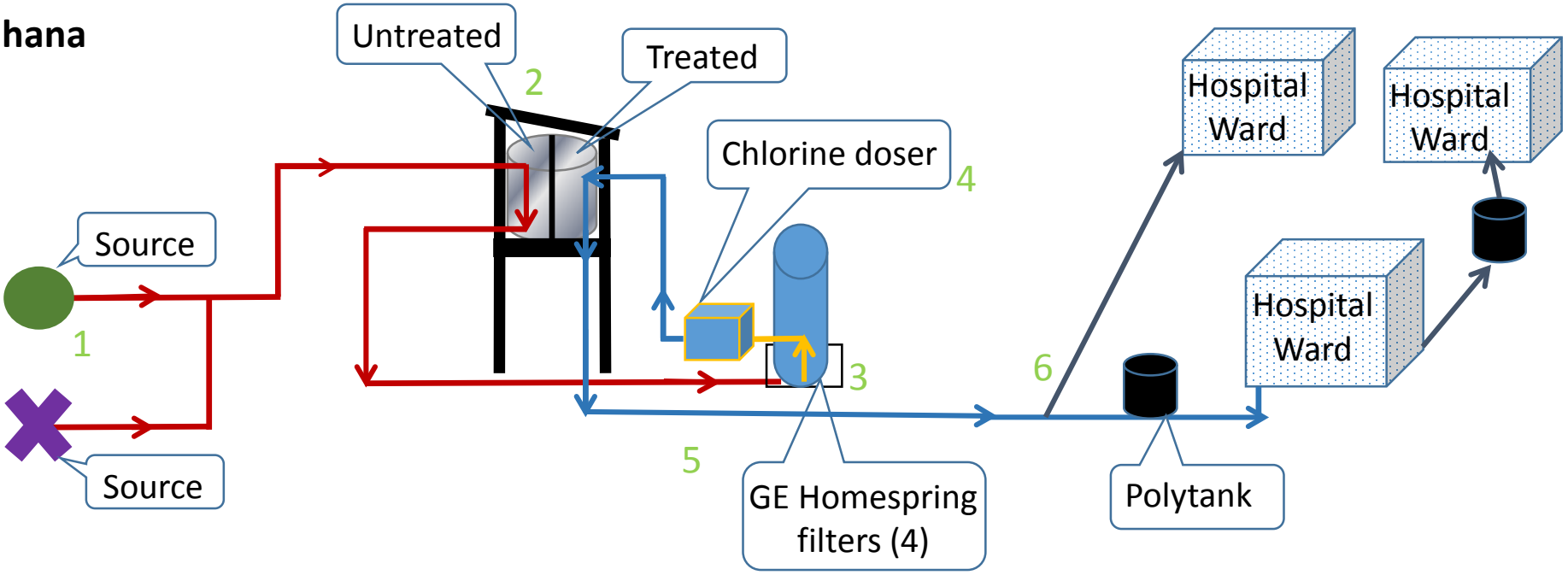
Project Overview

- General Electric Foundation (GEF) donated decentralized water filtration systems (DWFS) to 5 hospitals with **Homespring filters and chlorination systems**, 1 hospital with a sand filter system.
- **District Level Government Hospitals:**
  - 90-100 hospital beds
  - 100-200 patients in clinic per day
  - Rural areas



Typical Filtration System and Piped Water System Map

Ghana



Project Objective

1) To evaluate **water access**, **the use of safe water infrastructure for hygiene practices**, and the **quality of water** in healthcare facilities in developing countries.

2) To determine **sustainability** of ultrafiltration water treatment systems for healthcare facilities.

Methods

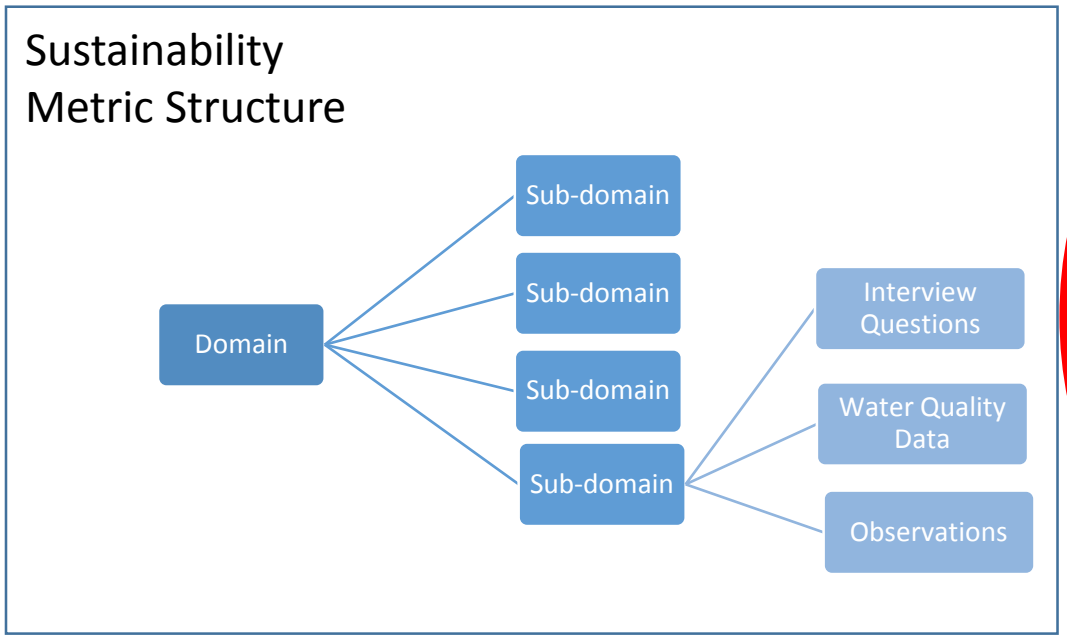
Emory MPH student, Ledor Igboh, thanks a nurse after an interview (Ghana).

Emory MPH student, Samantha Lie-Tjauw, evaluates the hospital water infrastructure (Honduras).

Mixed Methods Approach:

- **6 Health Care Facilities in Ghana**
  - **Survey data:** interviews addressing knowledge, attitudes, and practices related to water provision and use in the hospital. (N=~300)
    - **In-depth interviews** with administration, directors, maintenance, and lab personnel
    - **Surveys** with care providers, staff, patients, and visitors
    - **Facility inspections and Observations** regarding water/sanitation infrastructure
  - **Lab data:** Tested water samples for microbial and chemical indicators of water quality. (N=~750)
    - Total Coliforms, *E. coli*, *Pseudomonas aeruginosa,* Chlorine Residual, and Turbidity

Methods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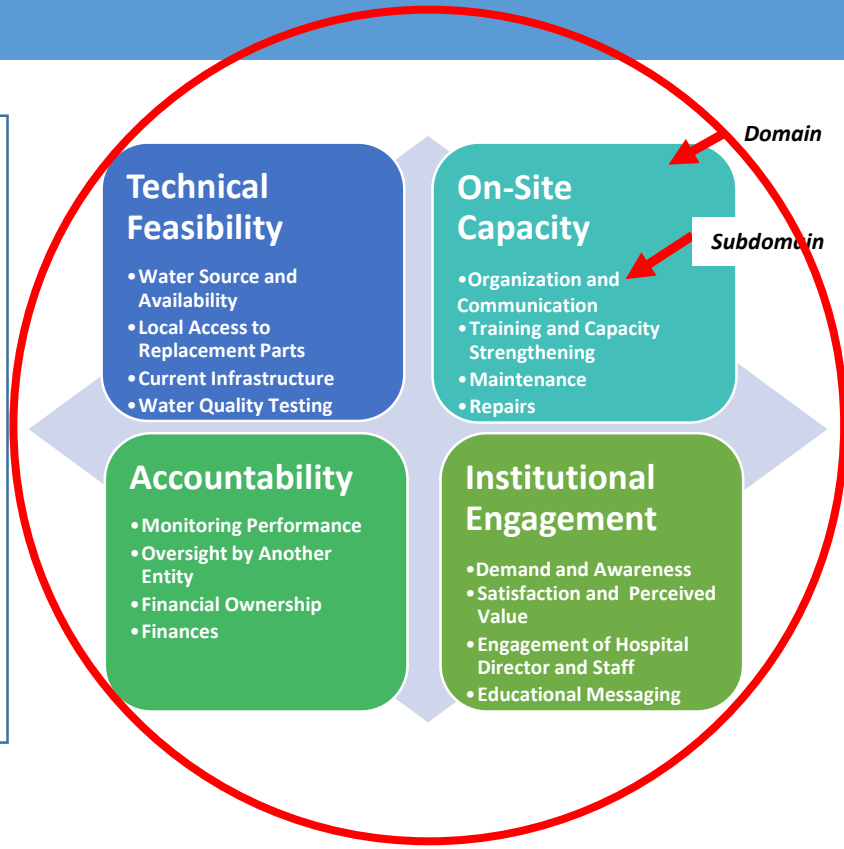
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•Training and Capacity Strengthening
•Maintenance
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•Monitoring Performance
•Oversight by Another Entity
•Financial Ownership
•Finances
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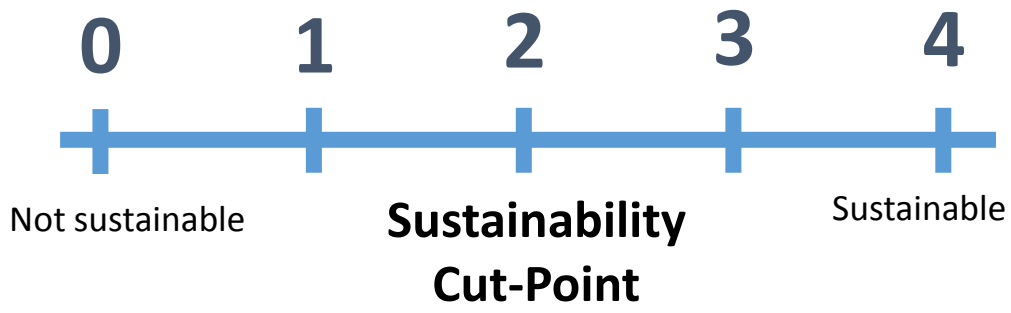
•Demand and Awareness
•Satisfaction and Perceived Value
•Engagement of Hospital Director and Staff
•Educational Messaging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1
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3
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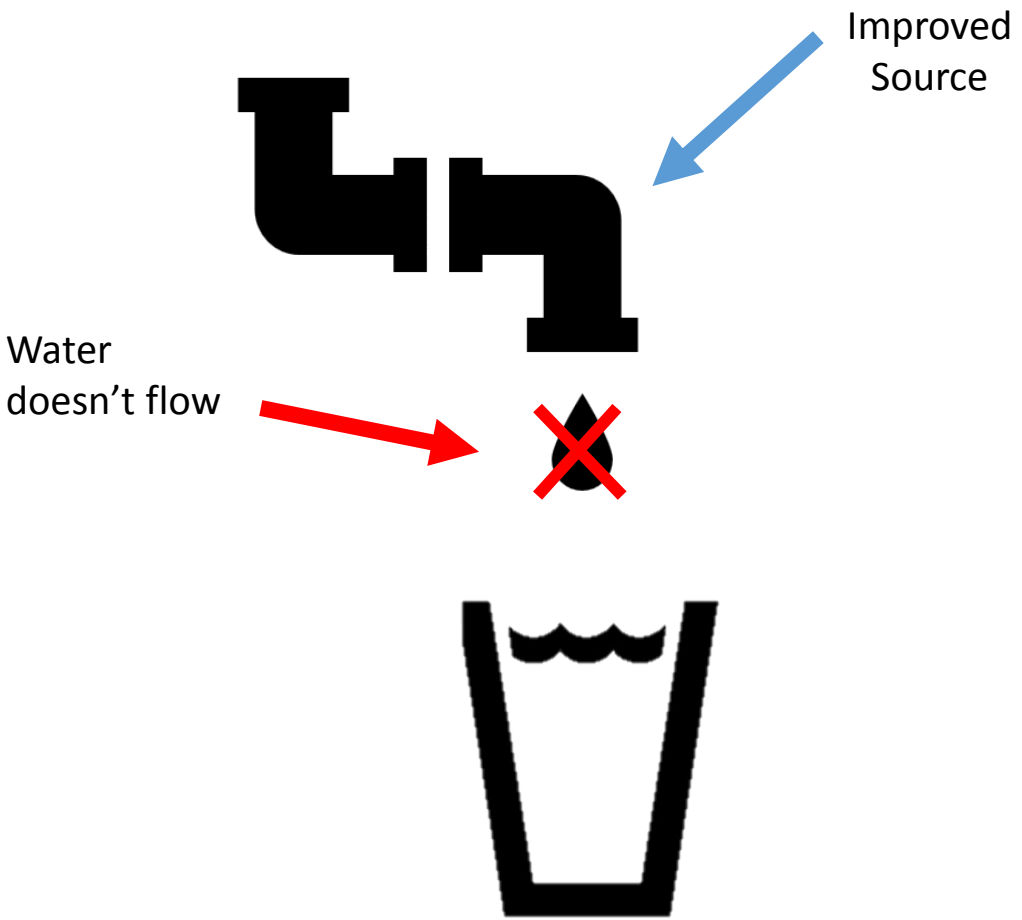
Not sustainable
Sustainability Cut-Point
Sustainable

Water Access



Shortages

In Ghana, **hospitals** on average **experienced water shortages once a week**.

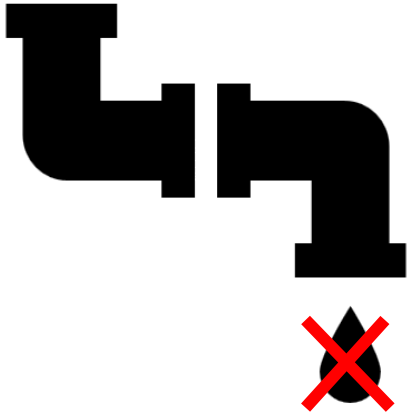
Shortages occur due to **seasonal changes** and frequent **power outages**.

Duration of the outage **varies**.

While hospitals in Ghana have access to an improved water source... hospitals do not have consistent water flowing from the taps 100% of the time.

Access to Safe Water Infrastructure and Hygiene

In addition to



Shortage issues

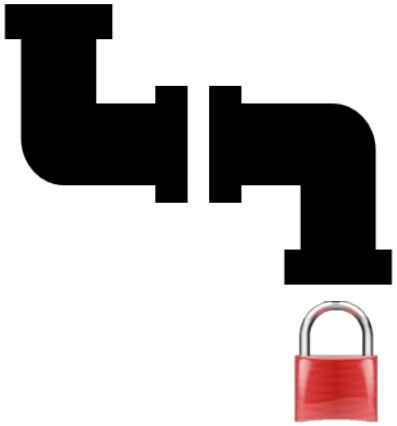
Taps are often …

Non Existent

Non Functional

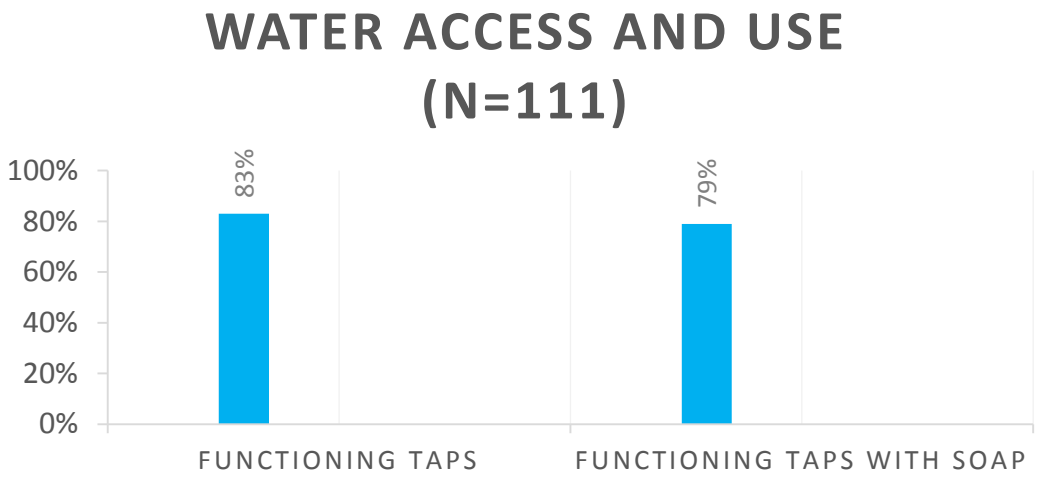
Locked

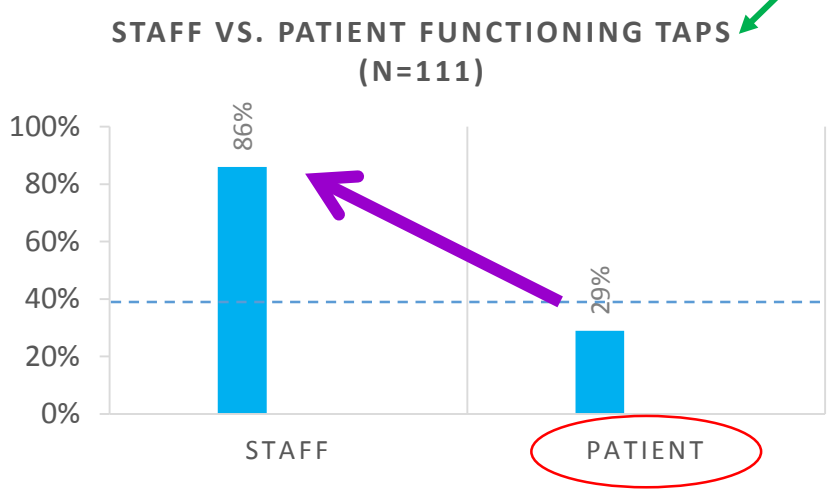
There are

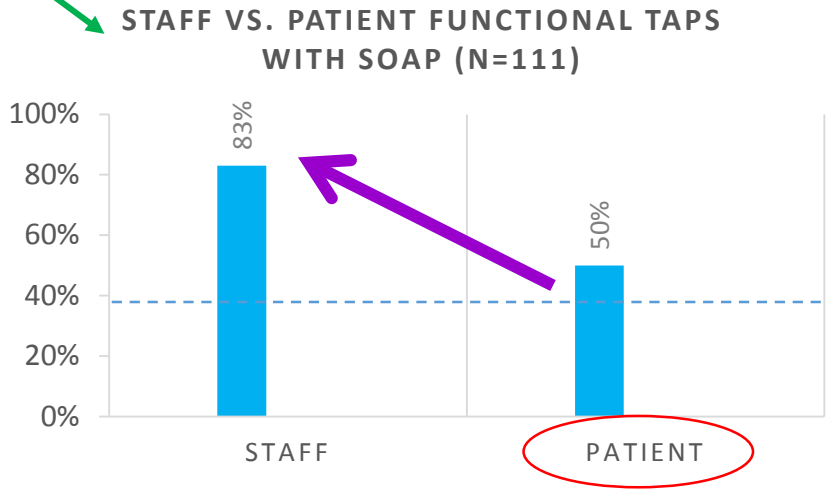


Access issues

Results – Water Access and use – Handwashing and Sanitation







Staff had better access to hand washing facilities and soap than patients.

Patient hand washing facilities are needed in order to increase patient hygiene practices and decrease the potential for hospital-acquired infections.


KIRKLAND

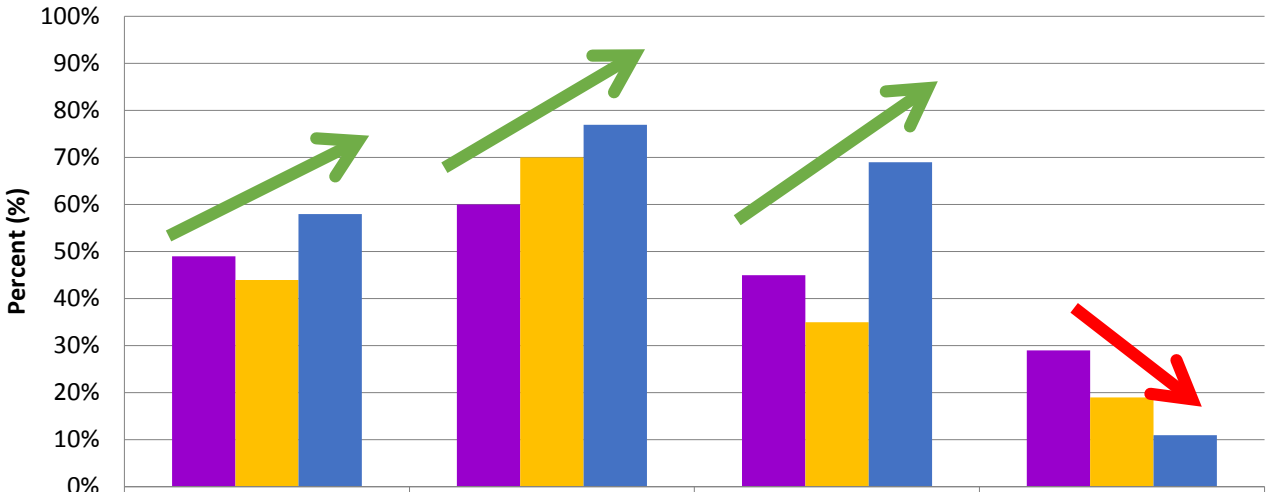

MEXX
OIL FILTER
MX

Water Quality Data

Water Quality Results -*Has the water quality changed over time?*

- The CGSW tested water samples for Total Coliforms, *E. coli*, *Pseudomonas aeruginosa*, turbidity, and free as well as total chlorine.
  - Positive change in water quality overtime
  - Percentage of samples that meet standards are improving.
  - Chlorine levels are not within WHO recommended range. In Ghana adherence to chlorine application protocols varied by hospital but overall levels were found to be low due to issues of chlorine supply.

Percentage of POU samples from Ghana that met standards between 2013-2015 (N=262)



	Total Coliforms	E. coli	Pseudomonas aeruginosa	Free Chlorine
2013	49%	60%	45%	29%
2014	44%	70%	35%	19%
2015	58%	77%	69%	11%

***WHO Guideline:** <1 MPN/100 mL

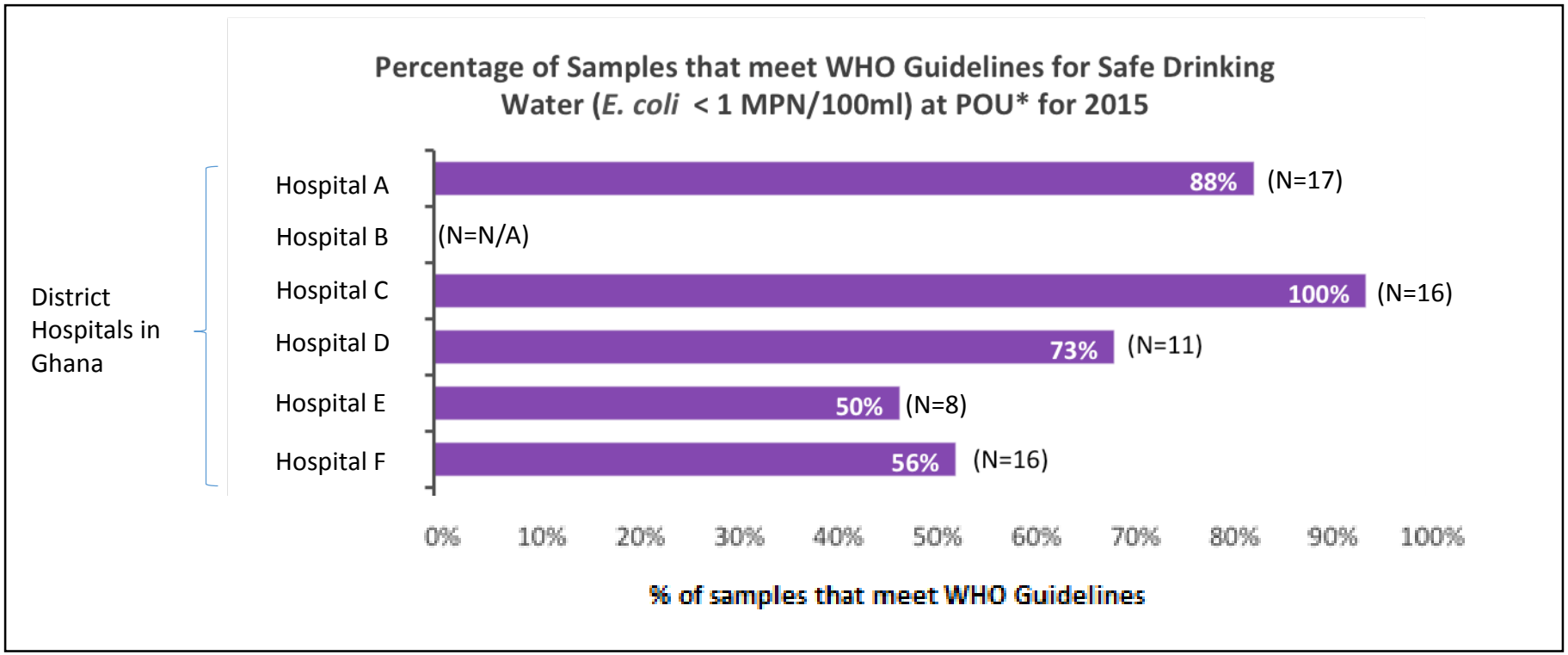
****CDC Safe Water System Guidelines for free chlorine residual:** 0.20-2.00 ppm

† Currently standards do not exist for *pseudomonas aerugionsa* because infectious dose has not been determined. According to expert opinion concentrations >10,000 MPN per 100 mL found in water could be of public health concern. This table notes the presence of *pseudomonas aerugionsa* in samples.

****** POU:*** Point of Use, Filtered water that comes from the tap within the department. POU samples in Ghana include samples collected from the tap as well as Veronica Buckets.

Water Quality Results

- Water quality results varied by hospital.
  - Only one hospital was able to achieve consistent access to water, which met WHO guidelines.



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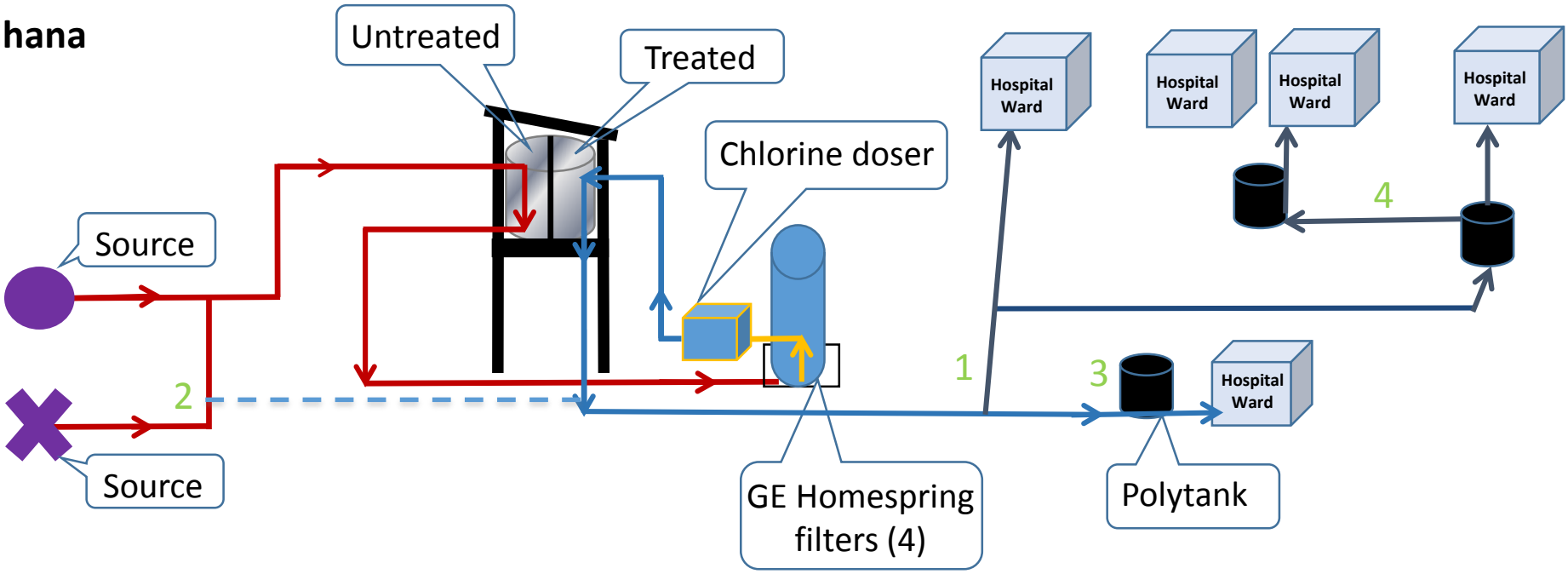
Typical Filtration System and Piped Water System Map

Ghana



- What makes delivering quality water difficult?
  - There are multiple buildings.
  - Built at different times by different groups.
  - No records of maps of the plumbing.
- Water quality can decrease within the piped network in the following ways:
  1. Water can flow directly from the filtration system into the wards.
  2. There can be multiple sources of water, some passing through the filtration system some not.
  3. Water can be stored in a polytank then go to the hospital ward.
  4. Water can cascade from 1 polytank to another then go into hospital wards.

Water Storage Containers

Typical Filtration System and Piped Water System Map

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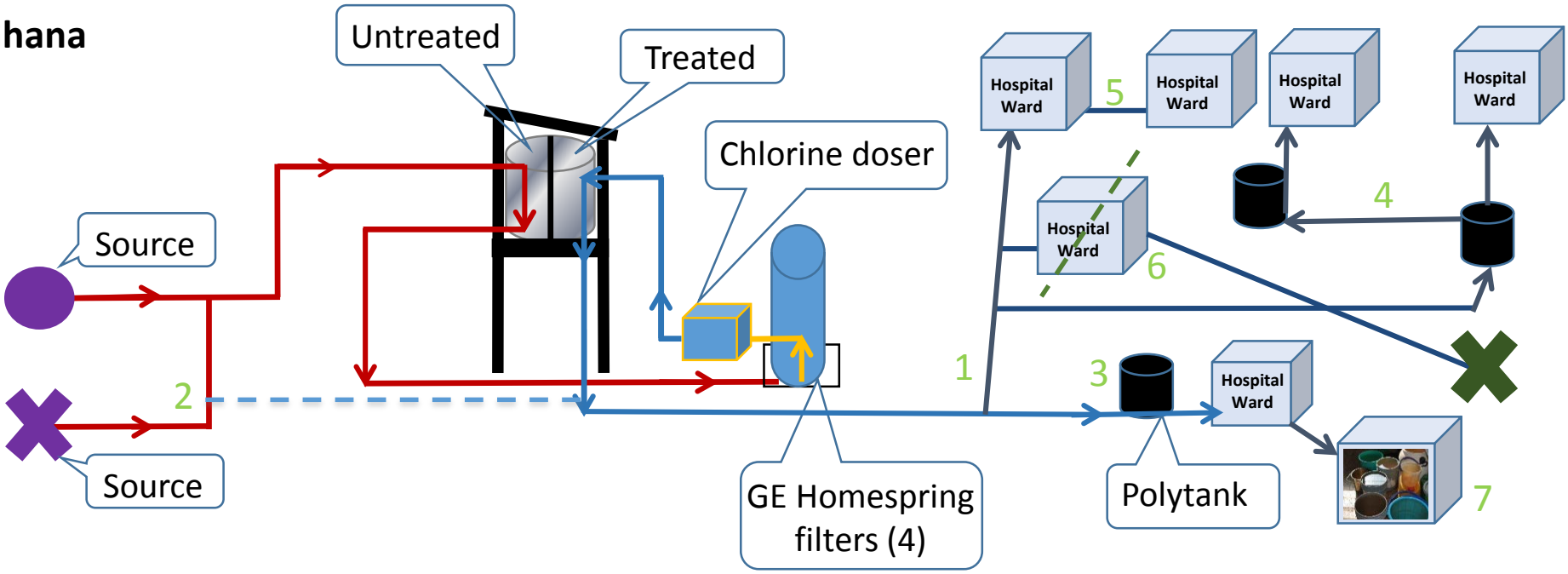

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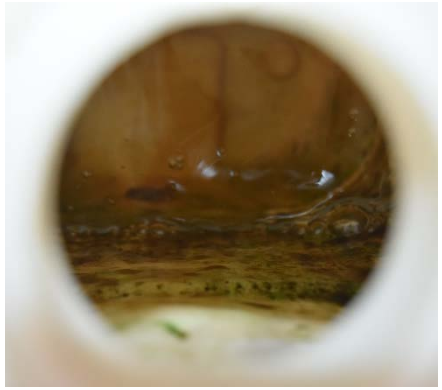
  3. Water can be stored in a polytank then go to the hospital ward.
  4. Water can cascade from 1 polytank to another then go into hospital wards.
  5. Water can flow directly from one ward to another.
  6. Hospital wards can be piped differently. (ex: half of the ward can be piped to receive filtered water, the other can be getting treated water).
  7. Water can be stored in various containers (ex: Veronica Buckets, bowls, jerry cans, and drums).

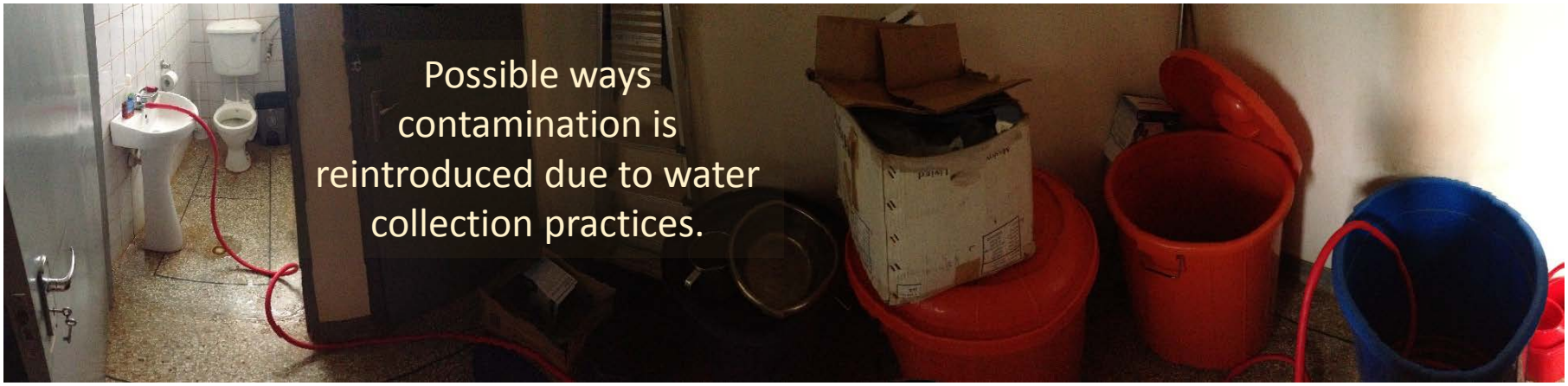
Water Storage Containers

Water Storage Containers

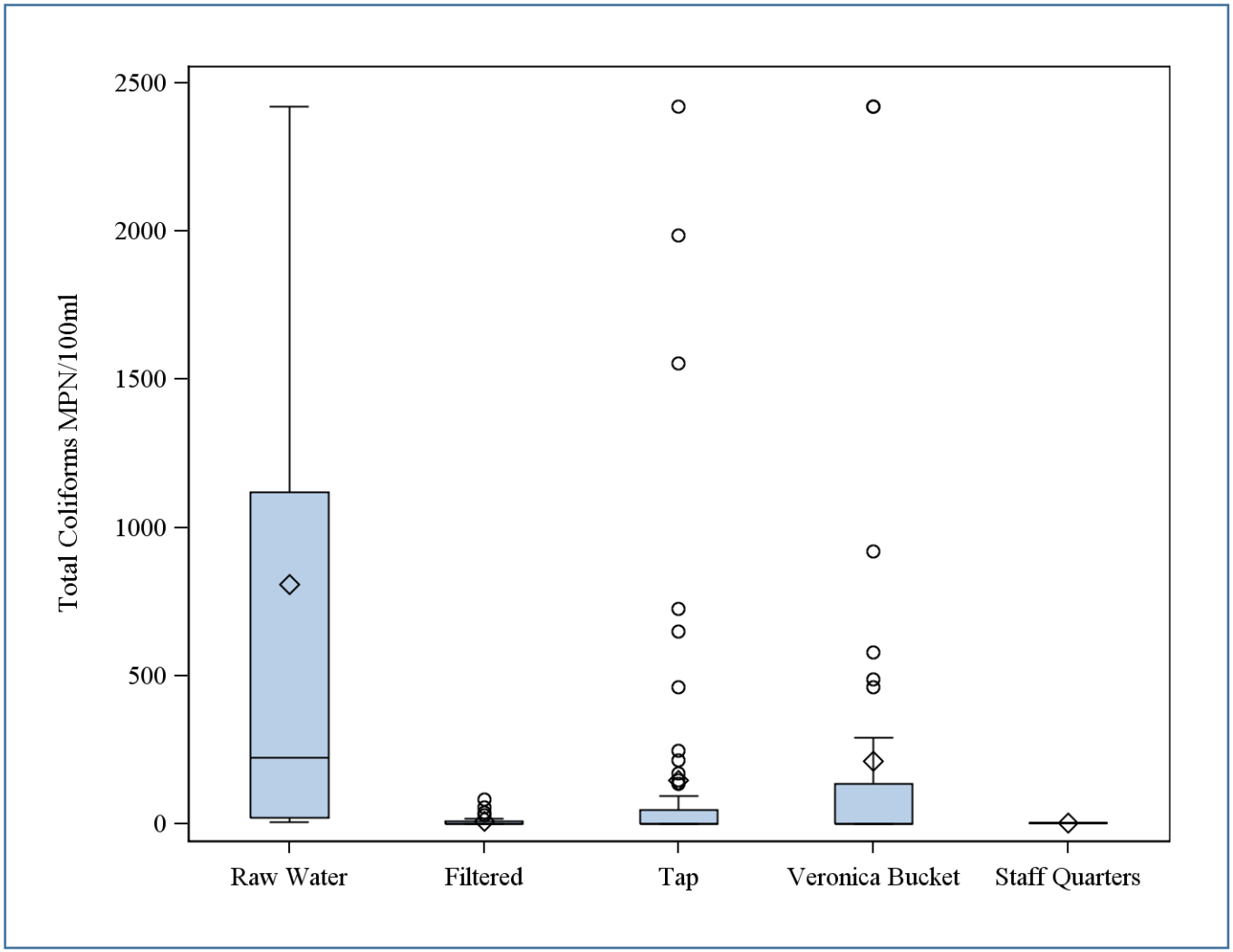


WHO Guidelines for Chlorine Residual: 0.20-2.0 ppm

If water remains in storage containers for more than 24 hours chlorine residual will not be present. (As seen in this picture). Additionally if storage containers are not cleaned regularly, chlorine residual levels will be lower than in storage containers that are cleaned regularly.


Possible ways contamination is reintroduced due to water collection practices.

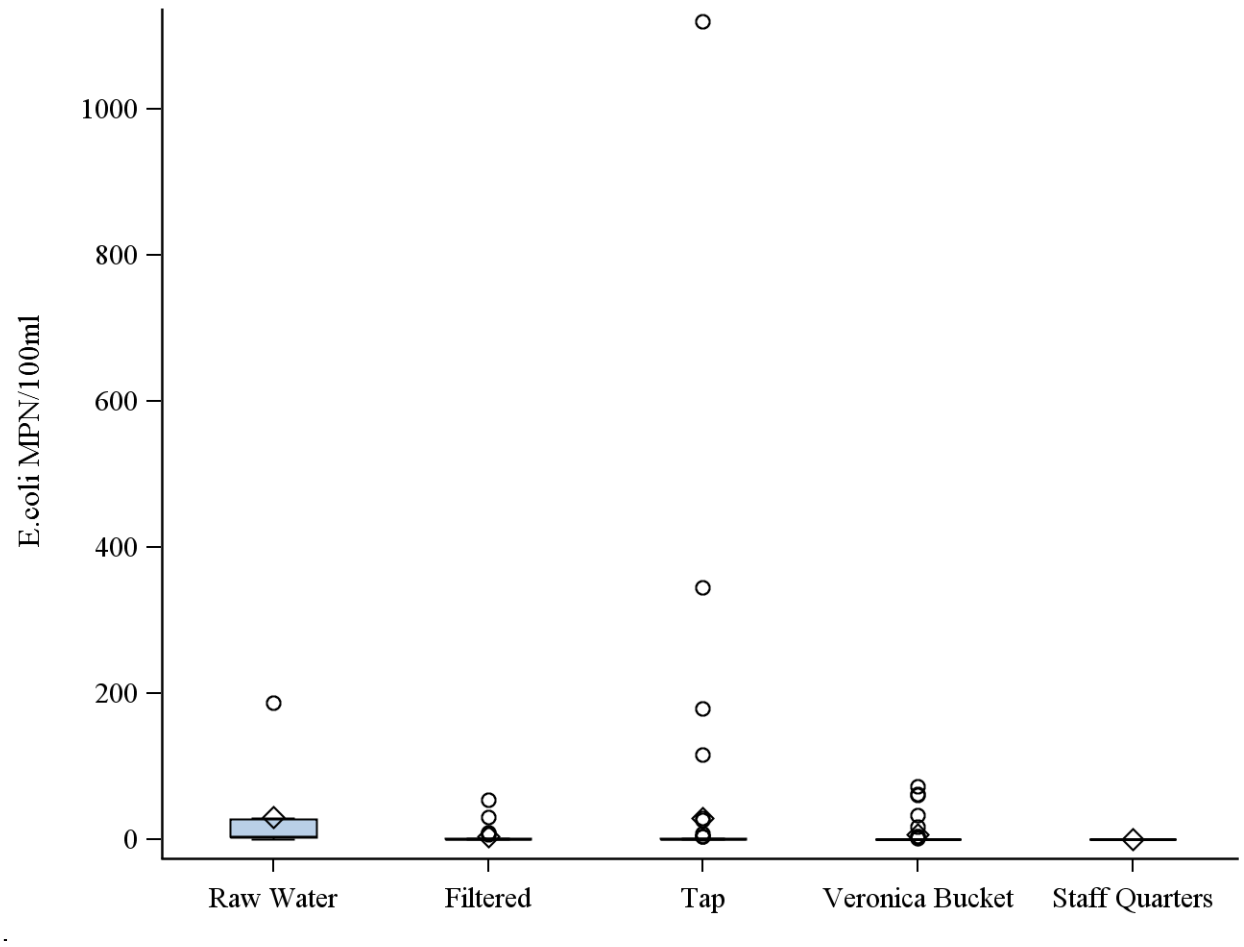
Water Quality Comparisons: Total Coliforms in Raw and Treated Water - 2014



Raw water was more contaminated than the filtered water and the tap water. However there was a rise in total coliforms in the water storage containers.

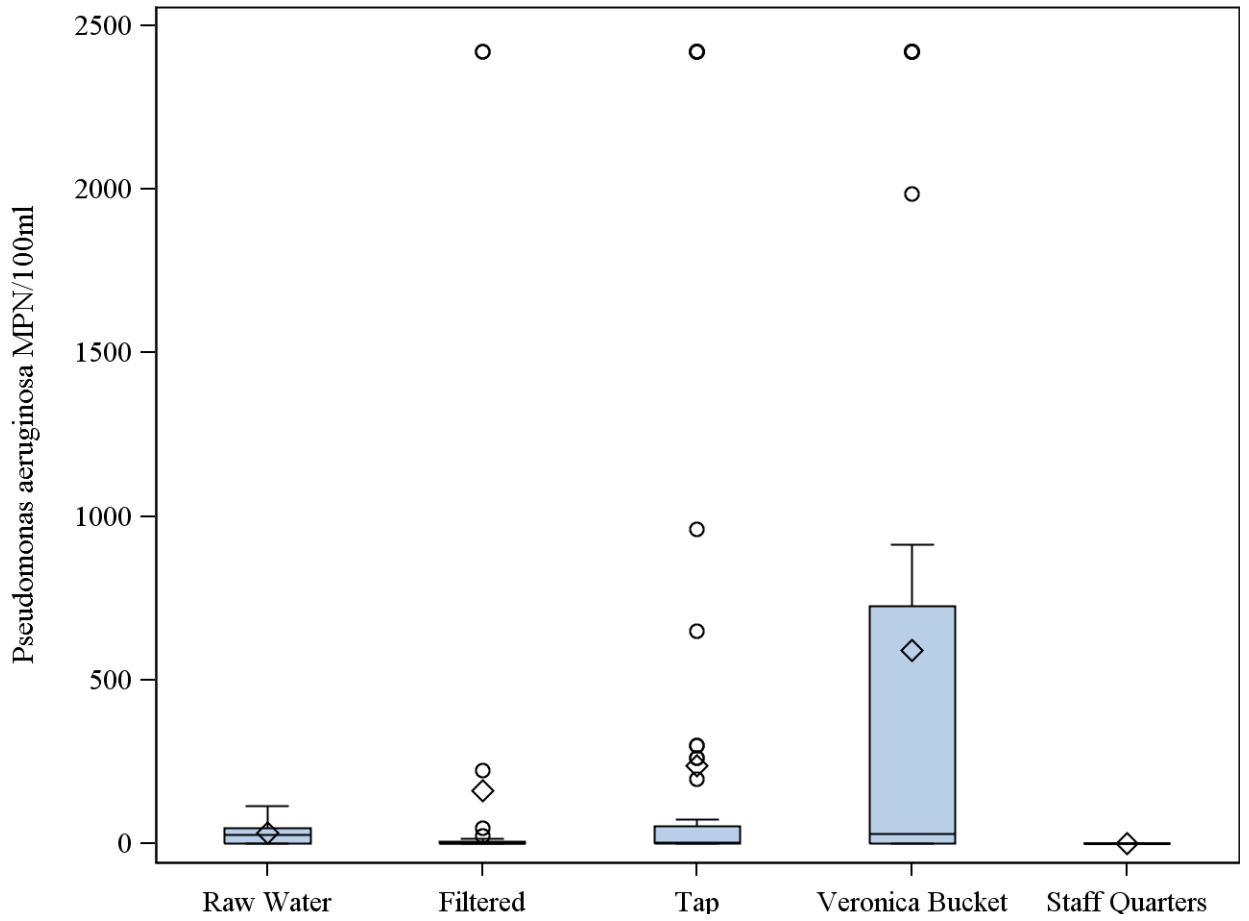
Dirt and biofilm inside a piece of pipe cut from hospital network.

Water Quality Comparisons: *E. coli* in Raw and Treated Water - 2014



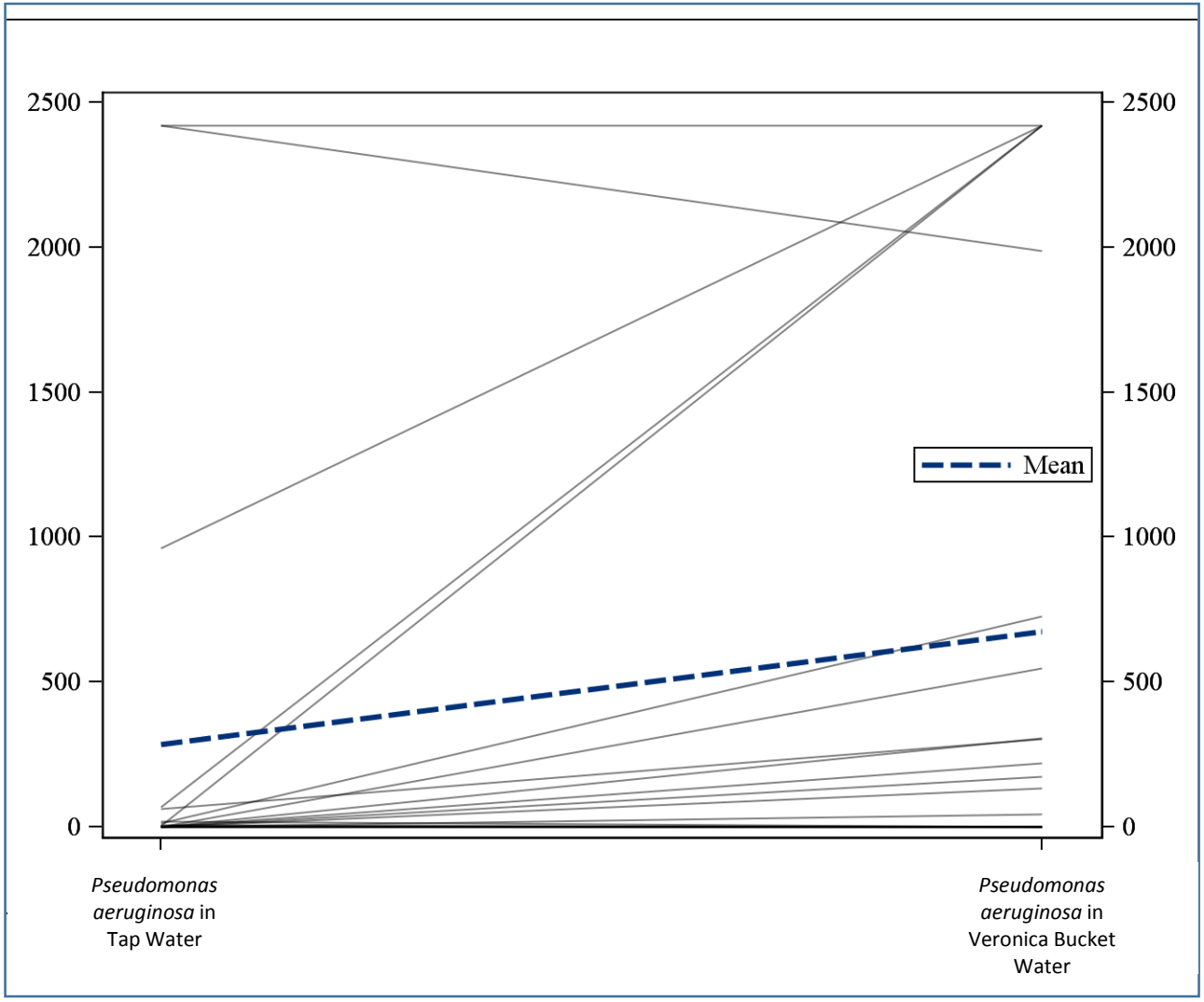
Raw water was more contaminated with *E. coli* than the filtered water. Recontamination with fecal bacteria was occasional.

Water Quality Comparisons: *Pseudomonas aeruginosa* in Raw and Treated Water - 2014



Pseudomonas aeruginosa was present in raw or filtered water but not in large amounts. Noticeable concentrations in tap water and Veronica Bucket water were found.

Water Quality Comparisons: Paired Profiles for Tap and Veronica Bucket Samples - Water - 2014



Most paired samples follow the same general trend and the change was significantly different.

(P value of 0.03).

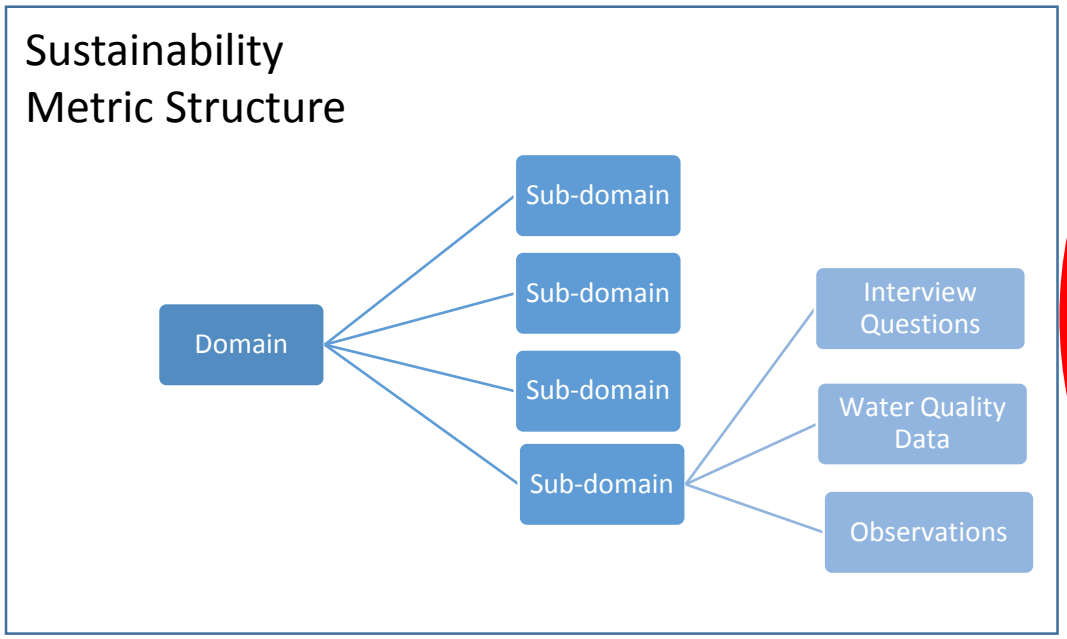
Water stored in veronica buckets within hospital wards are highly contaminated with *Pseudomonas aeruginosa*. For this reason, it is recommended that the use of veronica buckets should be **minimized** and **ultimately discontinued.**

Water Storage Containers

- The CGSW found contamination in Veronica buckets at 6 hospital sites in Ghana.
  - Buckets were used at all 6 hospital sites and were rarely cleaned.
- After Veronica bucket cleaning protocol and management system was implemented:
  - The presence of total coliforms, *E. coli,* and *Pseudomonas aeruginosa* were not found in 94% of samples collected from veronica buckets.
- Water quality was better in the hospitals that did not use Veronica buckets.

Sustainability Scores

Methods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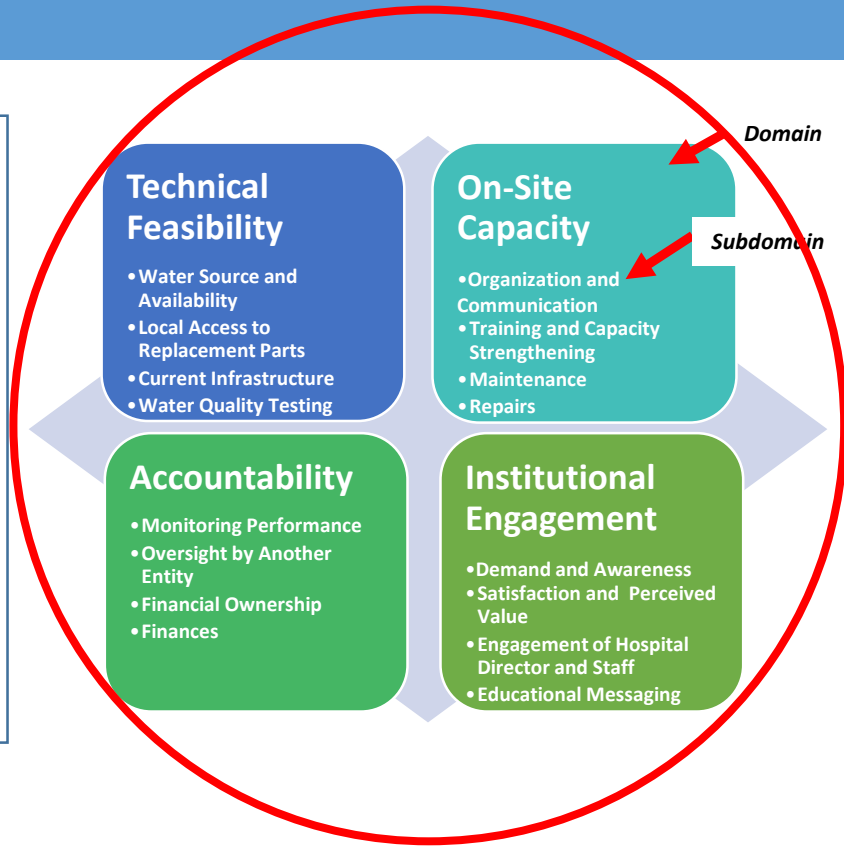
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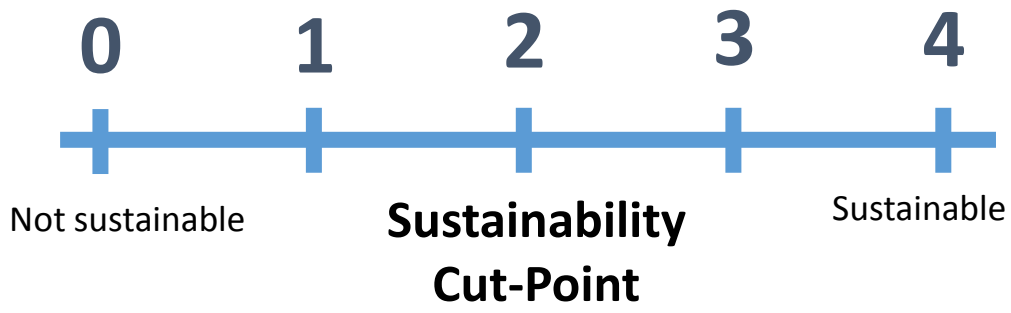
0
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2
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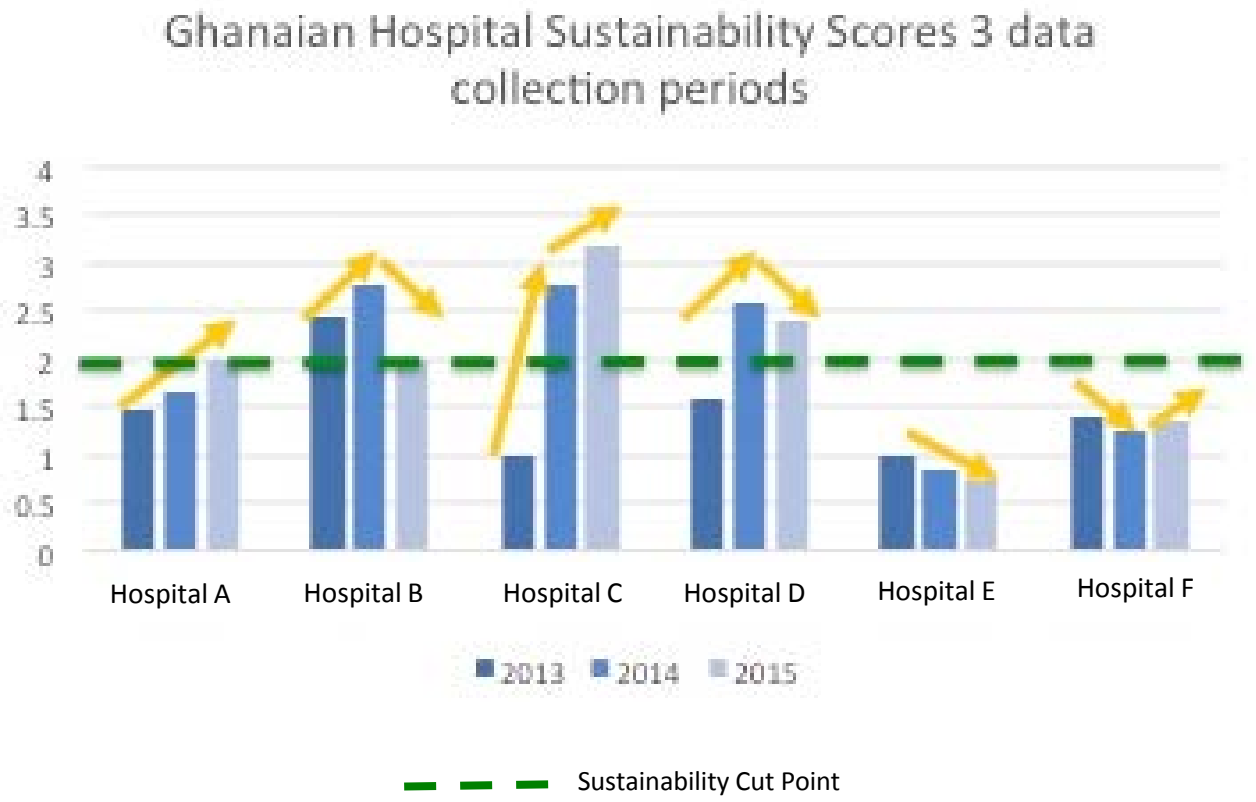
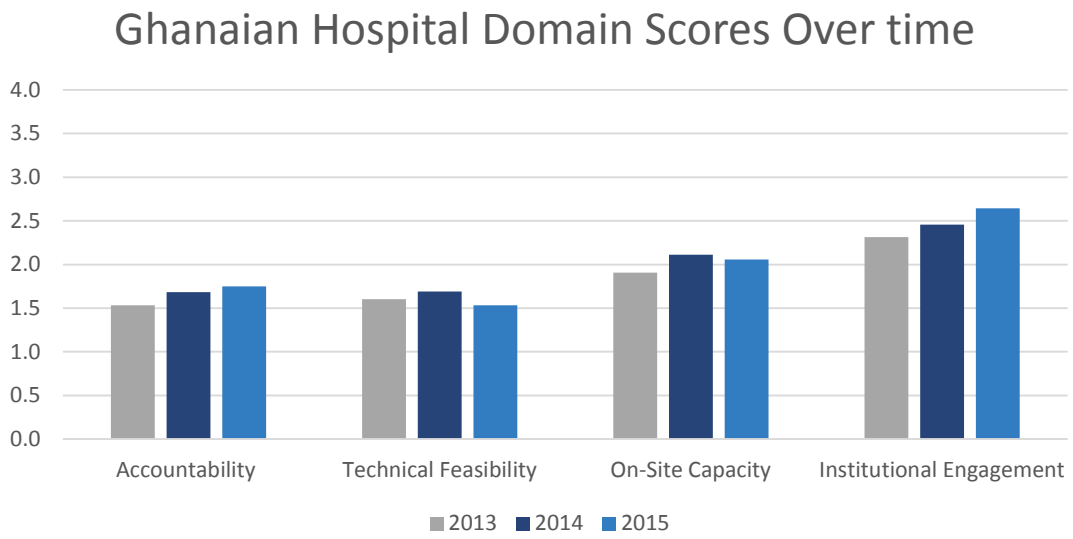
4
Not sustainable
Sustainability Cut-Point
Sustainable

Sustainability Scores Changes Over Time – Differences at the Hospital Level



Trend for Change: Varied for Ghanaian Hospitals over time.

Hospital Domain Scores during 2013, 2014, & 2015 Data Collection



	Change between Baseline (2013) and Endline (2015)
Accountability	+0.22
Technical Feasibility	- 0.07
On-Site Capacity	+0.15
Institutional Engagement	+0.33
Overall Change	**+0.16**

	Yearly Hospital Domain Scores		
	2013	*2014*	*2015*
Accountability	1.5	1.7	1.8
Technical Feasibility	1.6	1.7	1.5
On-Site	1.9	2.1	2.1
Institutional Engagement	2.3	2.5	2.6
Overall Sustainability Score	**1.8**	**2.0**	**2.0**

Three out of four domain scores showed a positive change between baseline and endline. The domain of Institutional Engagement showed the most change over time.

Results: Hospital water access in Ghana

- Water outages were a major problem
  - In Ghana, on average water stops flowing **once every week**
- Why does the water stop flowing?
  - Dry season, unpaid water bills, power outages, staff used to coping with shortages – TIA mentality
- How do hospitals cope with this?
  - Tanker trucks, water storage cisterns, limited access for patients and families, and bucket taps

WASH in HCF Recommendations

- SYSTEMS: Need for greater recognition and advocacy by healthcare systems/providers for improved WASH in healthcare facilities
  - Strong health care systems which can support ($) but also with good management
    - Impact of poor WASH on health service delivery and outcomes
    - Impact of poor WASH on infection control

- STUFF: Need to recognize that antibiotic use, personal protective equipment, and sterilization equipment are only part of infection control. → Water, infrastructure, etc.
  - Functional handwashing facilities and toilets, availability of soap and disinfectants, and proper waste disposal are also critical for infection control
  - Especially critical in low-resource settings where there is less use of disposal supplies and more reuse

- STAFF: Poor WASH in HCF is not just due to lack of infrastructure and resources – training and engagement of hospital directors and staff can make a big difference. Management is also key!

Four Lessons Learned: How MOH and NGOs can help

1. **Access to water** should be the first priority in order to achieve basic hygiene and sanitation within healthcare facilities.

2. **Veronica buckets cleaning protocols** and the addition of chlorine could be used to improve water quality in water scarce hospitals.

3. **Increasing tap availability, maintenance, and functionality and soap provision** at taps is important for staff as well as patients to sustain a safe hospital environment.

4. Need local beneficiaries to **understand piped water complexities**, work to fix them, and to be engaged.

The way forward

More research should be done to contribute to the evidence-base for promoting safe water in healthcare facilities as a priority within the global water sector.

The CGSW has developed:

- WASH in Healthcare Facilities Tool
  - Details the WASH Conditions within Healthcare Facilities
- WASH Sustainability in Healthcare Facilities Metric
  - The Sustainability Metric provides data to improve and maintain safe water provision, a necessary step in attaining universal and sustained safe water in healthcare facilities.

Contact us if you'd like to collaborate!

Mia Gallegos – MNGALLE@emory.edu or check us out at www.CGSWASH.org

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Thank you to:

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Dr. Christine L Moe

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Questions

Appendix

Who Standards for Health Care Facilities

WHO standards on Water, Sanitation, and Hygiene in Health Care Facilities:*

- Water should be available within all treatment wards and waiting areas
- 5-400 liters/person/day (depending on intervention)**
- Water and soap should be available in all key areas of the facility
- Drinking water should comply with WHO guidelines for drinking water quality for microbial, chemical, and physical aspects

*World Health Organization (WHO) and UNICEF report, released March 17, 2015, "Water, Sanitation, and Hygiene in Health Care facilities: status in low and middle income countries and the way forward" (Table 7).
**World Health Organization (WHO) 2008, "Essential Environmental Health Standards in Health Care," (Table 3.1, page 29).

Overview of Sustainability Metric

Purpose of Use	Evaluation of sustainability of safe water provision
Level of Use	Service provision in institutional (healthcare facility) setting with a centralized or ward-level water treatment system (any type of system)
Target User	Those interested in understanding the current sustainability of safe water provision at a healthcare facility with an installed water treatment system (MoH, MoE, NGOs, academia, donors)
Frequency of Use	Post-implementation; Annually
Inputs	Survey Questions (mobile data collection), Observations, Water Quality Testing
Outputs	Radar plot with sustainability Score 0-4, 4 domains of sustainability
Time and Resources	½ day at each hospital site (2 enumerators); analysis and data visualization pre-programmed based on inputs

Collaboration for Safe Water in Healthcare Facilities

- Since 2011, the Center for Global Safe WASH (CGSW) has partnered with GE Foundation (GEF) to evaluate and improve the sustainability of GEF's water in healthcare facilities program.
  - Past research in Ghana, Honduras, Rwanda (20 hospitals)
    - Sustainability metric developed and vetted
  - New projects in Cambodia and Uganda (15+ hospitals)
    - Sustainability metric informed new donation program

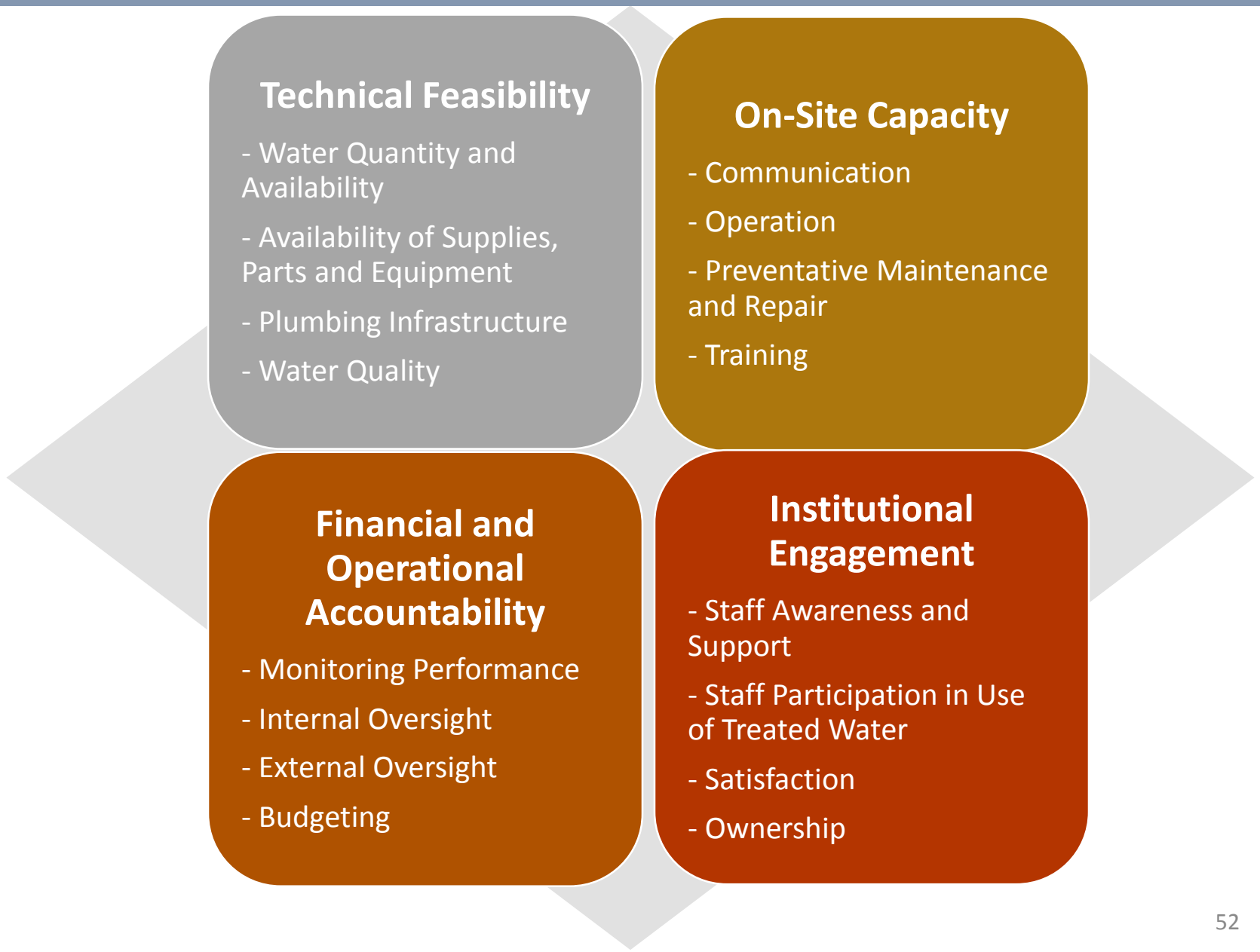
GE water filters in hospitals in Uganda (left) and Cambodia (right).

Overview

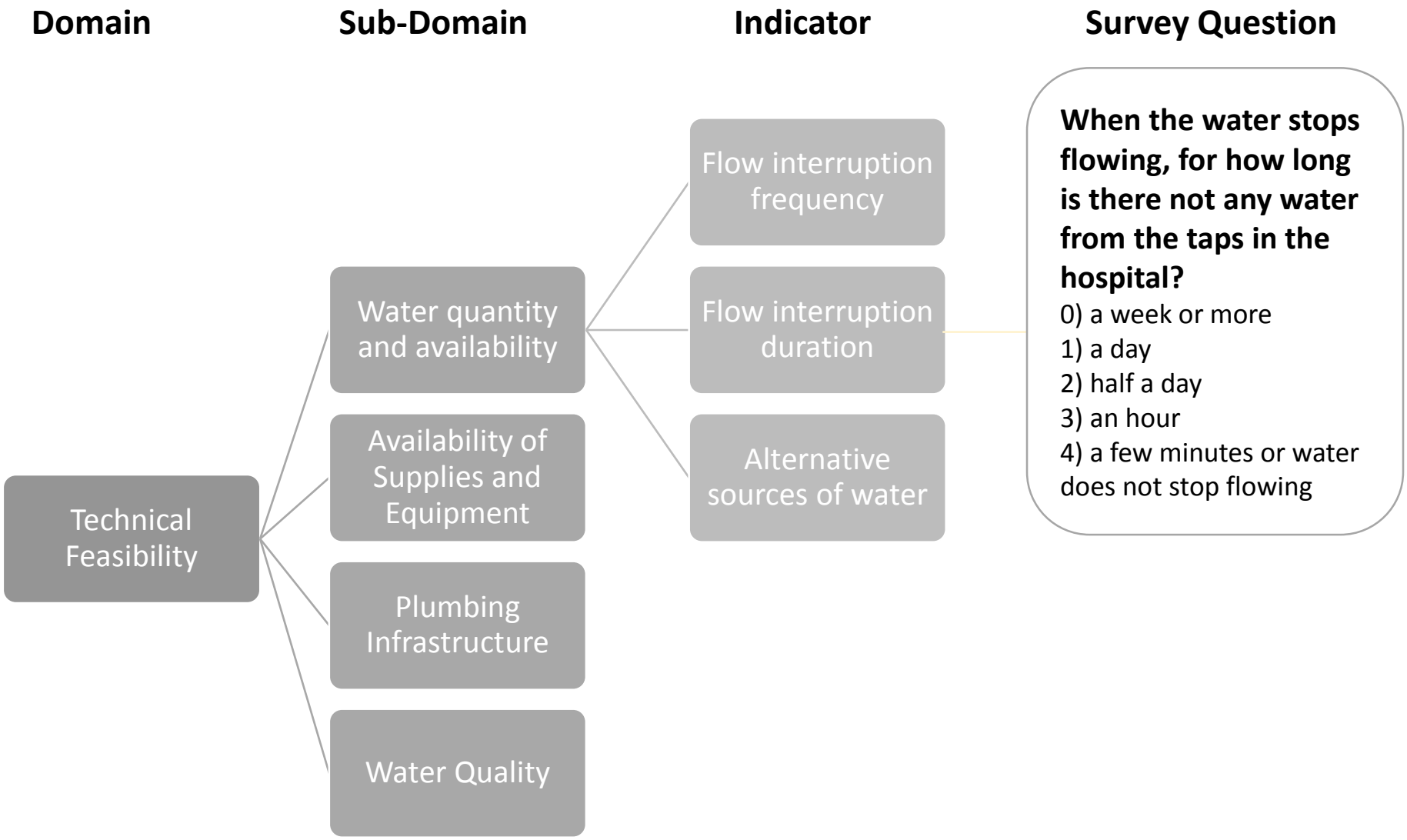
1) Development and Organization of the Sustainability Metric
2) Application at hospital sites in Cambodia
3) Lessons Learned from application at hospital sites in Honduras and Ghana

Sustainability Domains

Sustainability Sub-Domains



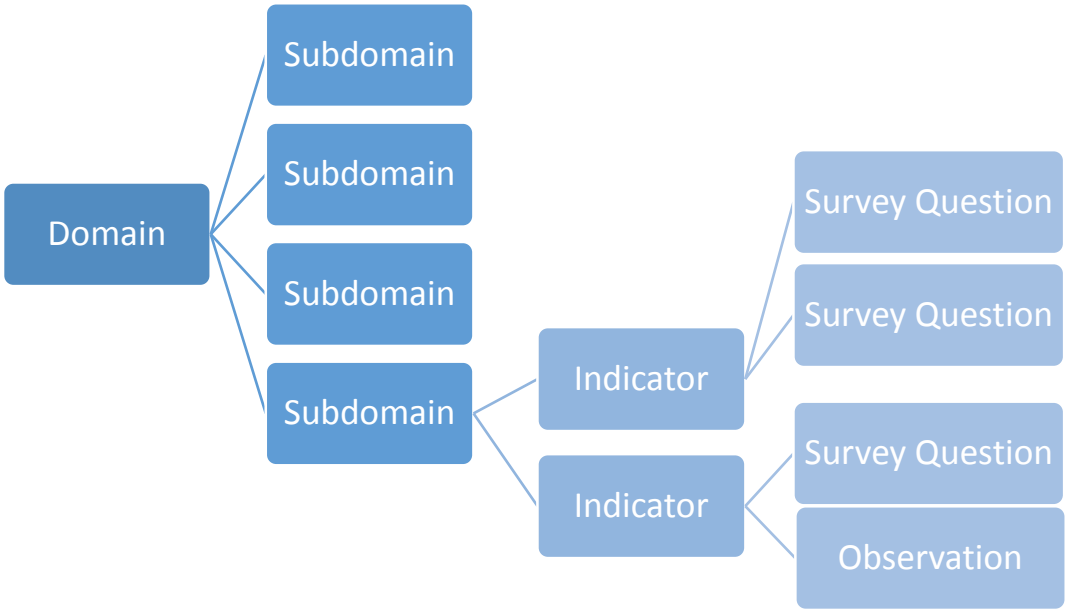
Sustainability Metric Structure

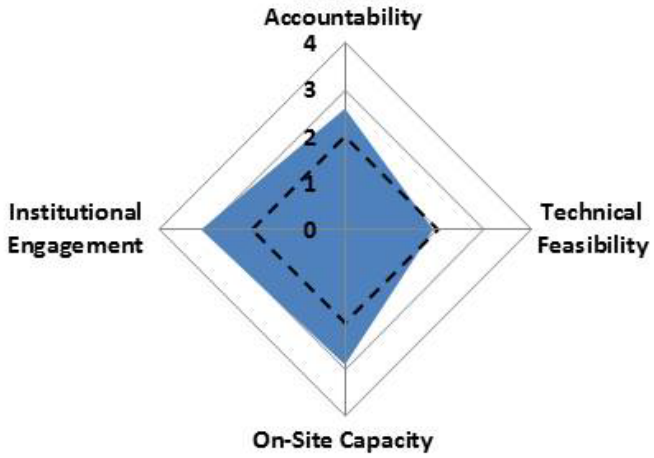


Sustainability Metric Structure

Each survey question is associated with answer choices with point values from 0-4.

- The greater the number, the greater evidence of an enabling environment for sustainability.
- By averaging the score a hospital receives for each indicator (survey question, observation, water quality) within a subdomain, a subdomain score is created.
- Subdomain scores are averaged to form a domain scores.





Methods

Surveys with:

- Hospital director (30 minutes)
- Maintenance staff (20 minutes)
- Hospital staff (5 minutes each)
  - 5 clinical staff
  - 5 non-clinical staff

Water quality testing (10 samples):

- *E. coli*/100ml
- Chlorine residual (if applicable)

Observations of:

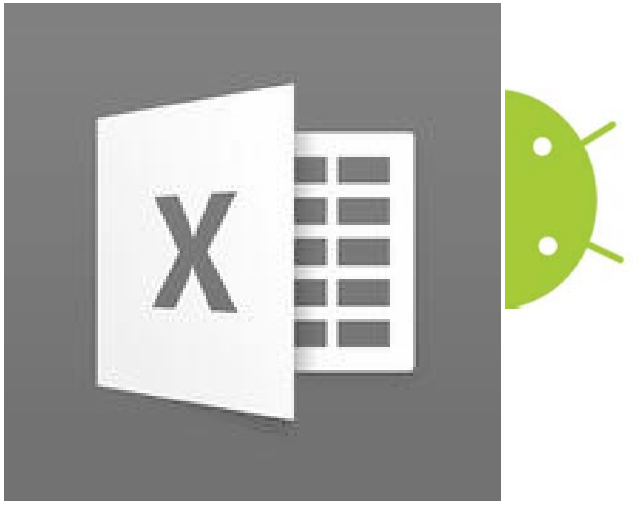
- Functionality of water infrastructure
- Record keeping related to hospital water

Conducting observations

Collecting a water sample

Technical Development

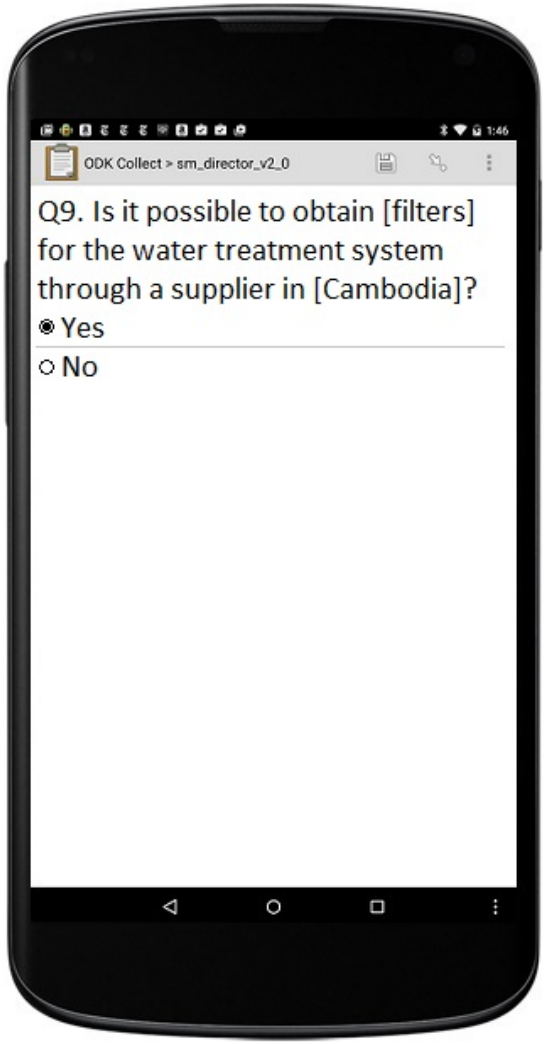
- Open Data Kit (ODK) to collect data on mobile phones and a custom Excel dashboard to automatically generate sustainability scores and data visualizations.



- Next steps: Developing an Android App that will allow for data collection and analysis/result generation

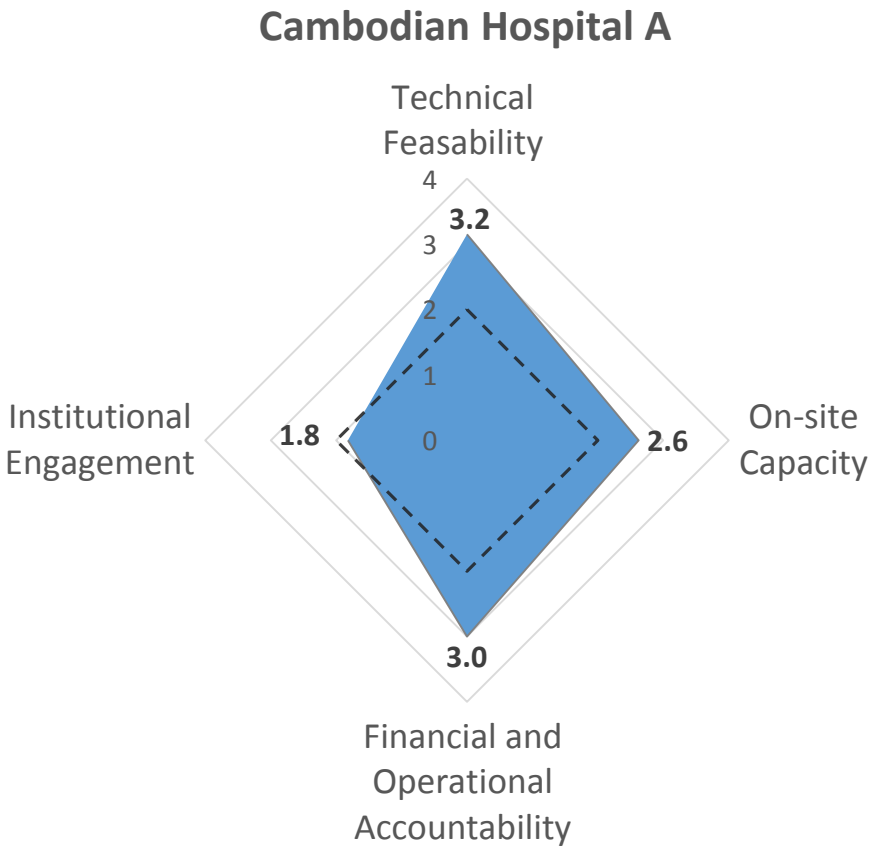
Customization of Sustainability Metric

- Customize based on relevant:
  - Water treatment equipment and parts
  - Water quality outcomes
  - Key leadership and operation and maintenance staff

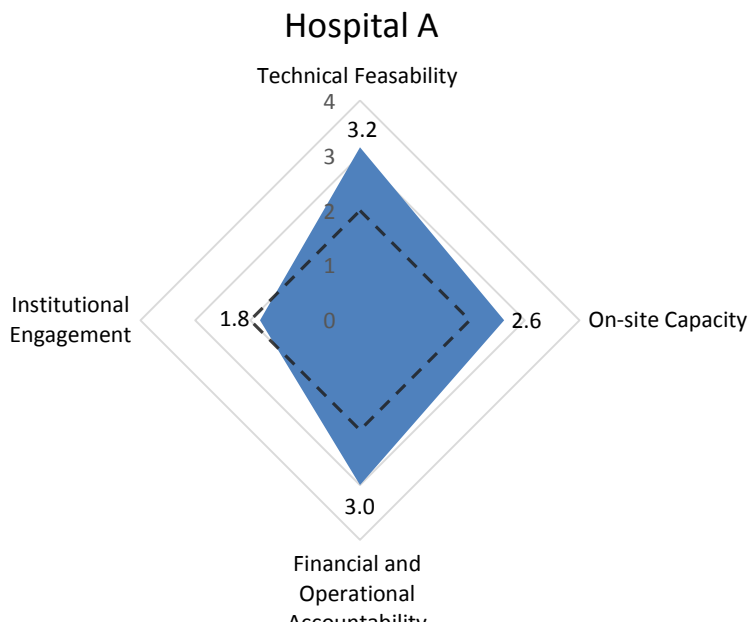


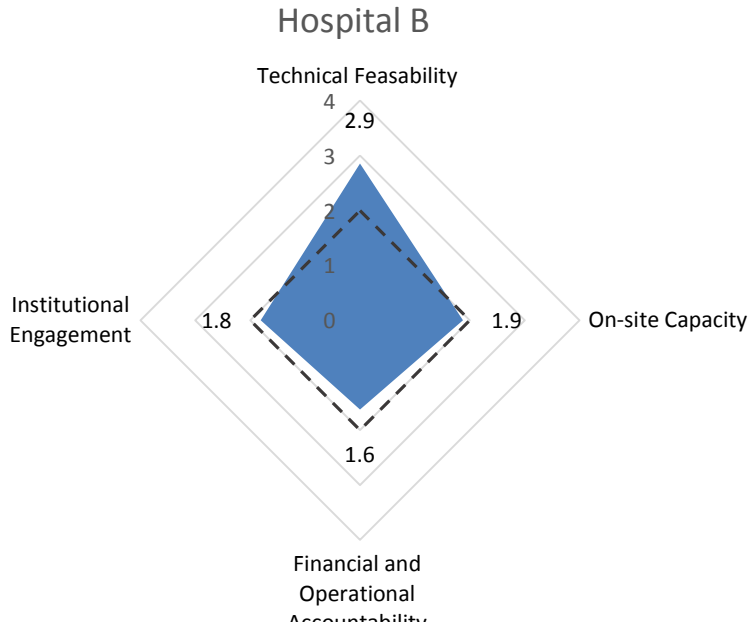
Sustainability Scores for a Cambodian Hospital

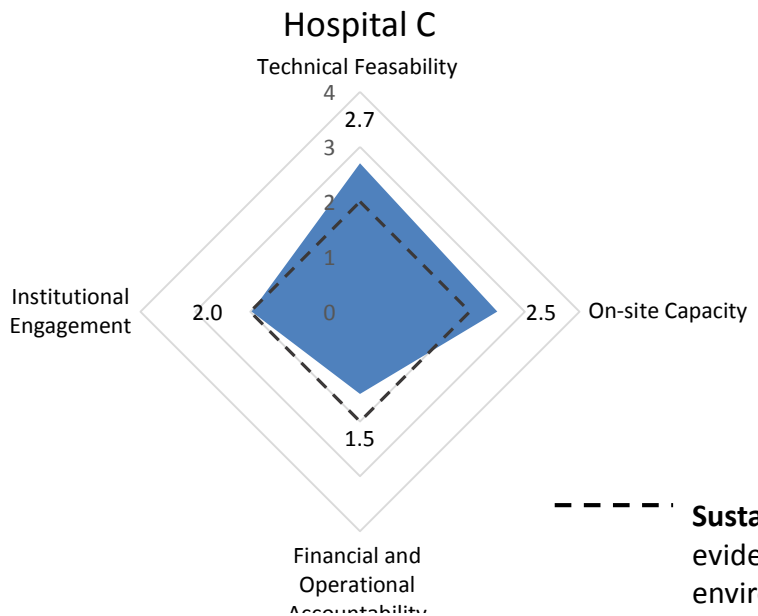
Overall Sustainability	2.6
Domain Scores	
Technical Feasibility	**3.2**
On-site Capacity	**2.6**
Financial and Operational Accountability	**3.0**
Institutional Engagement	**1.8**
Subdomain Scores	
Water Quantity and Availability	4
Availability of Supplies and Equipment	3
Plumbing Infrastructure	3
Water Quality	3
Communication	4
Operation	2
Preventative Maintenance and Repair	1
Training	4
Monitoring Performance	4
Internal Oversight	4
External Oversight	0
Budgeting	4
Staff Awareness and Support	2
Staff Participation in Use of Treated Water	3
Satisfaction	2
Ownership	0

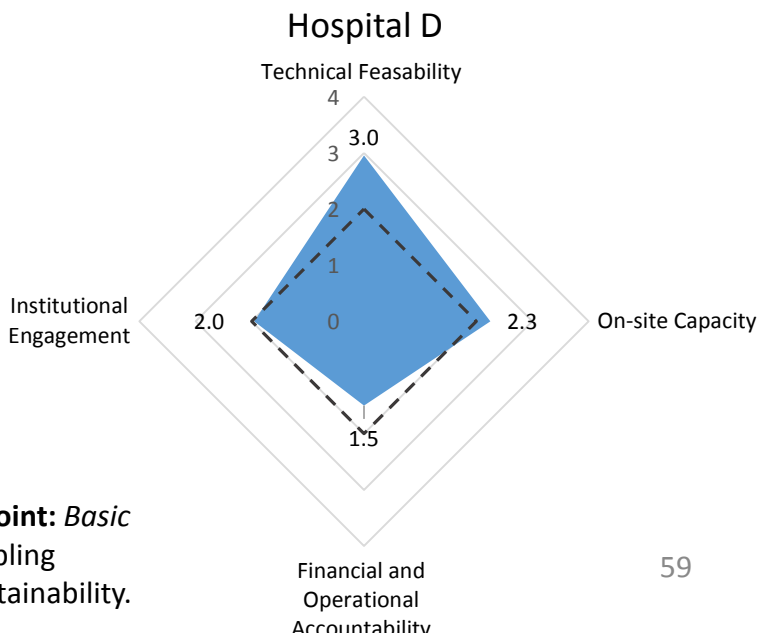


Sustainability Scores for Cambodian Hospitals



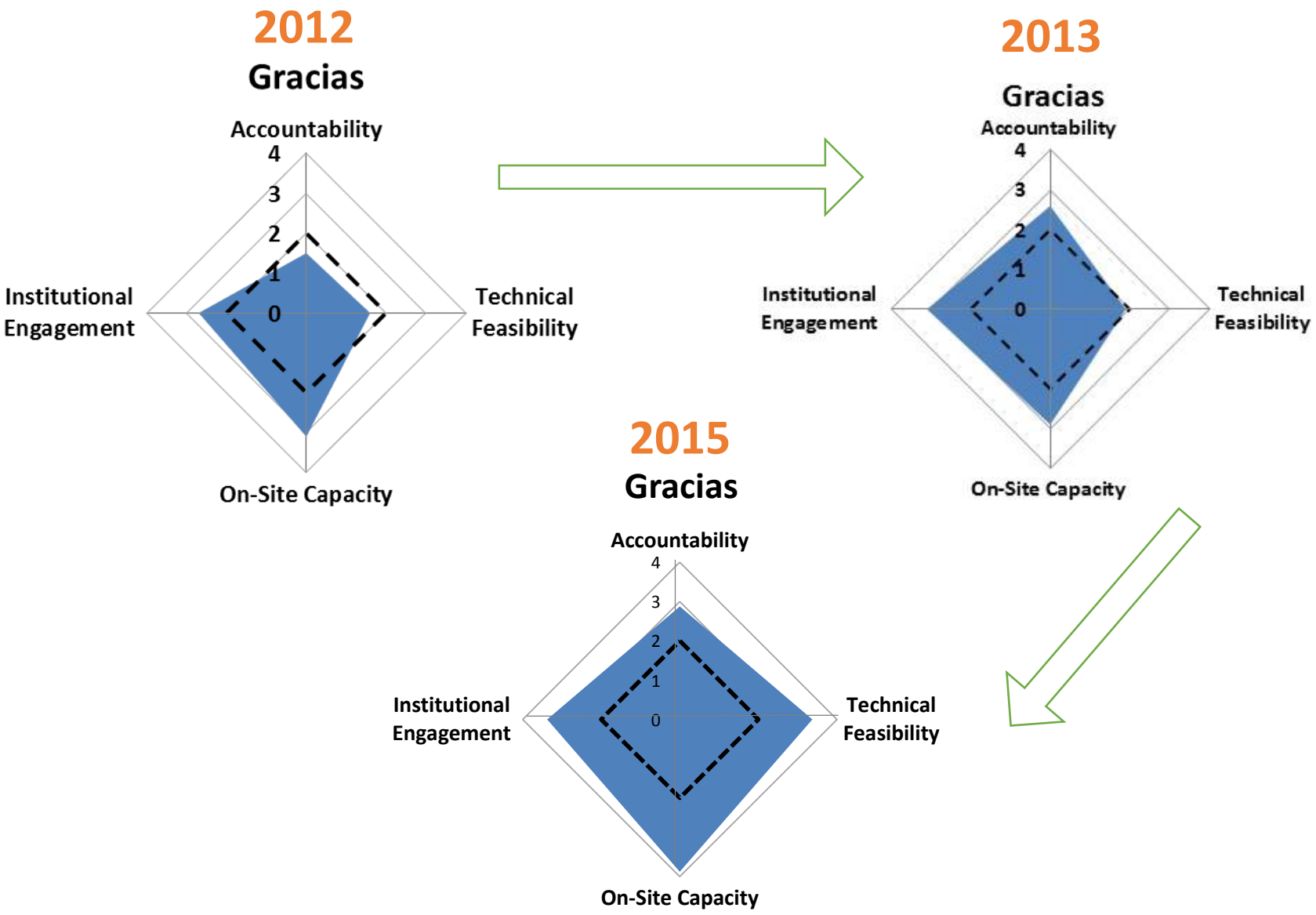






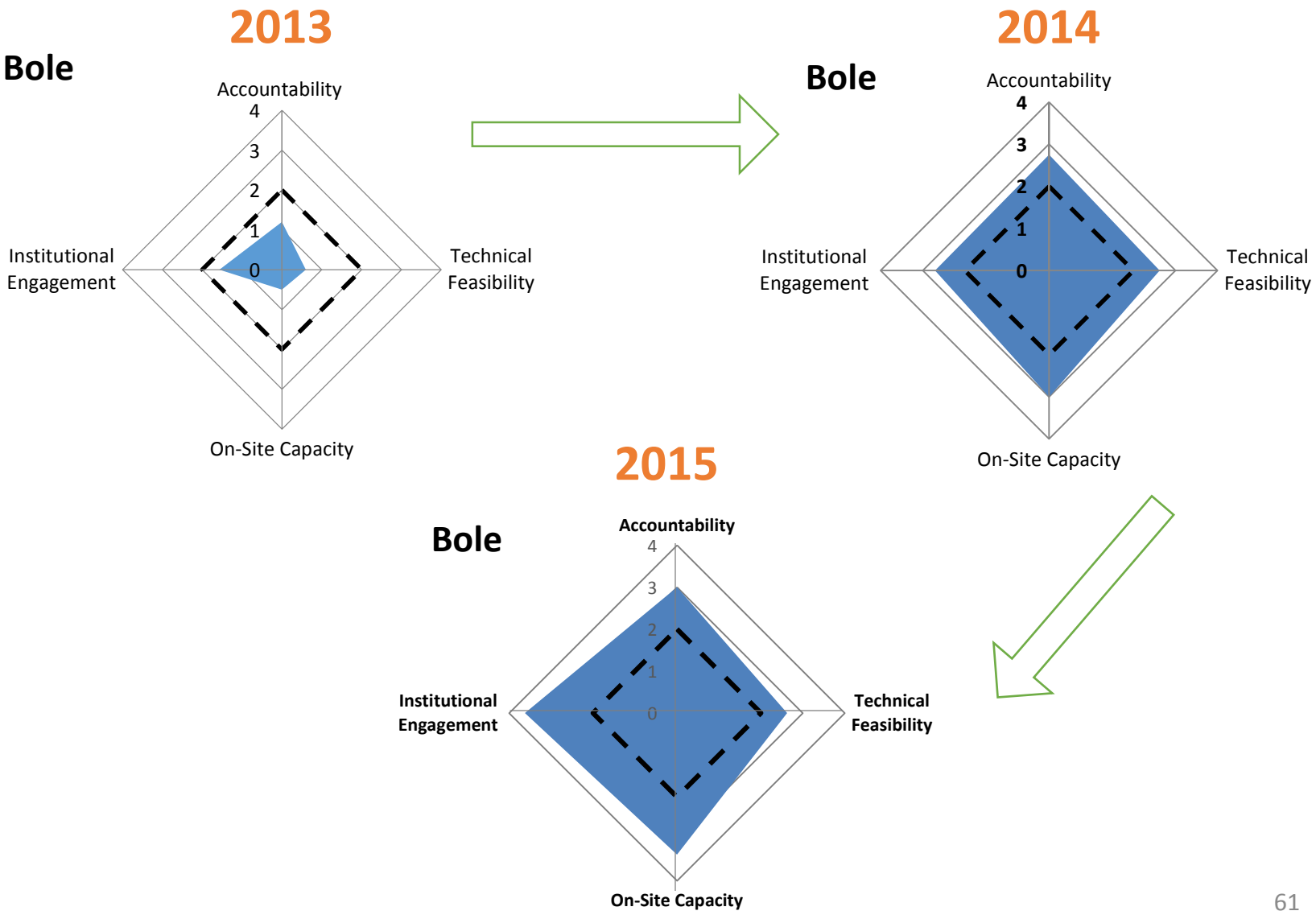
Sustainability Cut-Point: *Basic* evidence for an enabling environment for sustainability.

Sustainability Scores for a Honduran Hospital from 2012-2015

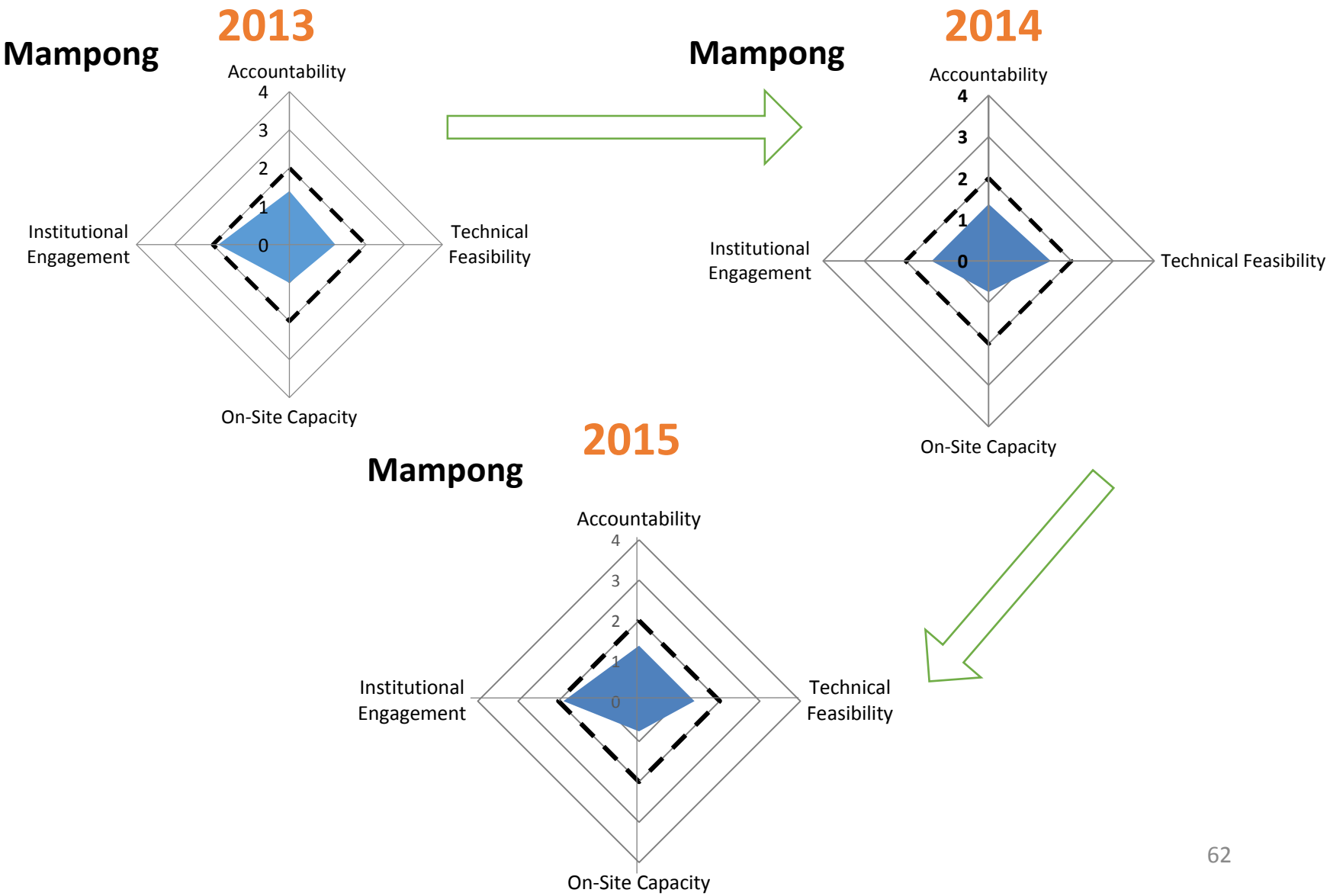


– – – · **Sustainability Cut-Point:** *Basic* evidence for an enabling environment for sustainability.

Sustainability Scores for a Ghanaian Hospital from 201-2015



Sustainability Scores for a Ghanaian Hospital from 2013-2015



Examples of Problems that are Identified through Sustainability Metric

Technical Feasibility

- Insufficient and unreliable water supply
- Sub-standard and poorly maintained piped water infrastructure
- Limited access to parts for repair

On-Site Capacity

- Lack of or infrequent routine maintenance
- High staff turn-over

Accountability

- Limited availability and funds for parts and chlorine
- Limited or no monitoring of water quality and enforcement of water quality standards

Institutional Engagement

- Water quantity is a higher priority over water quality
- Need for promotion of importance of safe water for drinking, hygiene and medical purposes

Examples of how results of sustainability assessment improve sustainability at hospital level

A nurse motivates her colleagues to take action to improve their water quality after viewing water quality testing results. (**Institutional Engagement** and **Technical Feasibility**)

A maintenance officer practices chlorine residual testing in front of administrative staff to improve monitoring capacity and oversight. (**Accountability** and **On-Site Capacity**)

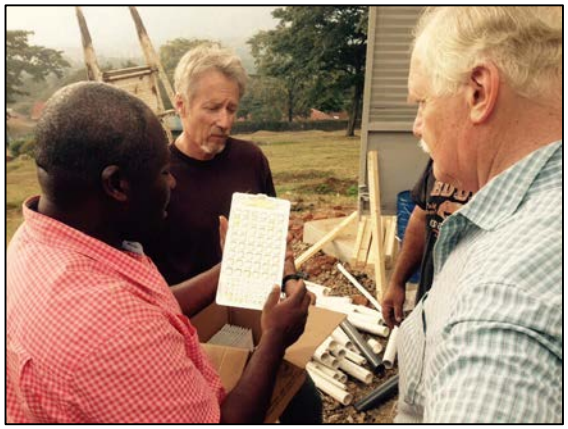
Improving Sustainability at the Donor Level

- The sustainability metric provides **evidence for targeted and informed action** for existing and future programs.

- Based on recommendations identified through use of the sustainability metric….

Manual controls replaced automated backwash so treatment can occur without electricity and repairs are easier. (**Technical Feasibility**)

Rotating field technician hired to build capacity and help resolve technical issues. (**On-Site Capacity**)



Hospital selection criteria and implementation guidelines developed for future GEF donation program; applied in Uganda and Cambodia

Strengths and Limitations

Strengths

- **Metric design**
  - Simple and systematic approach
  - Rapid data collection and automated analysis
  - Linked to sustainability theories and extensive pilot testing
- **Flexibility**
  - Can be used with any level of healthcare facility; customizable to various water treatment systems
- **Identifies target areas for improvement**

Limitations

- **Fixed weighting of subdomains/domains**
  - assumes that all sub-domains of sustainability are equally important (weighted equally)
- **Implementation**
  - Needs further testing with other types of water treatment systems in hospitals

Implications

- The 2015 Sustainable Development Goals include a target to achieve “universal access to safe drinking water in health facilities.”

- Majority of healthcare facilities will need to gain access to and maintain a safe water source.
- Despite improved water sources and on-site treatment systems, there exist persistent challenges to sustained safe water provision.

- The Sustainability Metric provides data to improve and maintain safe water provision, a necessary step in attaining universal and sustained safe water in healthcare facilities.

Veronica Bucket Cleaning Protocol

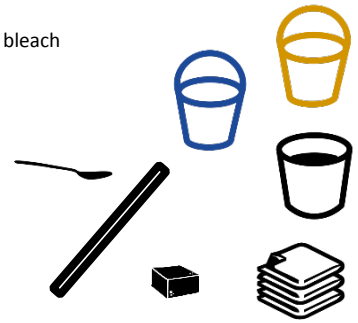
- Veronica Buckets should contain treated (filtered and chlorinated) water only.
- Each Veronica Bucket should be cleaned according to this protocol **every week** as preventative maintenance to maintain the integrity of the Veronica Bucket as a source of safe water and to minimize introduction of contamination during cleaning.
- Please plan **45 minutes** for the completion of this protocol.

Image: Nurse using a Veronica Bucket. Mampong, Ghana.

Veronica Bucket Cleaning Protocol

Materials

- 1 cup (250mL) of 5-6% household grade chlorine bleach
- 15 -20 gallons (60 - 80L) of filtered water
- (1) 7 gallon (26L) wide mouthed container
- Tablespoon
- Stirring rod (at least 18 inches in length)
- Sponge
- Dry, clean towels (as many as necessary)



Disinfection Procedure for Tools used to the Veronica Bucket

All tools used in the procedure MUST be disinfected prior to use to avoid cross-contamination and introduction of contaminated water into the Veronica Buckets which store water for critical use within the hospital.

- **Step 1:** Prior to completing any and all procedures **all individuals involved in this procedure must properly wash their hands** according to the WHO hand washing protocol
- **Step 2:** Use the following steps to disinfect (1) 7 gallon (26L) wide mouthed container
  - Remove any visible debris from the container
  - Rinse the container 5 times alternating between filtered water and 5-6% household grade chlorine bleach
  - Once Step 2 is completed the container is now disinfected
- **Step 3:** Use the following steps to prepare a 50ppm free chlorine solution using filtered water in the disinfected container
  - Combine 5 gallons (20L) of filtered water with 1.35 Tbsp. (20mL) of 5-6% household grade chlorine bleach in the disinfected container
  - Stir chlorine solution with the stirring rod for 30 seconds to ensure proper mixing
  - Once Step 3 is completed the chlorine solution is ready to use
- **Step 4:** Submerge and soak all tools (i.e. sponges) in the prepared chlorine solution for 15 minutes
- **Step 5:** Between the use of each tool, return the tools to the prepared solution for soaking
- **Step 6:** If necessary, dry tools using a dry, clean towel prior to use

Disinfection Procedure for Cleaning the Veronica Bucket

The following procedure should be used for the cleaning of **each** individual Veronica Bucket

- **Step 1:** Prior to completing any and all procedures **all individuals involved in this procedure must properly wash their hands** according to the WHO hand washing protocol (See page X)
- **Step 2:** Remove the Veronica Bucket from the frame and remove the lid and place the lid on a clean dry towel
- **Step 3:** Drain any remaining water
- **Step 4:** Using a disinfected sponge wipe the inside and outside of the Veronica bucket and return the sponge to the chlorine solution when finished
- **Step 5:** Use the following steps to prepare a 50ppm free chlorine solution using filtered water directly in the Veronica Bucket
  - Combine 5 gallons (20L) of filtered water with 1.5 Tbsp. (20mL) of 5-6% household grade chlorine bleach in the disinfected container
  - Stir chlorine solution with the stirring rod for 30 seconds to ensure proper mixing
  - Once Step 5 is completed the chlorine solution is ready to use
- **Step 6:** Allow the solution to sit in the Veronica Bucket for 30 min
- **Step 7:** During the 30 min it takes to complete Step 4, use a disinfected sponge to wipe the lid of the Veronica Bucket and place the cleaned lid on a new, dry, clean towel
- **Step 8:** Drain the chlorine solution from the Veronica Bucket through the tap at the bottom of the bucket. Germs can hide and grow in the tap and can make the water unsafe to drink, so it is very important to make sure the chlorine solution drains through the tap.
- **Step 9:** Rinse the Veronica Bucket 5 times with filtered water
- **Step 10:** Return the Veronica Bucket to its framework and fill with treated (filtered and chlorinated water)
- **Step 11:** To determine whether additional chlorine bleach must be added to the treated water in the bucket, use the color wheel to test the chlorine residual level
- **Step 12:** Securely place cleaned lid on the Veronica Bucket
- **Step 13:** Repeat this procedure every week

Domains Defined

Technical Feasibility

In order for safe water provision to be sustained, certain technical criteria must be met so that safe water can be generated, maintained, and accessed by users.

On-Site Capacity

On-site capacity is important for sustainability because it increases the likelihood that the institution can maintain safe water provision without relying on the support of outside entities.

Accountability

Financial and operational accountability of the institution are important for sustainability of safe water provision. Recurrent and fixed costs should be anticipated and a funding source must be available. Regular monitoring and oversight of performance requirements must occur to ensure that safe water provision is not limited due to lack of information.

Institutional Engagement

The engagement of the institution in safe water provision—through staff awareness, use of safe water, satisfaction with and ownership of safe water provision—increases the likelihood that leadership will support sustained safe water provision.