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A Cross-Country Analyses of Water Service Provisions in Healthcare Facilities in Afghanistan, Uganda, Malawi and Haiti using the WASHCon Tool

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Global Epidemiology

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Abstract

A Cross-Country Analyses of Water Service Provisions in Healthcare Facilities in Afghanistan, Uganda, Malawi and Haiti using the WASHCon Tool

By Jennifer Imaa

Background: Inadequate water sanitation and hygiene (WASH) conditions have negative consequences to the health and well-being of a population. There is a need to assess WASH conditions in healthcare facilities (HCFs), particularly in low and middle-income countries since poor conditions have been associated with higher rates of healthcare acquired infections and low health delivery uptake.

Methods: A cross-sectional study was carried out in 334 HCFs across four countries: Afghanistan, Haiti, Uganda, and Malawi using the WASHCon tool. A subset of the data related to water supply and quality was used to determine water service levels. This was classified as basic service, limited or no service. Proportion of facilities meeting CDC and WHO guidelines for free chlorine and *E. coli* concentrations in water samples was determined. Logistic regression was employed to identify factors associated with facilities meeting basic water service levels and water quality standards.

Results: A majority of the HCFs surveyed had water service levels that met the definition for basic service, ranging from 55.9% of HCFs in Uganda to 86.7% of HCFs in Haiti. In univariate regression analysis of HCFs in Uganda, there was a significant association between the managing body and basic water service. The odds for having basic water service was lower among governmental HCFs compared to non-governmental HCFs (NGOs, private, and faith-based) OR=0.25 (0.08, 0.70). There was also a statistically significant association found between water source and having water that meets the WHO guidelines for water microbial content.

Conclusion: Though a majority of the HCFs surveyed meet the definition for basic water service, there is still a substantial percentage of facilities in each country who have limited or no water service, with this proportion differing between countries. Further, our results indicated that in Uganda, there is an association between managing body and meeting basic water services. Associations were also found between water source and meeting WHO guidelines for water quality. This suggests there are inequalities within and between countries that need to be addressed and we need to consider characteristics of the HCFs as we prioritize regions for WASH interventions.

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Background/Literature Review

Global Water, Sanitation, and Hygiene (WASH)

Inadequate water, sanitation and hygiene (WASH) conditions have contributed to a large burden of infectious diseases worldwide. Diarrheal diseases remain one of the leading causes of death across the globe, and 88% of deaths due to diarrheal illnesses can be attributed to unsafe water, and inadequate sanitation and hygiene [1]. This burden of disease due to poor WASH conditions is even more significant in low-and middle-income countries (LMICs). A retrospective analysis of data from 145 LMICs found that in 2012 an estimated 840,000 deaths due to diarrheal diseases were linked to poor WASH conditions [2]. This study also estimated that more than 360,000 deaths in children under the age of five could be prevented by improvements to WASH.

There is widespread recognition of WASH being important for maintaining health and dignity in populations worldwide. The Millennium Development Goal target 7c sought to reduce by half the proportion of the population without sustainable access to safe drinking water and basic sanitation by 2015 [3]. Though this goal was achieved for water access, there is still a significant proportion of individuals, particularly those in LMICs, who rely on unimproved water sources and utilize unimproved sanitation facilities. Further, the focus of progress towards achieving WASH targets primarily focused only on household settings.

Sustainable Development Goal 6 (SDG 6) draws upon and expands on the previous MDGs by aiming to ensure availability and safe management of adequate and equitable

water and sanitation for all by 2030. SDG target 6.1 and 6.2 highlight the need to expand WASH services and monitoring beyond just the household setting and include non-household settings such as schools and healthcare facilities (HCFs) [4].

Consequences of poor WASH in Healthcare Facilities

Having good WASH conditions proves vital for HCFs since it is an important location where individuals seek care. However, inadequate WASH in HCFs can lead to the acquisition of healthcare-associated infections (HAIs). HAIs lead to extended hospital stays and increase the risk of death among patients, especially among vulnerable populations [5]. Though the burden of HAIs is global, there seems to be a higher prevalence in LMICs. Approximately, 5-19% of patients in hospitals in LMICs develop HAIs [6]. Studies have shown that many HAIs are linked to poor hand hygiene by increasing spread of infectious agents via direct contact or transmission by fomites [7]. Handwashing is still regarded as one of the most important preventative strategies for most HAIs [8]. When water and soap are not available within a facility, it makes handwashing difficult to perform, and thus increases the risk of spreading infections to the patients and staff within the facilities.

Additionally, poor WASH in HCFs can affect maternal health and impact health seeking behaviors. A systematic review of the association between WASH and maternal mortality found that higher levels of maternal mortality were associated with poor water and sanitation access in both the household and in healthcare settings [9]. Maternal mortality was measured as death during labor or after childbirth. Another systematic

review of studies of HCFs in LMICS revealed that patient dissatisfaction with quality of healthcare was associated with HCFs with poor WASH conditions [10]. Further, poor WASH provisions in HCFs can lead to HCF avoidance and lead to more women in LMICs choosing home deliveries, rather than deliveries at HCFs with poor environmental conditions. Improvement of WASH services within HCFs has the potential to decrease HAIs, increase HCF-based births and encourage individuals to practice positive WASH behaviors, such as handwashing at home.

Joint Monitoring Program, WASH in HCF

Through the Joint Monitoring Program (JMP), WHO and UNICEF are responsible for monitoring the progress toward SDG 6 by creating indicators to aid in monitoring WASH services in households, as well as schools and HCFs. The main goal of SDG 6 is to ensure the availability of water and sanitation for all [11]. This goal is to be achieved by providing safe and affordable drinking water (SDG 6.1) and providing access to sanitation and hygiene (SDG 6.2). The following four core indicators define "basic" water, sanitation, hand hygiene and waste management in HCFs. In regards to water supply, basic water service is defined as the proportion of HCFs where the main source of water is an improved source, located on premises, from which water is available at the time of survey. The proportion of HCFs with basic sanitation includes facilities with improved toilets or latrines that are functional, separated for patients and staff, at least one designated for women and allowing menstrual hygiene management and meeting the needs for people with limited mobility. The proportion of HCFs with basic hand hygiene include those with a basin with water and soap or an alcohol-based

hand rub present at critical points of care and near toilets. And in regards the healthcare waste management, this includes the proportion of HCFs where waste is safely segregated in the consultation area and infectious and sharps waste are treated and disposed of safely. By creating these normative definitions, the hope is to harmonize monitoring of WASH services in HCFs so as to generate better national estimates and determine priorities to ensure achieving the 2030 goal.

Assessment of WASH services in Healthcare Facilities

So far, a limited amount of primary research has been done assessing WASH services in HCFs. Also, many past studies focused only on one country or services within one region of a country. A study conducted in 17 rural HCFs in Rwanda found that 60% of water access points within the surveyed facilities were functional and only 32% of points had both water and soap available for handwashing [11]. Another study conducted in southwestern Uganda found that of the 50 HCFs surveyed, 94% had access to improved water sources, but only about 24% of these facilities had both water and soap present for handwashing [12]. These studies were limited in scope in that they only included a small number of HCFs within one region of a country.

Few studies have sought to do a cross-country comparison of WASH provisions within various LMICS. A study conducted in 1,318 rural HCFs in Ethiopia, Kenya, Mozambique, Rwanda, Uganda, and Zambia found that less than 50% of rural HCFs in each country surveyed had access to improved water sources on their premises [13]. Further, less than 25% of facilities had access to a combination of water, soap and hand

drying materials within their facilities at all times to perform proper handwashing. This study also highlighted the drastic differences in WASH service provisions between the different countries as the percentage of HCFs within each of the six countries surveyed differed substantially from each other, from a low of 16% of HCFs in Ethiopia having an improved water source on premises to a high of 89% of HCFs in Rwanda. This study was limited in that it focused only on rural HCFs in sub-Saharan Africa.

A 2015 report by the World Health Organization (WHO) and United Nations Children Fund (UNICEF) was the first cross-country report to make comprehensive estimates of WASH services across LMICs in different regions throughout the world. The report utilized secondary data collected for other purposes to estimate that about 38% of HCFs within 54 LMICs, including those in Africa and other regions such as the Caribbean and Middle East, lack basic access to WASH services within their facilities [14]. Not only were there large differences in coverage levels when comparing across countries, but coverage levels also varied sub-nationally. For example, higher rates of access to water within HCFs were observed among larger hospitals in Sierra Leona (87%) compared to smaller primary health care clinics (61%). The report also highlights large variations when comparing primary health care facilities to hospitals in different settings, with HCFs in rural areas having significantly lower WASH coverage levels than in urban areas.

The JMP's 2019 Global Baseline Report [15] follows up on the 2015 status report and makes estimates on the current conditions of WASH services in HCFs globally. The

report found that globally, 74% of HCFs had basic water services in 2016. It also highlighted inequalities that existed in HCFs based on facility type, geography and managing authority. For example, up to 12% of government HCFs had no water service compared to about 6% of non-government HCFs. Much like the prior report, these estimates were made based on data available from national sources collected for other purposes.

A 2018 paper by Cronk et al. (2018) further assessed inequalities in WASH coverage and environmental conditions in HCFs in six LMICs by factors such as facility type, managing body, and sub-national administrative area. The study determined that among 78 LMICs about 50% lacked piped water and that the proportion of HCFs that can be classified as meeting basic water services varied considerably by country [16]. They found that differences in availability of basic water services varied by as much as 31% between urban and rural settings. When comparing managing bodies, such as private, not-for-profit and governmental facilities, governmental HCFs tended to have the lowest coverage of WASH services. The differences noted between managing bodies and region were found to be statistically significant. However, this study is limited since the data used to make these estimates came from the Service Provision Assessment (SPA) surveys. The SPA survey gathers information about services available in HCFs, but uses definitions for water services that focus simply on presence of a water supply at or near the premises. Meanwhile JMP indicators for WASH in HCFs require that an improved water source be available on the premises at all times to qualify as a facility that provides

basic water services [17]. Therefore, the study's classification of facilities with basic water services are an approximation and may not represent the true proportion of HCFs within the countries that provide basic water services.

To address the gaps in the literature, this study aims to expand on past WASH service assessments within LMICs by utilizing a more comprehensive survey based on WASH service definitions developed by the JMP for Water Supply and Sanitation. The study objectives are to describe water services within HCFs surveyed in four countries: Afghanistan, Haiti, Malawi, and Uganda. This assessment examines water availability and water quality in these HCFs. Further, this report will highlight inequalities that exist in WASH coverage levels by factors such as region, facility type, and managing body. Secondarily, we aim to examine associations between water quality and various HCF and water source characteristics. This study seeks to establish estimates that will aid in prioritization of WASH interventions, particularly in the regions where WASH services are not meeting basic service levels.

Methods

Data Source

A subset of the WASHCon survey data was used for this investigation. WASHCon is a tool developed by Emory University's Center for Global Safe WASH. The tool consists of surveys and observational checklists used to assess WASH service levels for HCFs. Survey questions were developed by adapting JMP's core indicators for assessing WASH services in HCFs. There are five different domains that were assessed, including water supply and quality, sanitation facilities, hand hygiene, environmental cleanliness, and waste management. However, this analysis will only focus on the results for the water supply and water quality domain. Questions in this domain include the water sources available on the premises, the main water source, location of the water source, availability of water, and water treatment practices (Appendix 2).

Recruitment and Site Selection

A cross-sectional study was conducted at 334 HCFs within four countries: Afghanistan, Haiti, Malawi, and Uganda. Assessments began in select facilities in Uganda and Malawi in 2016. The most recent data collection occurred for HCFs in Haiti and Afghanistan in 2018. The HCFs were selected non-randomly, and selection was based in part on partnerships between Center of Global Safe WASH staff and organizations within the countries, such as UNICEF, World Vision and Partners in Health who had relationships with the facilities that were selected for assessment or interests in a specific geographic region. This included 104 HCFs in Afghanistan, 15 in Haiti, 15 in Malawi and 200 facilities in Uganda. Interviews with HCFs administrators, such as health

center directors, were conducted in order to determine water service levels. Additionally, water samples were collected from key wards in the HCFs and analyzed for water quality indicators. Water quality data from the wards in Malawi were not readily accessible at the time of this analysis, therefore Malawi was excluded from the water quality portion of this analysis.

Data Collection

Demographic Information

Demographic information for some HCFs was collected using the Registration and Administration forms as part of the WASHCon tool. This information was used to generate descriptive statistics regarding basic characteristics of the HCFs such as facility type, managing body, and number of outpatients seen monthly. It is important to note that this information was not available for all HCFs in the dataset.

Water Services

The WASHCon Director Survey Form was utilized to collect information related to the water supply for the facility. Questions on the survey related to water supply focused on water source, accessibility, shortage, storage, treatment and quality. Answers to the surveys were based on self-reports by the health director during the interview, with the exception of the question asking if water was available at the time of interview, which was based on observation, rather than self-report. Enumerators approached directors from HCFs with a letter of introduction about the study from the Ministry of Health and obtained verbal consent before administering the surveys and observational checklists. The data were collected via mobile devices, and the information was uploaded onto the

WASHCon CommCare application (Dimagi, Cambridge, MA) via a wireless internet network, which automatically downloads into a pre-programmed dashboard for analysis. The app was updated and forms synchronized on a daily basis.

Water Quality

Informed consent was given by the HCF staff before samples were collected. Water samples were stored on ice in order to avoid changes in microbiological quality before analysis. Water samples were analyzed for concentrations of total coliform, *Escherichia coli* (*E. coli*), and free chlorine residual. Total coliforms and *E. coli* were analyzed using the IDEXX Colilert method with Quanti-Tray® 2000 (IDEXX Laboratories, Westbrook, ME) and reported as most probable number (MPN) per 100 mL. Free chlorine was measured using a portable Hach® chlorine test kit (Hach, Loveland, CO) and reported as mg/L. A categorization of the percentage of samples from each HCF that met WHO and CDC guidelines for free chlorine residual and *E. coli* concentrations in water was reported in the dataset used for this analysis for facilities in Afghanistan, Haiti, and Uganda. Additionally, values for free chlorine residual, *E. coli* and total coliforms concentrations were reported for selected facilities (n=139) in Uganda.

Data Analysis Plan

Data from the surveys were exported from the WASHCon dashboard into an Excel spreadsheet, where it was coded and cleaned prior to data analysis. All data analysis was conducted using SAS 9.4.

Water Services

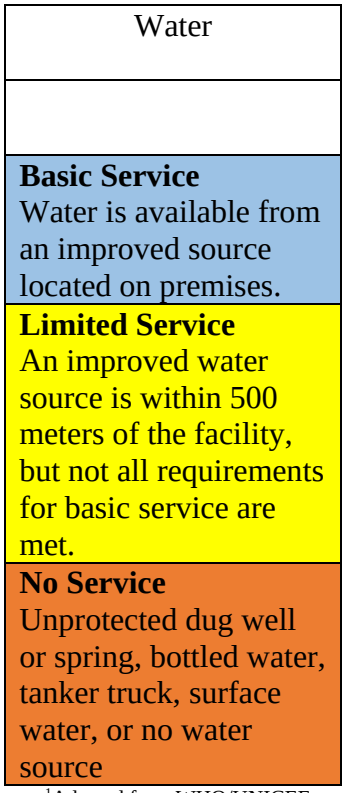
The classification of water services was assessed by utilizing the JMP service ladder definition (Figure 1) of what constitutes basic, improved, or unimproved water services and aligned with the data collected. The following definitions were used in the analyses:

1.) Basic service: Water from an improved source is available on premises

2.) Limited service: Water from an improved source is available off premise or an improved water source is on premises but water is not available

3.) Unimproved or No service: Water comes from an unimproved source

Figure 1: JMP Service Ladder Definitions for Water Service Levels in HCFs[1]



[1]Adapted from WHO/UNICEF

To estimate the proportion of HCFs that had improved sources of water available for their facility, water sources were classified as improved or unimproved based on where the main water supply came from. Improved sources included water from a piped

supply, borehole or tubewell, protected spring, protected well, and rainwater. Unimproved sources included water from a tanker truck, surface water, other, or no water source. These definitions of improved and unimproved sources were taken from the JMP service ladder framework. The proportion of HCFs that had water available on premises was determined by whether or not the main water source could be accessed within the building or on the facility grounds. The JMP monitoring indicators note that facilities with improved water sources available within 500 meters of the facility qualify as having limited service. Given that our dataset did not specify whether water off premises were more than 500 meters away, if water came from an improved source but was located off premise and was available, the HCF was classified as having limited water service. The proportion of facilities that had water available was determined based on observations of the main water source at the time of interview. If there was no available water observed at the time of interview, or this was not reported, then water was classified as unavailable.

Water Quality

Water quality was based on assessments of the water samples collected from key wards within selected HCFs in Afghanistan, Haiti and Uganda, typically during the same day the surveys were administered to the health directors. Water quality was evaluated by measuring concentrations of total coliforms, *E. coli* and free chlorine residual in the water samples. For the 139 facilities in Uganda that had the values for these measurements, a Wilcoxon ranked-sum test was performed to determine the correlation between free chlorine residual concentration and the concentration of *E. coli* or total coliforms.

HCFs were categorized based on the percentage of water samples from the facility that met CDC guidelines for free chlorine levels between 0.2 and 2.0 mg/L. The microbial quality of the water was classified based on the percentage of water samples from the facility that met the WHO guidelines for microbial water quality, which is defined as water containing less than 1 colony forming unit (CFU) of *Escherichia coli* per 100 mL [17]. Because the IDEXX water quality analysis method provides MPN estimates of total coliforms and *E. coli*, we assumed that 1 MPN was equivalent to 1 CFU [18].

To investigate factors associated with inequalities in water quality and water services within Uganda, logistic regression was performed. Water service level (dichotomized as basic service vs limited and unimproved/no service) was used as the outcome variable. Independent variables included facility type, managing body, and region. Regions included the Karamoja and West Nile regions of Uganda. Facility types included hospitals, which are defined as large HCFs that provide a wide range of inpatient and outpatient services, or health centers, defined as smaller facilities that also deliver patient care, mostly on an outpatient basis. Managing bodies included private, government, non-governmental organizations (NGOs), and faith-based organizations. A secondary analysis was performed in order to make an assessment about the factors associated with good water quality. The outcome variable was water samples from the HCFs meeting WHO standards for *E. coli*, while the predictors included water source, location on or off premises, facility type and chlorine treatment.

Results

Demographic information was not available for all HCFs in the dataset. Of the facilities in Uganda with data available, nearly 80% of the facilities were government HCFs, 77.4% of facilities were located in the West Nile region, and the average number of inpatient beds in each facility was about 29 beds (Table 1).

Table 1: Select Characteristics of HCFs in Uganda[1]

N=139 HCFs	
Region n (%)	
Karamoja	65 (22.6)
West Nile	222 (77.4)
Managing Body n (%)	
Government	111 (79.9)
Private	3 (2.2)
NGO	7 (5.0)
Faith-Based	18 (12.9)

[1]Demographic information is available for 139 of the 200 facilities in Uganda

Most facilities that were assessed in each country were health centers, rather than hospitals. This ranged from 94.8% of HCFs in Afghanistan to about 60% of HCFs in Haiti. There was also a large range in the reported number of outpatients seen per month in the facilities (Table 2).

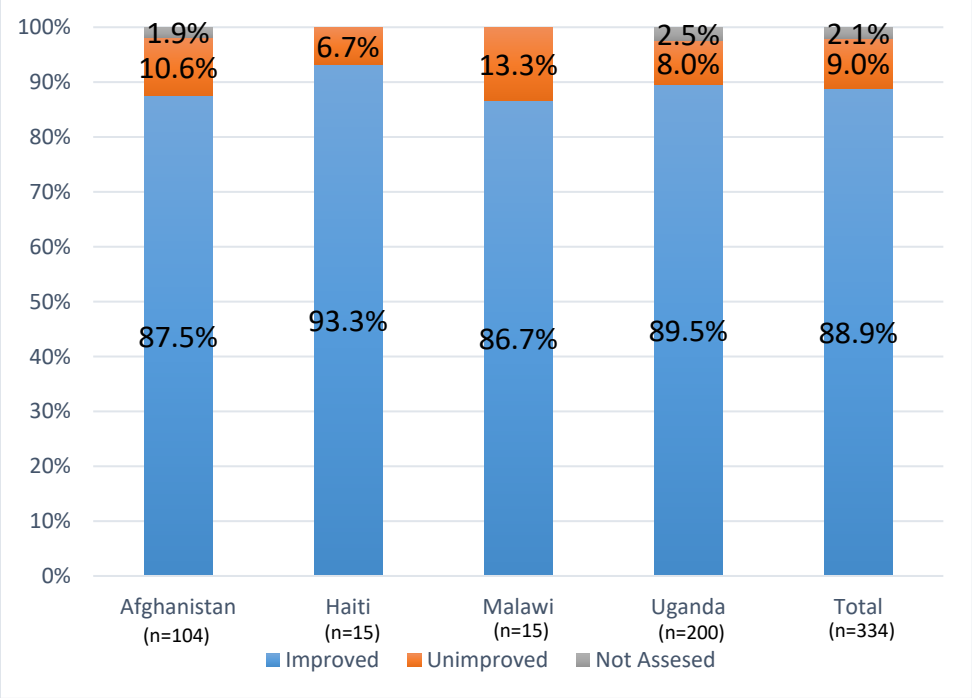
Table 2: Facility Type and Outpatients of HCFs by Country[1]

	Afghanistan (n=97)	**Haiti** (n=15)	**Malawi** (n=15)	**Uganda** (n=139)
Facility Type *n* (%)				
Hospital	5 (5.2)	6 (40)	3 (20)	8 (5.8)
Health Center	92 (94.8)	9 (60)	12 (80)	131 (94.2)
Outpatients Seen Monthly median (IQR)[2]	2,125 (2,200)	2,100 (4,800)	284 (362)	769 (589)

[1]97 of 104 HCFs in Afghanistan and 139 of 200 HCFs in Uganda had this information available.
[2]IQR=interquartile range

A majority of the HCFs in each country had an improved water source as their main supply (Figure 2). Improved water sources were mainly piped supplies, protected wells or boreholes (Table 3). Water from unimproved sources account for a portion of facilities in all countries surveyed. The percentage of facilities with the reported main water source as an unimproved source ranged from 6.7% in Haiti to 13.3% in Malawi. Typically, the unimproved water sources were surface water or another source.

Figure 2: Main Water Source of HCFs



[1]Water from an improved source includes water from a piped supply, protected spring, protected well, borehole/tubewell or rainwater. Unimproved sources include surface water, tanker truck, or another source or no source. 2 HCFs in Afghanistan and 5 HCFs in Uganda did not have their main water source assessed.

Table 3: Water Source Type[1] in Surveyed HCFs

N (%)	**Afghanistan**	**Haiti**	**Malawi**	**Uganda**
Improved Source	n=91	n=14	n=13	n=179
Piped Supply	26 (28.6)	8 (57.1)	6 (46.2)	63 (35.2)
Protected Spring	2 (2.2)	0	0	1 (0.6)
Protected Well	23 (25.3)	5 (35.7)	0	3 (1.7)
Borehole/Tubewell	38 (41.7)	1 (7.1)	7 (53.9)	73 (40.8)
Rainwater	2 (2.2)	0	0	39 (21.8)
Unimproved Source	n=11	n=1	n=2	n=16
Surface Water	6 (54.5)	1 (100)	2 (100)	1 (6.2)
Tanker Truck	2 (18.2)	0	0	4 (25.0)
Other	3 (27.3)	0	0	7 (43.8)
None	0	0	0	4 (25.0)
Not Assessed	n=2	n=0	n=0	n=5
	2	0	0	5
Total Facilities	**104**	**15**	**15**	**200**

[1]Reported main water source

The majority of water sources were located on the HCF premises, ranging from 70.5% in Uganda to 100% of the facilities in Haiti (Table 4). Water was also available at the time of the interview for most facilities in each country. Facilities that reported that water was not always available also noted the frequency that water was not available. For Malawi, 64% of facilities reported that water was not available on a daily basis, while for Uganda about 66% reported that water being unavailable was a yearly (seasonal) occurrence.

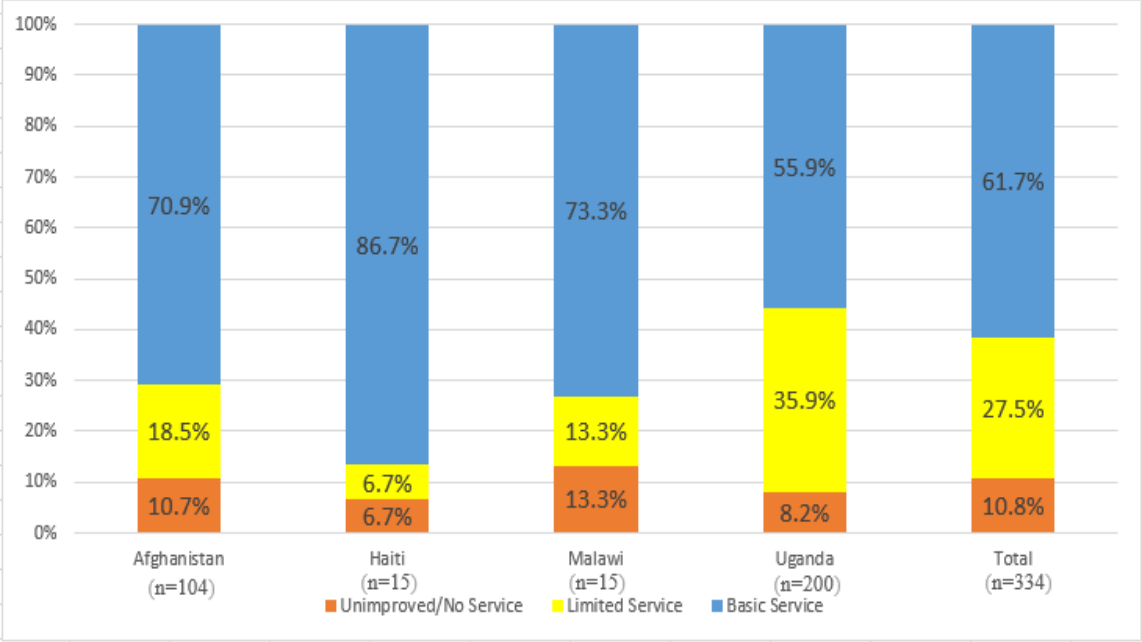
Table 4: Availability of Water at Surveyed HCFs

N (%)	**Afghanistan**	**Haiti**	**Malawi**	**Uganda**
	(n=104)	(n=15)	N=15)	(n=200)
Water on Premises				
On	78 (75.0)	15 (100)	14 (93.3)	141 (70.5)
Off	26 (25.0)	0	16.6)	59 (29.5)
Water Available at Time of Interview				
Yes	91 (87.5)	14 (93.3)	15 (100)	165 (82.5)
No	13 (12.5)	1 (6.6)	0	35 (17.5)
Frequency of No Water[1]				
Daily	17 (16.8)	5 (33.3)	9 (64.3)	28 (14.0)
Yearly	30 (29.7)	3 (20.0)	1 (7.1)	132 (66.0)
Water Always Available	54 (53.5)	7 (46.7)	4 (28.6	40 (20.0)

[1]Describes the frequency that HCFs reported water not being available. They reported if the water was not available for part of the day (daily) or part of the year (yearly). Yearly usually refers to water not being available due to seasonal concerns.

When approximating the JMP service levels for basic water service, 61.7% of all the facilities meet the definition for basic water service (Figure 3). The highest proportion of HCFs that met the definition for basic water service was in Haiti (86.7%), while the lowest proportion of HCFs that met the basic service definition was in Uganda, with about 55.9% of facilities with basic water service.

Figure 3: Water Service Levels[1] of Surveyed HCFs by Country



[1]Basic water service is defined as water from an improved source that is available on premises. Limited service is defined as water from an improved source that is available off premise or an improved water source is on premises but water is not available. Unimproved/No service is defined as water that comes from an unimproved source

The distribution of total coliforms, free chlorine and *E. coli* concentrations indicate that these water quality indicators are not normally distributed. Most of the water samples had no or low concentrations of total coliforms, *E. coli* or free chlorine residuals, but there were a small number of samples with a wide range of higher concentrations (Figures 6-10).The median free chlorine residual for water samples was 0.1 mg/L, though the values ranged from 0-0.6 mg/L. The median *E. coli* and total coliforms concentration were 0.5 MPN/100mL, though the concentrations ranged from 0 to 665 MPN/100mL and 0 to 2,419 MPN/100mL, respectively.

Because the data for each of these water quality indicators were not normally distributed, a Wilcoxon paired-ranked test was employed to determine the correlation between free chlorine residual concentration and total coliform concentration and the correlation between *E. coli* concentration and free chlorine residual concentration (Figures 7-10). There is a low linear correlation between the variables, as noted by the Spearman correlation coefficient for each of these relationships. A contingency table was created for chlorine residual concentrations and *E. coli* concentrations and chlorine residual and total coliforms to determine the association between chlorine and these two predictors using a Fisher's exact test (Figures 4-5). Both resulted in a p-value <0.05, indicating the variables are associated with each other. This indicates that water samples that did not meet CDC guidelines for chlorine residual were less likely to meet WHO guidelines for microbiological water quality.

Figure 4: Contingency Table of Total Coliforms and Free Chlorine Concentrations

		Total Coliform Concentration (MPN/100mL)	
Chlorine Residual Concentration (mg/L)	N(%)	<1 MPN/100mL	≥1 MPN/100mL
	<0.2 mg/L	98 (35.1)	135 (48.9
	≥0.2 mg/L	37 (13.4)	6 (2.2)

Figure 5: Contingency Table of *E. coli* and Free Chlorine Concentrations

Chlorine Residual Concentration (mg/L)	N(%)	<1 MPN/100mL	≥1 MPN/100mL
	<0.2 mg/L	191 (69.2)	42 (15.2)
	≥0.2 mg/L	43 (15.6)	0

E. Coli Concentration (MPN/100mL)

We then classified the HCFs into categories based on the proportion of samples that met the CDC guidelines for chlorine residual concentration in water. A large proportion of the samples from HCFs in Afghanistan (83.8%) and Uganda (81.5%) did not have chlorinated water or the chlorine residual levels were below CDC guidelines (Table 3).

Table 3: Chlorine Residual in Water Samples in Selected HCFs

N[1] (%)	**Afghanistan** n=104	**Haiti** n=11	**Uganda** n=130
Water is chlorinated and greater than 50% of samples meet CDC guidelines for chlorine residual[2]	12(11.4)	2 (18.2)	15 (11.5)
Water is chlorinated but fewer than 50% of samples meet CDC guidelines for chlorine residual	5 (4.8)	2 (18.2)	9 (7.0)
Water is not chlorinated or chlorine residual levels are all below CDC guidelines for chlorine residual	88 (83.8)	7 (63.6)	106 (81.5)

[1]N represents the total number of HCFs in each country. 11 of 15 HCFs in Haiti had information regarding chlorine residual available while 130 of 200 HCFs in Uganda had this information available. This data was not available for the HCFs in Malawi.
[2]Defined as chlorine residual levels between 0.2 and 2.0 mg/L

In contrast, a large proportion of the surveyed HCFs in Afghanistan (74.3%) and Uganda (77.7%) had water samples that met the WHO guidelines for *E. coli* in water (Table 4). Only one facility in Haiti met the WHO guidelines for microbial water quality.

Table 4: Detection of *E. coli* in Water Samples in Select HCFs

	Afghanistan	**Haiti**	**Uganda**
N[1] (%)	n=104	n=11	n=130
90- 100% of all samples met WHO guidelines for microbial water quality[1]	78 (74.3)	1 (9.1)	101 (77.7)
Between 50-89% of all samples met WHO guidelines for microbial water quality	11 (10.5)	2 (18.2)	10 (7.7)
Fewer than 50% of all samples met WHO guidelines for microbial water quality	16 (15.2)	8 (72.7)	19 (14.6)

[1]N represents the total number of HCFs in each country. 11 of 15 HCFs in Haiti had the information on *E. coli* detection in the water sample available while 130 of 200 HCFs in Uganda had this same information available. This data was not available for the HCFs in Malawi.

[2]Defined as a concentration of *E. coli* of >=1 MPN/100mL

In the bivariate regression analysis of HCFs in Uganda, the odds of meeting the criteria for basic water service level at government HCFs was lower than the odds for all the non-governmental HCFs (**OR**: 0.25, **95% CI**:0.09, 0.71). Health centers and HCFs in the West Nile region had a lower odds of having basic water service compared to hospitals and HCFs in the Karamoja region, respectively (Table 5).

Table 5: Factors Associated with Basic Water Service in Surveyed HCFs in Uganda[1]

Outcome: Basic Water Service		
	OR	**95% CI**
Managing Body		
Government	0.25	[0.09, 0.71]
Non-Governmental[a]	1.0	
Facility Type		
Health centers	0.83	[0.19, 3.61]
Hospitals[a]	1.0	
Region		
Karamoja	1.11	[0.52, 2.36]
West Nile[a]	1.0	

[1]Estimates were based on 139 HCFs from Uganda that had information available for both the independent and outcome variables
[a]Referent category

HCFs with water that met the WHO *E. coli* standards were significantly more likely to have water from an improved source (OR:1.13, 95% CI:1.13,5.32). HCFs having chlorinated water and water on the premises were positively associated with having water quality that met WHO microbial water quality standards (Table 6).

Table 6: Factors Associated with Water Quality in Surveyed HCFs[1]

Outcome Variable	Independent Variable	N	Odds ratio	95% CI
Met WHO standard for *E. coli* concentration[2]	Water Source	238		[1.13, 5.32]
	Improved		2.46	
	Unimproved[a]		1.0	
	Facility Type	231		
	Health Center		0.60	[0.23, 1.60]
	Hospital[a]		1.0	
	Chlorine Residual[3]	127		
	Yes		7.53	[0.96, 58.69]
	No[a]		1.0	
	Water On Premises	232		
	Yes		1.92	[1.01, 3.62]
	No[a]		1.0	

[1]Includes HCFs in Afghanistan, Haiti, Uganda and Malawi that had information for both the outcome variable and predictor available. HCFs missing the information were excluded from each regression analysis.
Defined as *E. coli* concentrations of <1MPN/100mL
[2]Presence of any amount of chlorine residual in water
[a]Referent category

Discussion

This cross-sectional assessment of water services in HCFs in Afghanistan, Haiti, Malawi, and Uganda, found more than half of the surveyed facilities in each country had access to an improved source of water that was available on the premises, which are the key characteristics necessary to meet the JMP service ladder definition for having basic water services. Though a majority of the facilities met this criteria, there was still a substantial proportion of facilities that only had limited service or unimproved/no service, ranging from a high of 44.1% of surveyed facilities in Uganda to a low of 13.4% in Haiti. These results are similar to the recent JMP report that provided global baseline assessment of WASH in HCFs. Globally, about 74% of facilities meet the standards for having basic water service [15]. The report also highlights that the availability of a basic water service varies between countries, as shown in our study. This is important to note since it shows that there is still substantial work to be done if we are to achieve SDG 6 of providing universal access to safe water by 2030 and specifically to ensure that all HCFs have at least basic water services.

Hospitals had a higher odds of having basic water services available compared to health centers. Though our results were not statistically significant, this is consistent with the findings from the WHO/UNICEF WASH in HCFs baseline assessment that showed that there were a lower proportion of health centers in LMICS that met the criteria for having basic WASH services, as compared to hospitals [15]. Hospitals tend to be larger than health centers and serve a large patient population [19], so it is likely that hospitals would have more money and resources to devote to improving and maintaining WASH

infrastructure within their facilities, which could be a contributing factor to the inequality in water service levels that was apparent in this analysis. There findings are also consistent with the findings of Cronk et al. (2018) which reported a significant association between facility type and availability of water services in a stratified analysis of data from six countries, though this was only a significant association for some countries in the dataset [16].

When analyzing demographic factors that were associated with basic water services in HCFs, the managing body of the HCF was a significant determinant of whether basic water services were available for surveyed facilities in Uganda. Government-managed HCFs had 75% lower odds of having basic water services available than non-governmental HCFs, which included HCFs managed by private organizations, NGOs, and faith-based organizations. This is important because government HCFs are one of the major providers of healthcare services in Uganda and a significant proportion of the population, especially the poor, seek care at these types of HCFs [20]. Not having basic water services may compromise the quality of care provided by these facilities. These results were also consistent with the findings of Cronk et al. (2018) that reported a significant association between managing body and water service levels [16]. The JMP baseline assessment of WASH in HCFs also notes that differences in WASH services exist between facilities with different managing bodies [15].

Our analysis of factors associated with water quality revealed that there was an association between water source and microbial water quality. These results are

unsurprising since unimproved sources of water, such as surface water and unprotected wells, are not shielded from environmental contamination. The design of piped water supplies and boreholes are meant to protect the water source from external contaminants in the environment and may also include some form of water treatment [21].

Although a large proportion of HCFs in Afghanistan, Haiti, and Uganda met the standard for having basic water service, the majority of HCFs where water samples were collected and analyzed had water that did not meet water quality standards for chlorine residual. A closer look into our data revealed that many facilities did not chlorinate their water. Chlorination of water is known to be important to prevent transmission of waterborne pathogens [22]. Many waterborne diseases can be transmitted in HCFs, including *Legionella*, which can cause severe illness in patients and can lead to healthcare-associated outbreaks [23]. This finding suggests that though the HCFs may meet the definition of having basic water service, it is possible that the water available will not be of a quality that is safe for patients and the wide range of healthcare and hygiene activities in HCFs that require clean water. Future monitoring of water services in HCFs should include water quality indicators, such as chlorine residual, total coliforms or *E. coli*, and not just water availability and type of source.

Study Limitations

There are many limitations of this study. The HCFs that were included in this assessment were selected based on different criteria, including partnerships with NGOs already working within the HCFs surveyed. Therefore, these HCFs cannot be considered a representative sample of all HCFs in these four countries. It is possible that there was

selection bias that may have caused our results to be an overestimation of the true proportion of HCFs with basic water service levels. The recent JMP report estimated that only 31% of facilities in Uganda met the criteria for having basic water service [15], while our assessment indicates in Uganda about 55% of HCFs surveyed had basic water service. However, the HCFs included in this analysis were mostly concentrated in the northern region of Uganda, so our results likely align more closely with regional estimates in Uganda rather than national estimates.

Another limitation in this study is that demographic information was not available for all the HCFs in this study. If that information had been available, a more robust analysis could have been conducted about factors associated with having basic water services. Also, we had small sample sizes in Malawi and Haiti, so our assessments of water services in these countries likely are not a true approximation of the proportion of HCFs having basic water services.

Additionally, there was a lack of detailed water quality information for Afghanistan, Haiti, and Malawi. Therefore, water quality assessments were not as comprehensive for these facilities as they were for Uganda.

Further, this study focused only on water provisions in HCFs, however it is important to also consider the hygiene and sanitation conditions within a facility. Even with water available, if there is no soap to practice hand hygiene or if there is inadequate sanitation or unsafe waste management, the HCF staff and the patients are at risk of disease transmission, and it is not possible to provide quality healthcare. It is important to

determine water service levels, but it is equally important to also assess the sanitation and hygiene of HCFs, as each part is vital for ensuring the health and well-being of patients.

Future Directions

This study provides some important insights about the status of water services within HCFs. It also revealed that water service and water quality inequalities exist between HCFs. Future monitoring for WASH in HCFs should go beyond just determining if HCFs meet basic water, sanitation and hygiene service levels. Environmental cleanliness in HCFs and infection control practices are also vital for providing healthcare services. Future research should also track other environmental indicators that are known to be associated with good HCF conditions.

The WASHCon Tool proves to be a valuable systematic approach for collecting primary data on WASH in HCFs across a range of countries. Current baseline estimates for WASH in HCFs draw from a variety of data sources, which contain differing sets of questions and core indicators. To achieve more useful results, tools like WASHCon should be used universally across HCFs to collect harmonized data to ensure more accurate tracking of SDG 6 progress. In this manner, more accurate estimates can be made in a variety of countries which will aid in setting priorities of which countries and regions need the most attention so that we can work together to ensure progress towards achieving access to safe WASH services for all.

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Appendix 1

Figure 6: Distribution of *E. coli* concentration within water samples from HCFs with improved water sources in Uganda

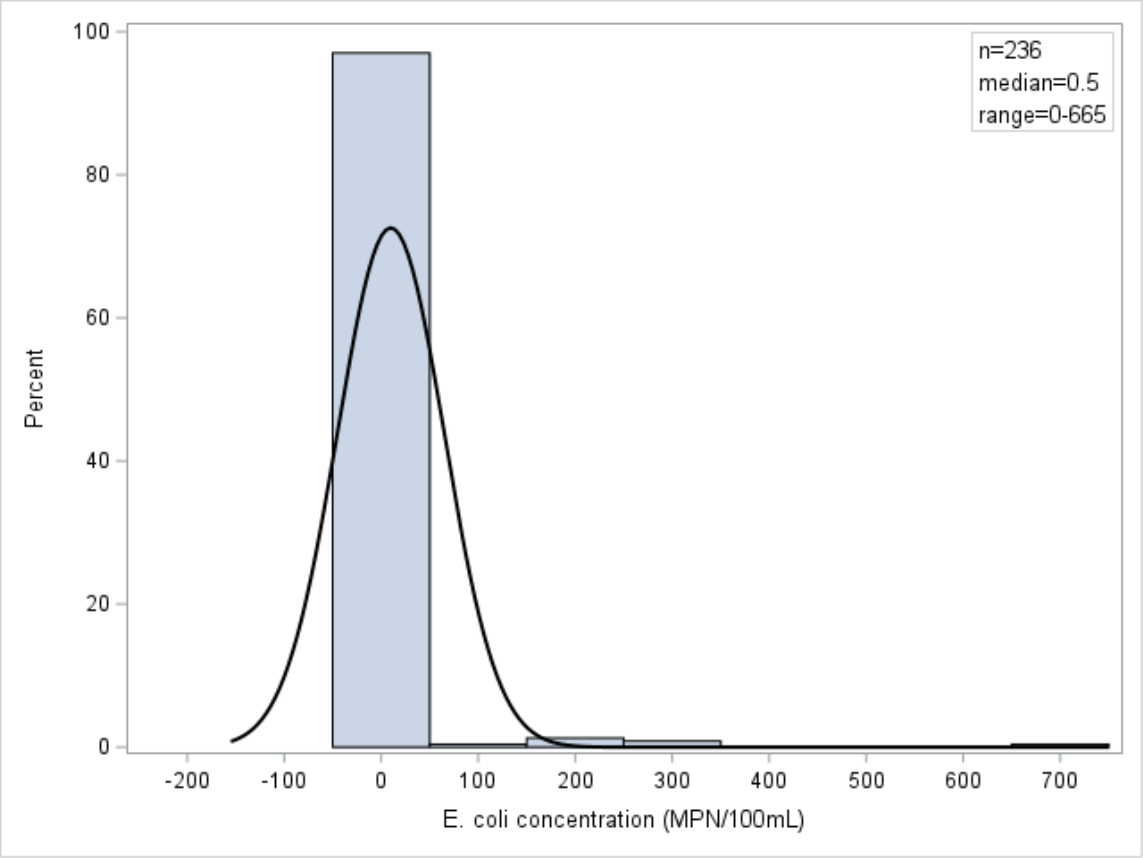


Figure 7: Distribution of *E. coli* concentration in water samples from HCFs with unimproved water sources in Uganda

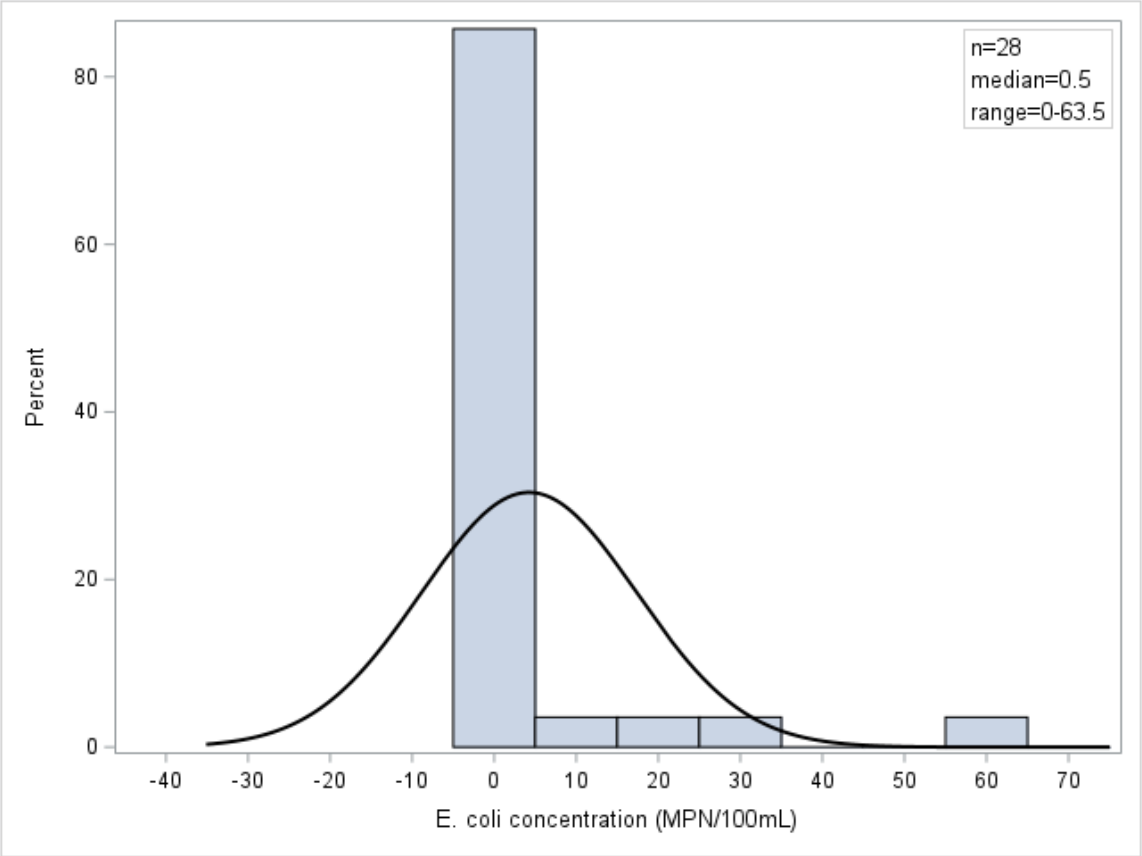


Figure 8: Distribution of total coliform concentration in water samples from HCFs with improved water sources in Uganda

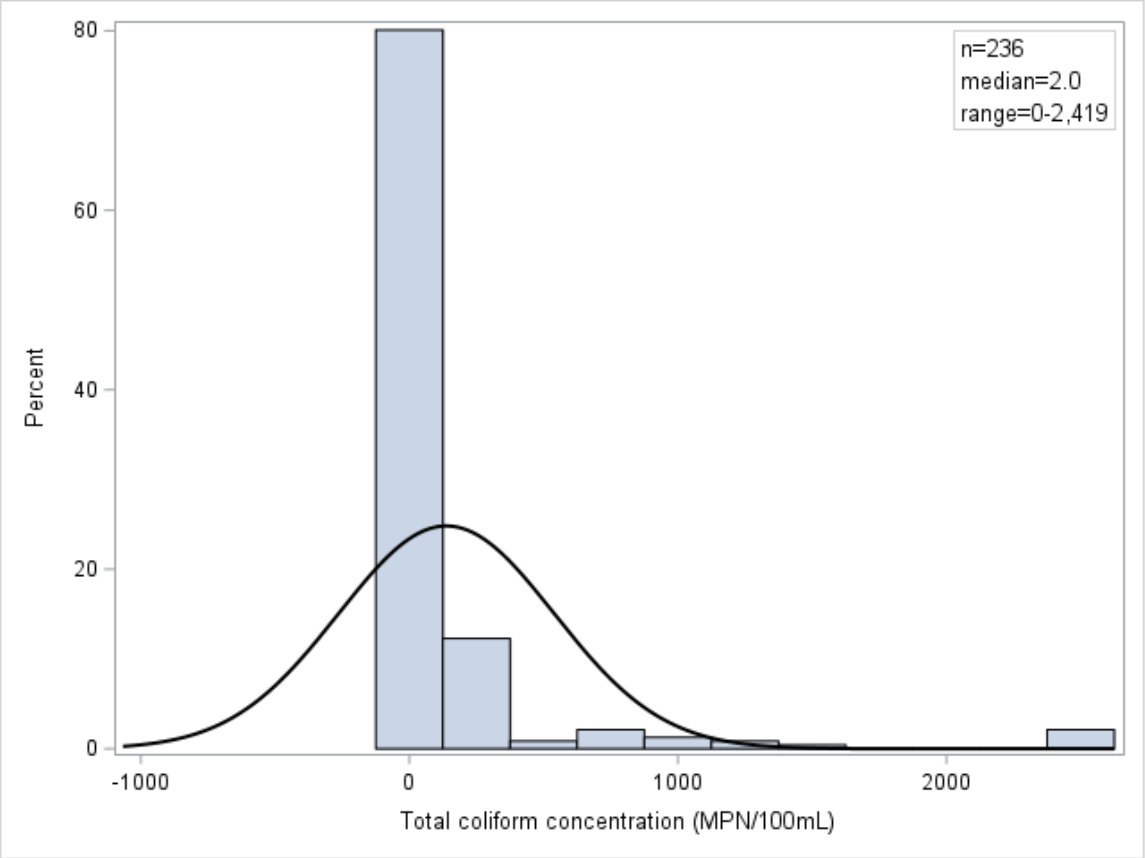


Figure 9: Distribution of the *E. coli* within water samples from Healthcare Facilities with unimproved water sources in Uganda

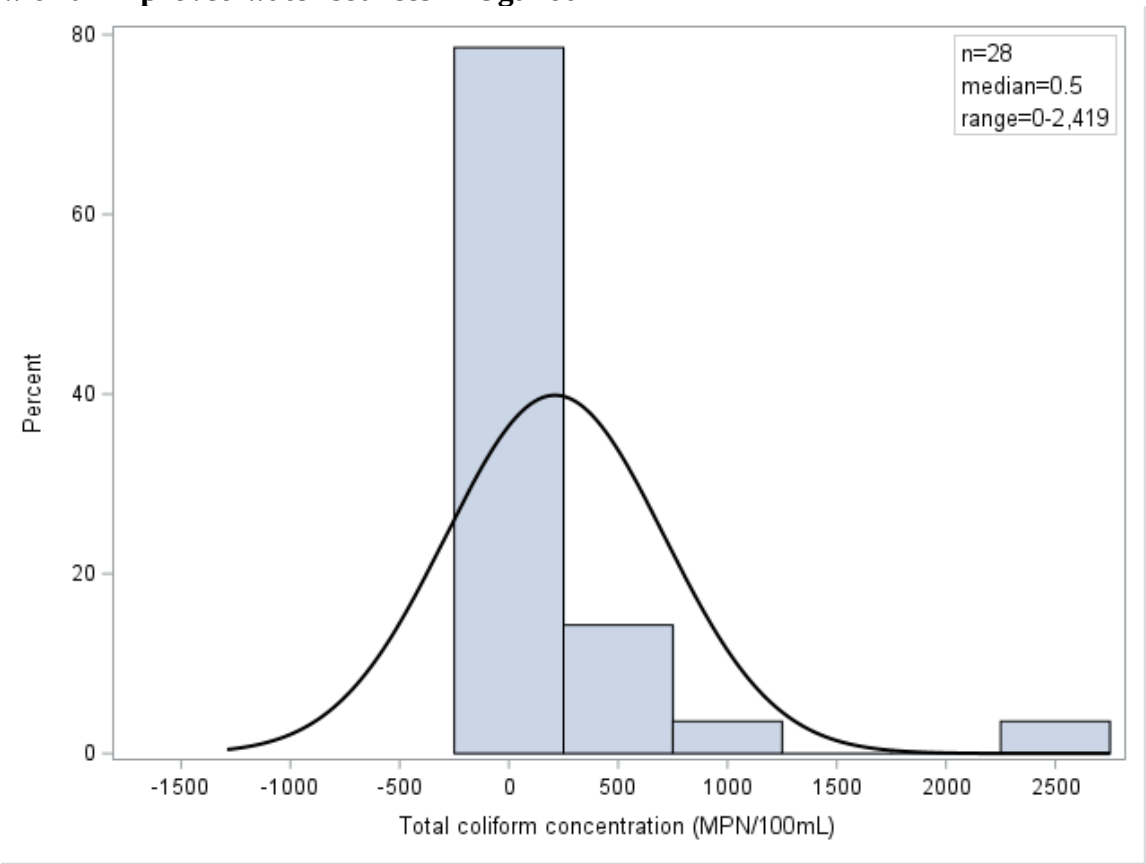


Figure 10: Distribution of free chlorine residual concentrations in water samples of select HCFs in Uganda with improved water sources

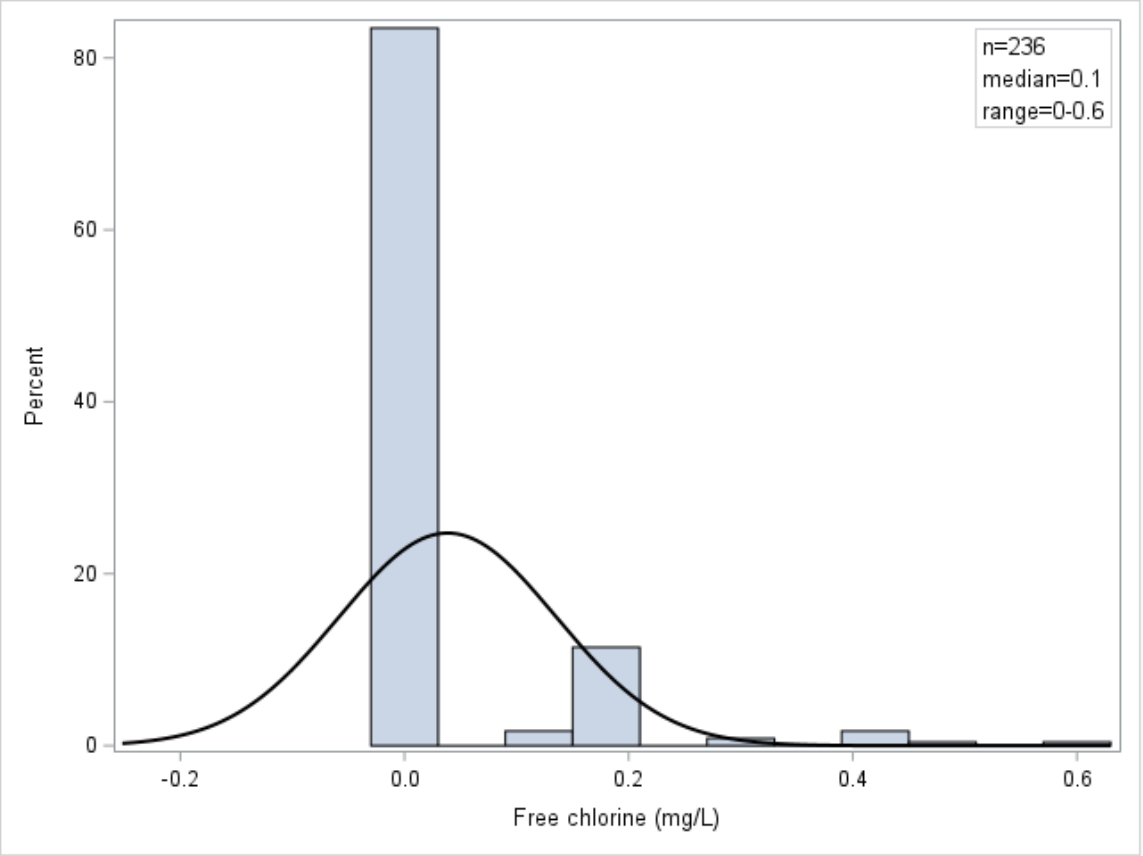


Figure 11: Distribution of free chlorine residual concentrations in water samples of select HCFs in Uganda with unimproved water sources

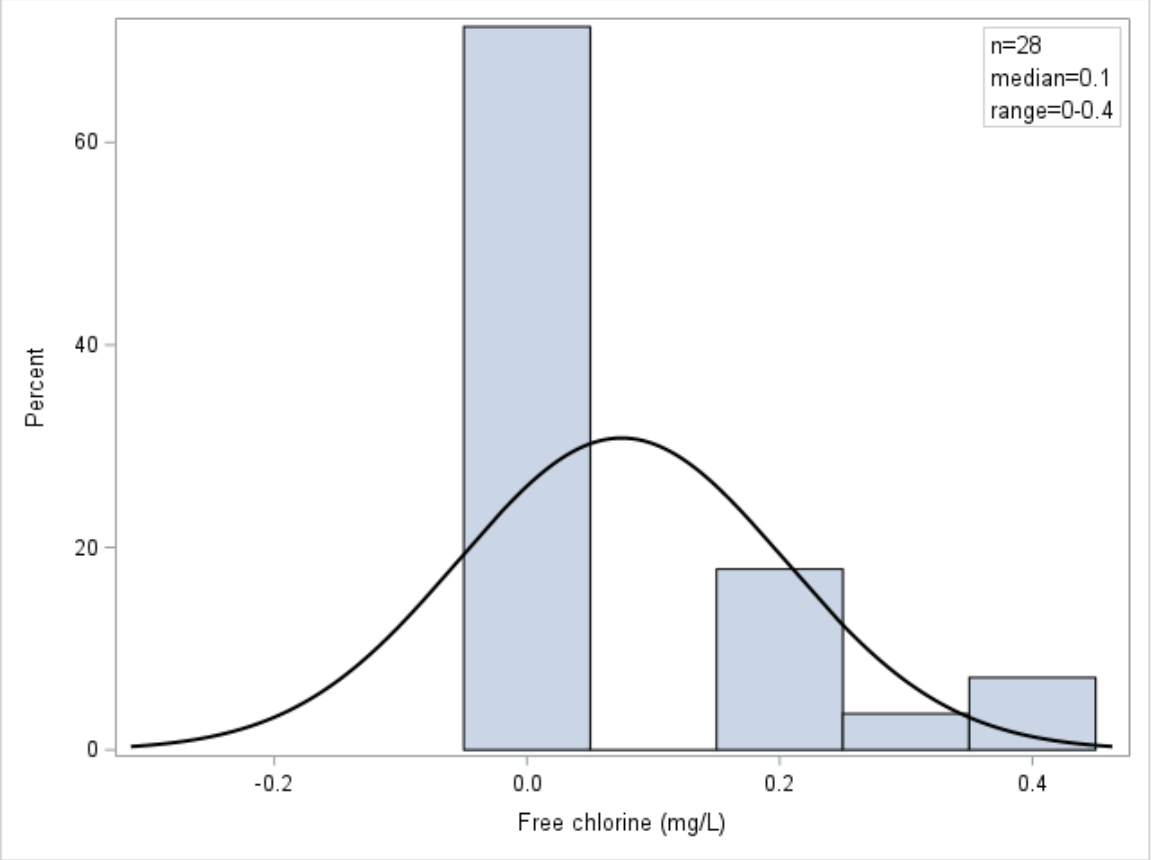
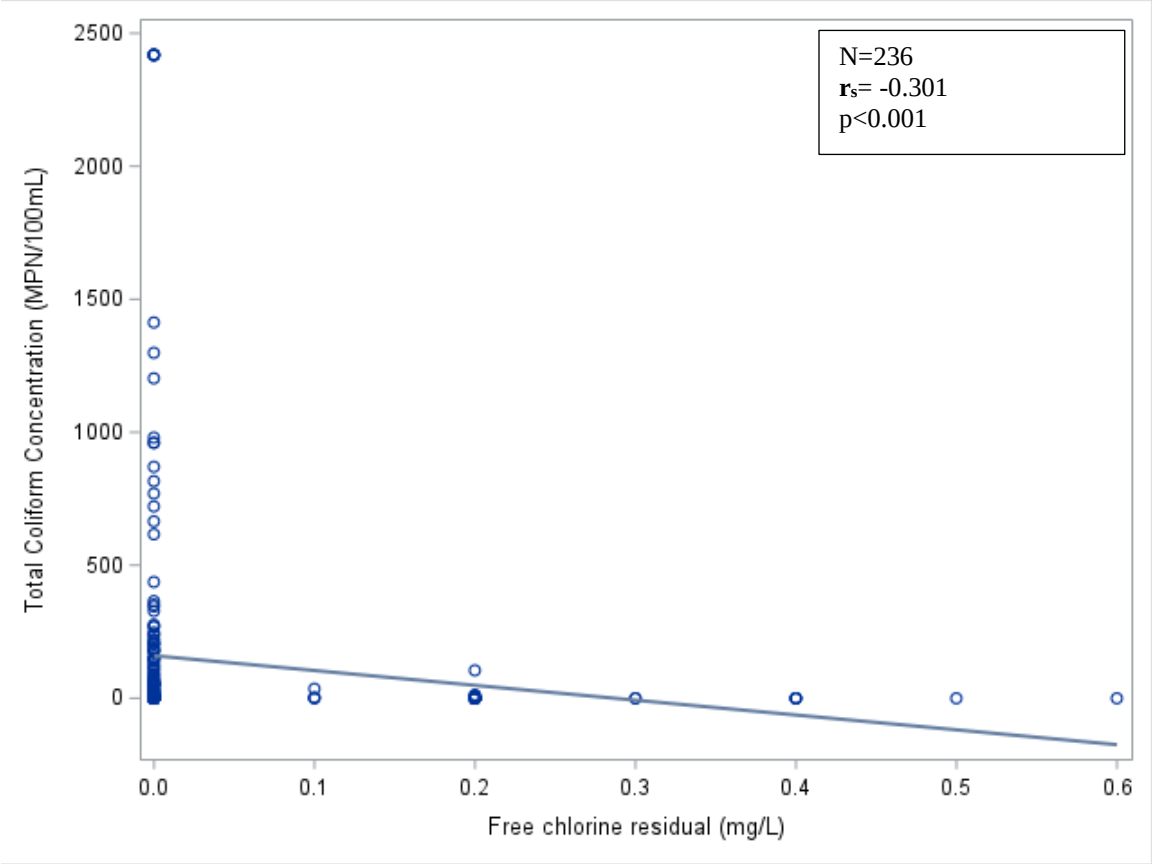


Figure 12: Relationship Between Free Chlorine Residual and Total Coliform Concentrations of Water Samples in HCFs in Uganda with Water from an Improved Source



[1]N represents the total number of water samples. More than one sample was collected from a given healthcare facility.

Figure 13: Relationship Between Free Chlorine Residual and Total coliform concentration in Water Samples of Healthcare Facilities in Uganda with Water from an Unimproved Source

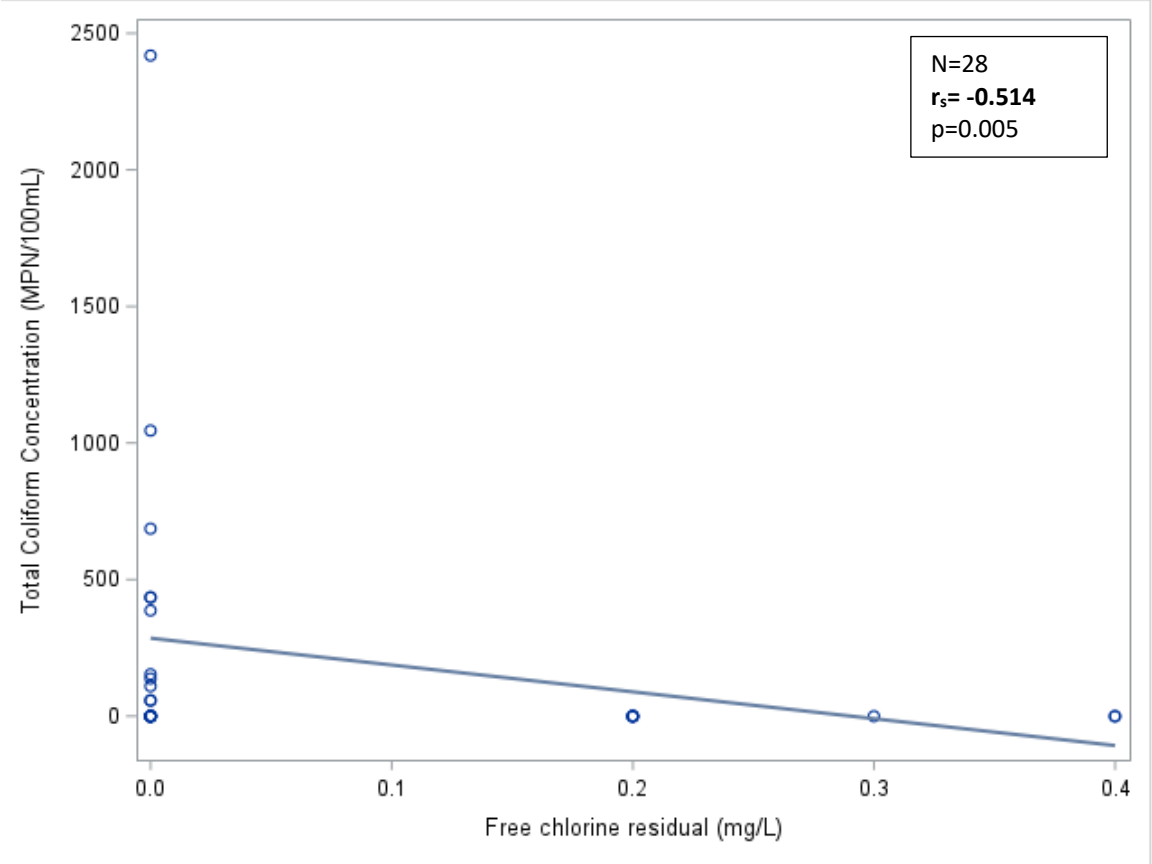


Figure 14: Relationship Between Free Chlorine Residual and *E. coli* Concentrations in Water Samples of HCFs in Uganda with Water from an Improved Source

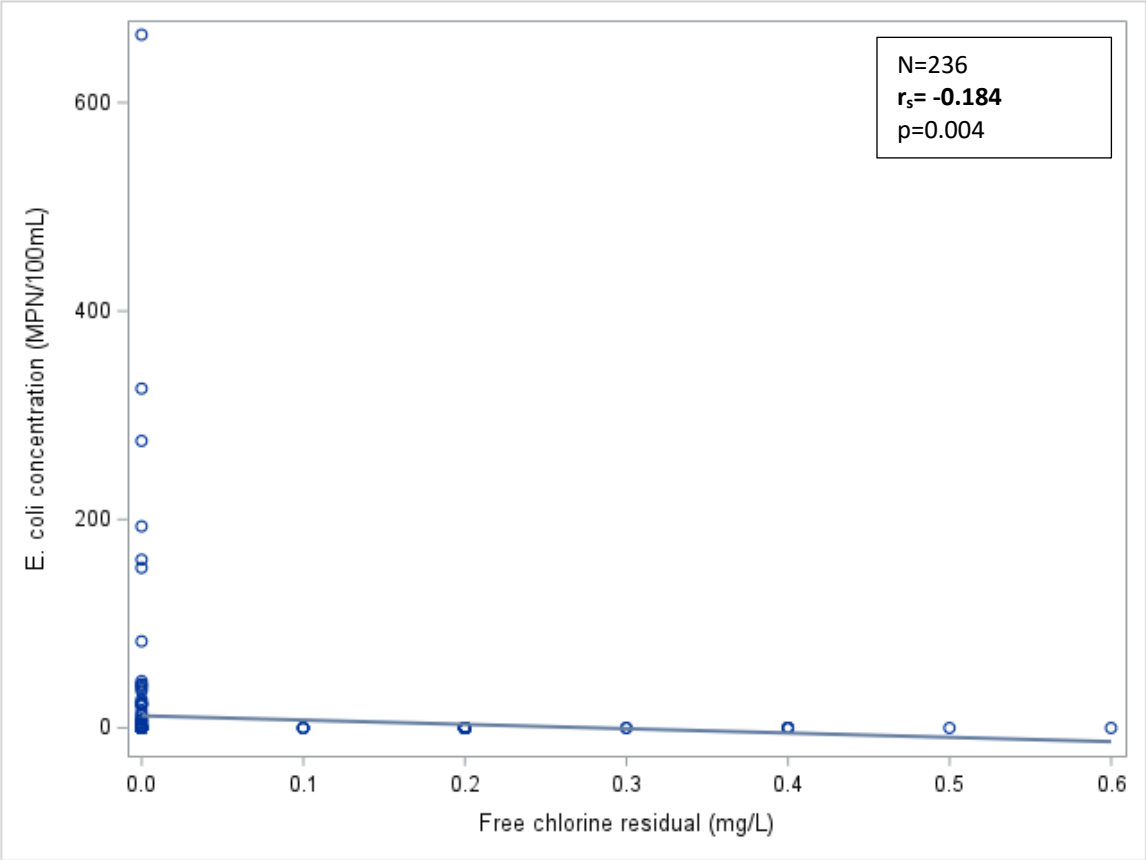
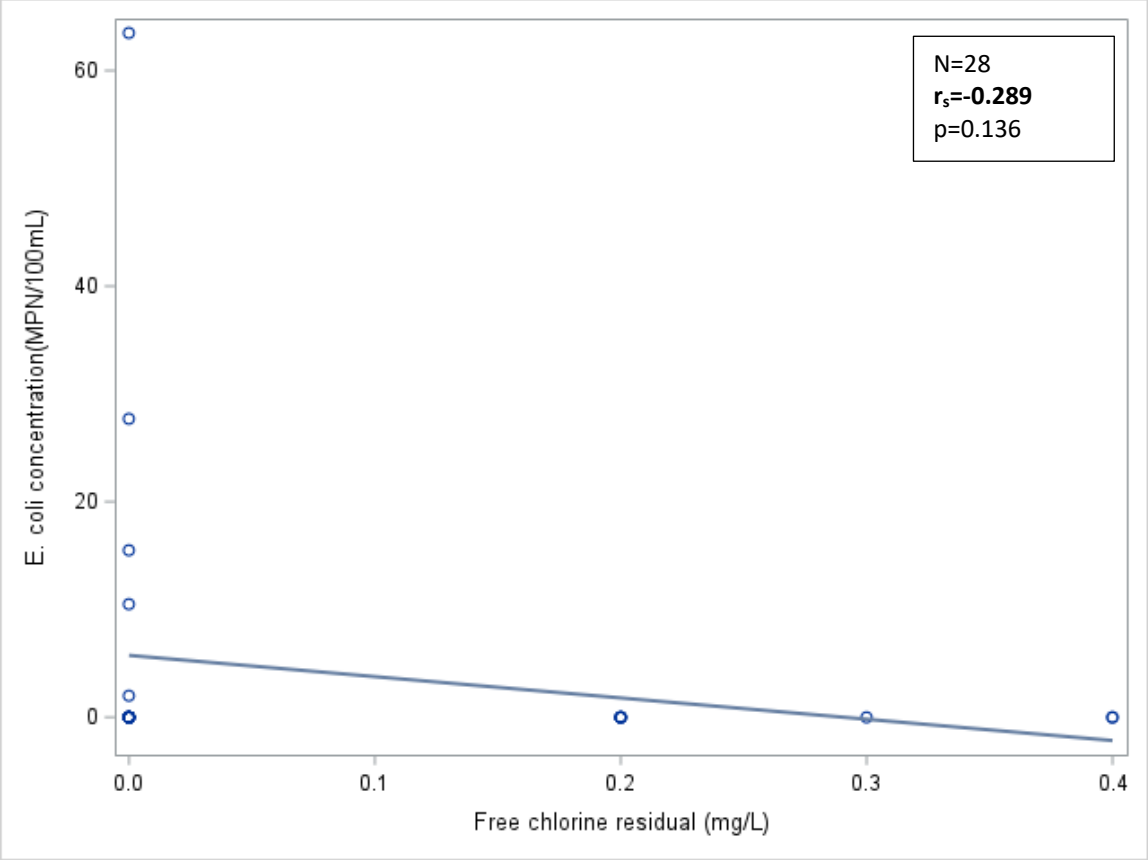


Figure 15: Relationship Between Free Chlorine Residual and *E. coli* concentration in Water Samples of Healthcare Facilities in Uganda with Water from an Unimproved Source



Appendix 2

WASHCon Survey Questions: Water Domain

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WASHCon: Administrative Data Form

1	**Does this healthcare facility have outpatient services (OPD)?** If NO, skip to Q4	☐ Yes ☐ No
2	**On average, how many outpatients are seen per month?**	
3	**How many days in a month are outpatients seen?**	
4	**Does this healthcare facility have inpatient services?** If NO, skip to Q8.	☐ Yes ☐ No
5	**On average, how many inpatients are seen per month?**	
6	**On an average day, how many inpatients are at the healthcare facility?**	
7	**How many inpatient beds are available?**	
8	**On average, how many deliveries take place per month?**	
9	**Of these deliveries, how many were cesarean sections?**	
10	**Are surgical procedures performed at this healthcare facility?** If no, skip to Q12	☐ Yes ☐ No
11	**If yes, on average, how many surgical procedures are performed each month?**	
12	**How many clinical staff are employed at the healthcare facility?** (i.e. doctors, midwives, nurses, etc.)	
13	**Of the clinical staff, how many are medical doctors?**	
14	**How many non-clinical staff are employed at the healthcare facility?** (i.e. administrative staff, janitorial staff, etc.)	
15	**Of the non-clinical staff, how many are cleaners?**	
16	**On average, how much water is used daily (in liters)?** Note: information may be found on water bill or best estimate from reliable source	

1

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WASHCon: Aggregated Water Quality Data Form

1	**Does the water have appropriate levels of chlorine residual?** CDC guidelines recommend between 0.2-2.0 mg/L (or ppm)	□ Water is chlorinated and more than 50% of samples meet CDC guidelines for chlorine residual □ Water is chlorinated but less than 50% of samples meet CDC guidelines for chlorine residual □ Water is not chlorinated OR chlorine residual levels are all below CDC guidelines for chlorine residual
2	**Does the water quality meet WHO microbial water quality guidelines?** WHO guidelines recommend less than 1 CFU E. coli per 100mL sample	□ Between 90-100% of all samples met WHO guidelines for microbial water quality □ Between 50-89% of all samples met WHO guidelines for microbial water quality □ Less than 50% of all samples met WHO guidelines for microbial water quality

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WASHCon: Director Survey Form

1	**Which of the following services or departments are available at this healthcare facility?** Read all options. Check all that apply.	□ Antenatal Care □ Dentistry □ Emergency Department □ Environmental Services □ Eye Clinic □ HIV/VCT/ARV Clinic □ Housing for Staff □ Immunization □ Inpatient □ Intensive Care Unit □ Kitchen □ Labor and Delivery □ Laboratory □ Major Surgery □ Morgue □ Minor Surgery □ Nutrition Services □ Outpatient (OPD) □ Pediatric □ Pharmacy □ Postnatal □ TB Services □ Other:	
ELECTRICITY: "Now I'm going to ask you some questions about electricity."			
2	**What sources of energy are used at the healthcare facility?** Read all options. Check all that apply. If "No power source" is selected, skip to Q5.	□ Utility power □ Solar power □ Generator (petroleum) □ Firewood □ Charcoal □ LPG □ No power source □ Other: □ Don't know	
3	**What is the main source of energy?**	□ Utility power □ Solar power □ Generator (petroleum) □ Firewood □ Charcoal □ LPG □ No power source □ Other: □ Don't know	

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WASHCon: Director Survey Form

4	**If electricity** (utility, solar, generator) **is used to power the facility, how many days last month was the electricity interrupted for more than 2 hours?**	□ Everyday □ Most days but not every day □ Several times □ Once □ Never □ Don't know	
WATER SUPPLY: "Now I'm going to ask you some questions about water supply."			
5	**Please tell me which of the following sources of water are available to the healthcare facility:** Read all options. Check all that apply. If no water source, skip to Q32	□ Piped supply from outside the facility □ Tube well □ Borehole □ Protected dug well □ Rain Water	□ Unprotected dug well □ Surface water □ Tanker truck □ Other □ Don't know □ No water source
6	**What is the main water source for the healthcare facility?** The question refers to the source of water for general purposes, including drinking, washing, and cleaning. In case of water being available at multiple points, record the response closest to the outpatient area.	□ Piped supply from outside the facility □ Tube well □ Borehole □ Protected dug well □ Rain Water	□ Unprotected dug well □ Surface water □ Tanker truck □ Other □ Don't know □ No water source
7	**Where is the main water source for the facility?** If on premises, skip to Q10	□ On premises □ Off premises, within 500m □ Off premises, farther than 500m □ No water source □ Don't know	
8	**What is the roundtrip travel time to collect water off premises?** (in minutes)		
9	**Who collects the water off premises?**	□ Patients/caregivers only □ Staff only □ Both patients/caregivers and staff □ Other □ Don't know	
10	**Are there times when the main water source is unavailable?** If NO, skip to Q14.	□ Yes □ No □ Don't know	

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WASHCon: Director Survey Form

11	**If yes, why?** Read all options. Check all that apply	□ Power outage □ Water rationing/shortage □ Equipment malfunction (i.e. broken pump) □ Season (dry or wet)	□ Pipe breakage □ Problems at the water provider □ Other: □ Don't know
12	**How often is the main water supply unavailable?** Read all options.	□ For part of the day, rarely □ For part of the day, frequently □ For part of the year (seasonal problem), frequently □ For part of the year (seasonal problem), rarely □ Don't know	
13	**Is there routinely a time of year when the healthcare facility has a severe shortage or lack of water?**	□ Yes □ No □ Don't know	
14	**Does the healthcare facility ever ration water?** (i.e. is water use intentionally limited or used sparingly) If NO, skip to Q16	□ Yes □ No □ Don't know	
15	**If yes, why?** Check all that apply.	□ Cost of water □ Concerned water will run out □ Other: □ Don't know	
16	**How does the healthcare facility store water?** Check all that apply. If NO, skip to Q20	□ In centralized storage tank(s) (plastic/concrete/steel) □ In storage tanks (plastic/concrete/steel) at the various wards □ In containers (such as buckets/jerry cans) inside the wards □ In containers on the facility premises □ Other □ No water storage available □ Don't know	
17	**What type of water storage facilities are available?** Check all that apply.	□ Plastic tanks □ Concrete tanks □ Elevated steel tanks □ Buckets/jerrycans within wards □ Other □ Don't know	
18	**What is the total water storage capacity at the healthcare facility in liters?**		
19	**Can this storage capacity provide at least 24 hours of water supply for the needs of the healthcare facility?**	□ Yes □ No □ Don't know	

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WASHCon: Director Survey Form

20	**Which users have access to water?**	□ Patients/caregivers □ Staff □ Community members □ None □ Don't know
21	**Is water accessible to all users at all times?** i.e. water can be accessed any time of day by anyone (patients, staff and caregivers) at the healthcare facility *Note: this question is asking about equity of access, not water outages.*	□ Yes □ No, patients/caregivers do not have access at all times □ No, staff do not have access at all times □ No, both (patient/caregivers and staff) do not have access at all times □ Don't know
22	**Are there tastes, odors or colors that discourage consumption or use of the drinking-water?**	□ Yes □ Sometimes □ No □ Don't know
23	**How is water accessed within the healthcare facility?** Read all options. Check all that apply.	□ Piped taps □ Uncovered buckets/barrels □ Covered buckets/barrels □ Covered buckets with taps on bottom □ Uncovered buckets with taps on bottom □ Jerry cans □ Other □ Don't know
24	**If buckets/barrels selected, how is water removed from buckets/barrels for use in the wards?** Read all options. Check all that apply.	□ Cup or ladle □ Tap □ Pour □ Other □ Don't know
25	**Does this healthcare facility expect that pregnant women will bring their own water when they come to deliver?**	□ Yes □ Sometimes □ No □ Don't know
WATER TREATMENT: Now I am going to ask you some questions about water treatment.		
26	**Is water from the main water source chlorinated (treated with chlorine)?**	□ Yes □ No □ Don't know
27	**Does chlorination occur on the healthcare facility premises?** As opposed to the water being chlorinated by the water utility.	□ Yes □ No □ Don't know

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28	**Does the healthcare facility purchase or produce drinking-quality water for staff, patients and caregivers?** This includes bottled water. If NO, skip to Q31.	□ Yes □ Sometimes □ No □ Don't know
29	**If yes, how does the healthcare facility provide treated drinking-water?** Read all options, select all that apply.	□ Chlorination of drinking water onsite □ Filtration of drinking water onsite □ Boiling of drinking water onsite □ UV treatment of drinking water onsite □ Bottled (or sachet) water available □ Water is treated before reaching the healthcare facility (i.e. by a utility treatment plant) □ Other □ Don't know
30	**In the previous two weeks, was drinking-water available for patients throughout each day?**	□ Yes □ No □ Don't know
I'm now going to ask you questions about water treatment for various medical purposes.		
31	**How is water treated for the following medical purposes?** Read all purposes. Check all that apply and circle the type of treatment. Note: Select "Not Applicable" if the medical purposes does not occur at this facility	□ Surgical procedures Chlorination, Filtration, Boiling, Distillation, Purchase, UV, Other, No Treatment, Not applicable, Don't know □ Labor and delivery Chlorination, Filtration, Boiling, Distillation, Purchase, UV, Other, No Treatment, Not applicable, Don't know □ Wound and burn care Chlorination, Filtration, Boiling, Distillation, Purchase, UV, Other, No Treatment, Not applicable, Don't know □ Processing of medical equipment Chlorination, Filtration, Boiling, Distillation, Purchase, UV, Other, No Treatment, Not applicable, Don't know □ Use in medical devices (CPAP, incubator, etc.) Chlorination, Filtration, Boiling, Distillation, Purchase, UV, Other, No Treatment, Not applicable, Don't know □ Dentistry Chlorination, Filtration, Boiling, Distillation, Purchase, UV, Other, No Treatment, Not applicable, Don't know □ Mixing medication Chlorination, Filtration, Boiling, Distillation, Purchase, UV, Other, No Treatment, Not applicable, Don't know □ Laboratory Chlorination, Filtration, Boiling, Distillation, Purchase, UV, Other, No Treatment, Not applicable, Don't know

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32	**When is water typically treated?**	□ Prior to storage □ After storage □ Both prior to and after storage □ No water treatment

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WASHCon: Water Sample Form

Sample Number:				
1	**Sample Location**	□ Water Source □ Antenatal Care □ Dentistry □ Emergency Department □ Environmental Services □ Eye Clinic □ HIV/VCT/ARV Clinic □ Housing for Staff □ Inpatient □ Intensive Care Unit □ Kitchen □ Labor and Delivery		□ Laboratory □ Major surgery □ Morgue □ Minor surgery □ Nutrition Services □ Outpatient □ Pediatric □ Pharmacy □ TB Services □ Other: □ Don't know
3a	**Free Chlorine**		**Units**	□ ppm □ mg/L
3b	**Total Chlorine**			
4	**Total Coliform**		**Units**	□ CFU □ MPN
5	***E. coli***			□ Presence/Absence