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Water, sanitation and hygiene at health care facilities in Afghanistan and Uganda: an analysis of access, quality, and predictors of disparity

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An abstract of
a thesis submitted to the Faculty of the
Rollins School of Public Health of Emory University
in partial fulfillment of the requirements for the degree of
Master of Public Health
in Global Health
2019

Abstract

Water, sanitation and hygiene at health care facilities in Afghanistan and Uganda: an analysis of access, quality, and predictors of disparity

By Hannah L. Wilson

Background: Basic water, sanitation, and hygiene (WASH) in health care facilities (HCFs) are critical for infection prevention and control, containment of anti-microbial resistance, and provision of quality health care. Data on HCF WASH conditions remain scarce. There is a need for field assessments and for identifying determinants of WASH among HCFs in low-development/high-risk areas.

Methods: Primary survey, observation, and microbiological water quality data were collected from >250 HCFs in selected regions of Afghanistan and Uganda through the WASH Conditions (WASHCon) Assessment Tool. This report describes the WASH conditions and uses country-specific multivariable logistic regressions to identify determinants of 4 key outcomes: 1) basic water service; 2) hand hygiene facilities; 3) Six Cleans for safe delivery, and 4) microbiological water quality.

Results and Conclusions: Among HCFs assessed in Afghanistan and Uganda, respectively: 70% / 60% had basic water service; 86% / 74% had hand hygiene facilities at ≥1 point of care; 23% / 33% had all of the Six Cleans; and 21% in both countries had *E. coli* detected in ≥1 100mL water sample. Differences in coverage estimates emerged from small changes to indicator definitions, indicating need for careful consideration of these definitions. Private HCFs were more likely to have basic water service, access to hand hygiene facilities, and superior water quality compared to public HCFs in Uganda. Sub-national region was associated with hand hygiene access and water quality in both countries and Six Cleans access in Uganda. Higher levels of care were associated with basic water service in Uganda but poorer water quality in Afghanistan. Main water source type was the strongest predictor of *E. coli* detection in ≥ 1 water sample among HCFs in both countries. These analyses support development of evidence-based WASH interventions for HCFs and provide a roadmap for future research on the determinants of HCF WASH conditions.

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Acknowledgements

First, I would like to extend my profound gratitude to my advisor, the brilliant and exacting Dr. Christine Moe. She embodies the balance of kindness and rigor that all mentors should hope to achieve. Any inaccuracies or inelegance remaining in this work are entirely my own. Dr. Moe, thank you for the opportunity to work on this important project, and thank you for challenging me and inspiring me along the way.

Sincerest thanks to Lindsay Denny and Habib Yakubu for their assistance tracking down answers and for their continuing patience with my many questions. Thank you to the rest of the Center for Global Safe WASH at Emory University, including Dr. Joanne McGriff for her leadership, Kat Peters for her tireless support, and Andrew Wang for his analytics advice. Thanks also to our esteemed partners at World Vision in Afghanistan, especially Rosanna Keam, Seyar Haqmal, and Dr. Shakib Popal. Thank you as well to our valued colleagues at UNICEF in Uganda. Thanks and appreciation to the General Electric Foundation for supporting the WASHCon study.

I extend tremendous gratitude and appreciation to my family and friends for their steadfast confidence in me. I love the fact that there are too many of you to name.

Special thanks to Momo and Pabu, support cats, for all the snugs.

Finally, I offer my deepest thanks to my compassionate, brilliant and talented husband.
Joe Reb, you are the best. Thank you for loving me and for everything you do. I love you.

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Terms

AMR	Anti-microbial resistance
FCR	Free chlorine residual
HCAI	Health care-associated infection
HCF	Health care facility
IPC	Infection prevention and control
MDGs	United Nations Millennium Development Goals (2000 – 2015)
NGO	Non-governmental organization
SDGs	United Nations Sustainable Development Goals (2015 – 2030)
SSI	Surgical site infection
WASH	Water, sanitation, and hygiene
WQ	Water quality

Organizations

CGSW	Center for Global Safe WASH at Emory University
JMP	WHO/UNICEF Joint Monitoring Programme for Water Supply and Sanitation
UN	United Nations
UNICEF	United Nations International Children's Emergency Fund
WB	World Bank
WHO	World Health Organization

Regions and Development Categories

AFR	Africa region (WHO)
CSA	Central and Southern Asia region (UN – SDG)
EMR	Eastern Mediterranean region (WHO)
LDC	Least Developed Countries (UN – SDG)
LLDC	Landlocked Developing Countries (UN – SDG)
LIC	Low-Income Countries (WB)
LMIC	Low- and Middle-Income Countries (WB)
SA	Southern Asia region (UN – MDG)
SSA	sub-Saharan Africa region (UN – SDG and MDG)

--END--

Chapter I. Literature Review

1. Introduction to WASH in HCFs

Among the United Nations' Sustainable Development Goals (SDGs), SDG 6 seeks to provide clean water and safe sanitation for all by 2030 (UN, 2018), and SDG 3 includes a mandate to "achieve [...] access to quality essential health-care services" for all. At the intersection of these two SDGs is the pursuit of safe water, sanitation, and hygiene (collectively, WASH) at health care facilities (HCFs).

HCFs are intended to prevent and cure disease. Without safe WASH, HCFs can instead become places of disease transmission for patients and staff alike. Unsafe WASH in HCFs may cause healthcare-associated infections (HCAIs), especially among vulnerable populations (Allegranzi et al., 2013). Moreover, the effects of unsafe HCF WASH extend far beyond an HCF's doors: poor WASH conditions at HCFs erode trust in the health care system and discourage the sick from seeking needed care and mothers from delivering in HCFs, contributing to greater morbidity and mortality among entire communities (WHO, 2015). Inadequate sanitation and hygiene in health care settings can also contribute to the spread of antimicrobial-resistance (AMR), which the World Health Organization (WHO) has identified as one of the greatest threats to human health globally (JMP, 2019). Even individuals and communities that have safe WASH in their own HCFs must concern themselves with safe HCF WASH for all.

There is a well-established body of research demonstrating that safe WASH saves lives (Benova, Cumming, & Campbell, 2014; Fink, Gunther, & Hill, 2011), and there is a growing understanding of its unique importance in HCFs (Allegranzi et al., 2011; Li, Abebe, Cronk, & Bartram, 2017; Zaidi et al., 2005). However, international monitoring of HCF WASH is only a recent development. Little is known about actual WASH conditions and practices at HCFs, especially in the world's lowest-income and least-developed settings. This chapter reviews existing primary and secondary literature pertaining to two HCF WASH research domains: *access* to WASH services at HCFs, and water *quality* at HCFs. It focuses on low-resource and high-risk settings, and on geographic regions related to this study's two countries of interest, Afghanistan and Uganda. It covers international monitoring frameworks and standards for HCF WASH, estimated rates of access to WASH services at HCFs, and theorized drivers of variation in service coverage. It also reviews literature on water quality at HCFs and potential drivers of variation in water quality violation rates, though little primary data is available in the context of HCFs. It concludes by reviewing the health consequences that stem from a lack of safe HCF WASH, reinforcing the pressing need to describe and analyze WASH conditions at HCFs – especially in settings characterized by a lack of resources – to identify risk factors, prioritize interventions, and improve public health and services.

2. Monitoring WASH in HCFs: Goals, Targets and Indicators

2.1. UN Mandate: SDGs 6 and 3

The SDGs were adopted in 2015 and explicitly prioritized both improvements to WASH access (Goal 6) and improvements to quality and availability of health care services (Goal 3). Also in 2015, the United Nations Children's Fund (UNICEF) partnered with the WHO to publish a landmark report focused on the status of WASH access in low- and middle-income country (LMIC) HCFs (WHO, 2015). This report was the first of its kind to focus on WASH in HCF settings: previously, UNICEF and WHO's reporting in the WASH sector had been exclusively at the household level. The two organizations had monitored household WASH through a jointly-managed body called the Joint Monitoring Programme (JMP) (JMP, 2018).

Following the 2015 LMIC HCF WASH status report, the WHO and UNICEF proposed a global plan for joint action between the WASH and healthcare sectors, and authorized new monitoring of WASH access at HCFs under the JMP (WHO, 2015b, 2015c). They cited three SDG targets to justify monitoring in this new setting: target 3.8, universal health coverage and access to quality healthcare services for all; target 6.1, access to safe drinking water for all; and target 6.2, access to safe sanitation and hygiene for all (JMP, 2018). These targets used inclusive language like "universal" and "for all", which empowered the JMP to broaden its mandate to include non-household settings. Moreover, the invocation of target 3.8 to justify monitoring WASH in HCFs demonstrated these powers' shared understanding that safe HCF WASH is a precondition for delivery of "quality" health services.

2.2. JMP Guidance: Five WASH Service Ladders

In 2018, the JMP released guidance on monitoring HCF WASH under the SDGs: five "service ladders" that categorize HCF WASH conditions in five domains (JMP, 2018). Slightly-updated service ladders were released in 2019 (**Fig. 1**) (JMP, 2019).

	WATER	SANITATION	HYGIENE	WASTE MANAGEMENT	ENVIRONMENTAL CLEANING
BASIC SERVICE	Water is available from an improved source[1] on the premises.	Improved sanitation facilities[2] are usable, with at least one toilet dedicated for staff, at least one sex-separated toilet with menstrual hygiene facilities, and at least one toilet accessible for people with limited mobility.	Functional hand hygiene facilities (with water and soap and/ or alcohol-based hand rub) are available at points of care, and within five metres of toilets.	Waste is safely segregated into at least three bins, and sharps and infectious waste are treated and disposed of safely.	Basic protocols for cleaning are available, and staff with cleaning responsibilities have all received training.
LIMITED SERVICE	An improved water source is within 500 metres of the premises, but not all requirements for basic service are met.	At least one improved sanitation facility is available, but not all requirements for basic service are met.	Functional hand hygiene facilities are available either at points of care or toilets but not both.	There is limited separation and/ or treatment and disposal of sharps and infectious waste, but not all requirements for basic service are met.	There are cleaning protocols and/or at least some staff have received training on cleaning.
NO SERVICE	Water is taken from unprotected dug wells or springs, or surface water sources; or an improved source that is more than 500 metres from the premises; or there is no water source.	Toilet facilities are unimproved (e.g. pit latrines without a slab or platform, hanging latrines, bucket latrines) or there are no toilets.	No functional hand hygiene facilities are available either at points of care or toilets.	There are no separate bins for sharps or infectious waste, and sharps and/or infectious waste are not treated/disposed of.	No cleaning protocols are available and no staff have received training on cleaning.

Figure 1. *JMP service ladders for monitoring WASH in HCFs*

For each domain of WASH service – water, sanitation, hygiene, waste management, and environmental cleaning – the JMP defined the conditions that constitute No Service, Limited Service, and Basic Service under the SDGs, leaving Advanced Service to be defined at the national level. The definitions in the service ladders enabled the first global benchmarking of HCF WASH conditions, the results of which were published in 2019. Standard indicator questions for each of the five service ladders were included in this publication to further facilitate collection of uniform and internationally-comparable data (JMP, 2019).[1]

The JMP service ladders do not attempt to measure health outcomes or the actual safety of the services provided. Instead, the service ladders rely on readily observable metrics,

1 The JMP's service ladders and related indicators were finalized in 2018, after the collection of WASHCon data used in this study. In order to estimate coverage of basic water service among HCFs assessed through WASHCon in Afghanistan and Uganda, data on each HCF's main water source type, main water source distance, and water availability was retroactively mapped to the JMP water service ladder, as described in Chapter III.

often employing proxy measures where the true outcomes of interest are difficult to measure. For example, the JMP uses “improved” water as a proxy for *safe* water, because the former is easier to observe and less likely to experience random fluctuations that could influence results. And safe water is itself a substitute for the real outcomes of interest: reduced morbidity and mortality from waterborne disease.

An improved water source is a source that, “by nature of [its] design and construction, [has] the potential to deliver safe water.” In the context of HCF water service, WHO defines improved sources to include piped water, boreholes or tube wells, protected dug wells, protected springs, rainwater, and packaged or delivered water (JMP, 2019). Studies show that improved water sources are more likely to be free from fecal contaminants, and other studies have established that clean water reduces incidence of waterborne disease and leads to better health outcomes (Bain et al., 2014; WHO, 2012).

However, even with a well-supported ‘theory of change’ like this one, there are still drawbacks to using proxy measures in monitoring. Measuring whether a water source is “improved” or meets the JMP’s new definition for “basic water service” does not guarantee that the water is safe, sufficient, or reliable (JMP, 2018; Shaheed, Orgill, Montgomery, Jeuland, & Brown, 2014). One meta-analysis found that more than a quarter of water samples from improved sources in LMICs had evidence of fecal contamination (Bain et al., 2014). The JMP emphasizes that its global basic service indicators are a compromise: they are not intended to capture all aspects of service that are important for HCF WASH, and each indicator was chosen in part for its ability to be practically monitored and aggregated under the SDGs (JMP, 2019).

2.3. WHO Guidance: Water Service and Water Quality

Though the JMP's water service indicators do not consider water safety, water quantity, or continuity of service, the WHO has issued guidance in these areas. Water service at all HCFs should be continuous and water should be available at all times (WHO, 2008b), but these standards are not attainable at many HCFs. In terms of continuous access to water, the WHO defines four service continuity levels ranging from truly continuous service to service characterized by both seasonal and non-seasonal interruptions (WHO, 2008b). Discontinuous service is associated with higher contamination levels, as loss of water pressure results in a pressure vacuum that can draw contaminants into the water system (Guo, Bowling, Bartram, & Kayser, 2017). Unreliable or discontinuous water service necessitates the ability to store sufficient water, treat it, and keep it safe while stored. The WHO recommends having access to a minimum of 40 – 60 liters of water per patient per day in an inpatient setting and 100 liters per intervention in a surgical or maternity setting, whether stored or directly from a water source (WHO, 2008). Water storage is also associated with increased risk of contamination (Bain et al., 2014), and the combination of discontinuous service and reliance on stored water create elevated need for water treatment at the point of use in an HCF.

The WHO's Essential Environmental Health Standards for Health Care call for water quality in HCFs to be "safe […] for the purpose intended," acknowledging that some purposes may represent higher risk than others. Regardless of the water's purpose, the guidance indicates that neither *E. coli*, nor any other thermotolerant (fecal) coliforms, should be detected in any 100-mL sample. It points to chlorine disinfection as the most appropriate method to achieve microbial safety in HCF water, especially in low-resource settings, and states that the free chlorine residual (FCR) at all points of the HCF's water system should be between 0.5 and 1.0 mg/L – a notably higher standard than WHO's general guideline for drinking water, which advises an FCR of 0.2 to 0.5 mg/L (WHO, 2008, 2008b). However, the JMP expert working group that devised the WASH service ladders seemed to indicate that they would consider an FCR of ≥ 0.2 mg/L sufficient if measured at the place of delivery (JMP, 2016). These three guidelines – no detectable *E. coli*, no detectable fecal coliforms, and ≥ 0.2 mg/L FCR – together constitute the WHO minimum standard for microbiologically safe water in HCFs.

The microbiological and chemical testing required to monitor water quality can be expensive and difficult to implement. Microbiological testing can never fully prove that water is "safe" and free from contamination – it can only show whether a given sample had detectable levels of contaminants. In order to be useful, water quality testing should be completed in a comprehensive and systematic fashion that will require political commitment on a global scale. Thus, despite the existence of international water quality standards and water safety requirements, there is currently no global monitoring of microbiological quality or chlorine residual sufficiency in HCFs' water. Monitoring programs instead focus on access to improved water sources, as shown in the JMP service ladders, relying on the somewhat-generous assumption that improved water sources will deliver safe, high-quality water.

3. Access to WASH Services in HCFs

This section reviews published rates of access to WASH services in HCFs, focusing on regions related to this study's two countries of interest: Afghanistan and Uganda. Following the JMP's conventions for grouping countries, our use of the term "region" may refer to traditional regions – countries grouped by geography – or to less-traditional groupings of countries by characteristics (JMP, 2019). (For example, the JMP's Landlocked Developing Countries "region" refers to the group of countries that share those characteristics, whether or not they are geographically associated.)

3.1. Access Rates

The first global estimates of WASH access in HCFs were published in 2015 by WHO and UNICEF, prior to the launch of international JMP monitoring specifically of WASH in HCFs. It is important to note that the data reviewed to produce these estimates was not specifically collected to assess WASH in HCFs, but rather was survey data collected for other purposes that happened to include some questions about WASH services and infrastructure. This kind of survey data may record presence of WASH infrastructure, but generally does not record information like the infrastructure's functionality or condition. Therefore, these early estimates are likely to over-state the true prevalence of access to WASH services and infrastructure in HCFs, and should be regarded with some skepticism.

Reviewing data representing more than 66,000 HCFs in 54 low- and middle-income countries, the WHO and UNICEF estimated that about 62% of LMIC HCFs had access to an improved water source within 500 meters (m) – i.e., about 62% of LMIC HCFs had Limited Service or better as measured on the JMP's new water service ladder (WHO, 2015). Among the countries representing WHO's African region (AFR), [2] estimated coverage of improved water within 500m was 58%. Approximately 65% of LMIC HCFs reported access to soap; 64% in the AFR region. About 81% of LMIC HCFs globally reported access to improved

[2] The WHO in its 2015 documentation used its WHO region classifications. Afghanistan was part of WHO's Eastern Mediterranean Region (EMR), and Uganda was part of WHO's Africa Region (AFR). Afghanistan data was from a UNICEF survey, 2009. Uganda data was from a national survey, 2008 (WHO, 2015).

sanitation, and 84% in the AFR region (WHO, 2015). Coverage rates were not available for the Eastern Mediterranean [EMR] region, this study's other geography of interest.

In 2018, the International Journal of Hygiene and Environmental Health published the first peer-reviewed coverage estimates of certain environmental conditions at LMIC HCFs, reviewing data representing more than 120,000 HCFs in 78 LMICs (relying on some of the same data used in the 2015 WHO report).[3] Cronk estimated that almost 71% of LMIC HCFs globally had access to an improved water source within 500m, and about 50% had piped water on premises (Cronk, 2018). Among low-income countries (LICs), coverage of improved water within 500 m was 65%. Cronk estimated 61% of LMICs and 54% of LICs had soap for hand washing, but when both soap and running water for handwashing were considered, those proportions dropped to 44% and 43% respectively (Cronk, 2018). About 67% of LMIC HCFs and 65% LIC HCFs had an improved toilet for patients (Cronk, 2018).

Using the early versions of the JMP service ladders (JMP, 2016), Cronk also estimated coverage for approximated service levels in six countries. National coverage estimates for basic water service at HCFs ranged from 61% in Senegal to 32% in Tanzania, including 51% in Malawi, 50% in Bangladesh, and 44% in both Nepal and Haiti (Cronk, 2018).[4] The average among all six countries was 47%. Senegal also had the highest estimated rates of access to handwashing materials at its HCFs (86%), followed by Haiti (73%), Malawi (72%), Tanzania (66%), Bangladesh (59%), and Nepal (55%). Average hand hygiene coverage at HCFs among

[3] Cronk (2018) used regional classifications from the Millennium Development Goals (MDGs). Afghanistan was part of MDG Southern Asia (SA) region, and Uganda was part of MDG sub-Saharan Africa (SSA) region. Afghanistan data was from its Ministry of Public Health's Report for Baseline Study on Water Sanitation Services and Hygiene Practices in BHC/HCF, 2009. Uganda data was from WHO's Service Availability and Readiness Assessment, 2012. (Cronk, 2018).

[4] Of the six countries where Cronk calculated country-level service estimates, five were in geographies of interest. Nepal and Bangladesh were both part of Cronk's Southern Asia region along with Afghanistan. Malawi, Senegal, and Tanzania were all part of Cronk's Sub-Saharan Africa region along with Uganda (Cronk, 2018).

all six countries was estimated at 63% (Cronk, 2018). Basic sanitation service coverage at HCFs was higher than basic water or basic hygiene service, with overall average basic sanitation coverage of 84%. Senegal led in coverage with 93%, followed by Malawi and Nepal with 89%, Bangladesh with 86%, Haiti with 82%, and Tanzania with 70% (Cronk, 2018). Again, these coverage estimates reported by Cronk and by the WHO prior to the launch of official JMP monitoring of HCF WASH are likely to be overestimates because they are based on secondary data collected for other purposes. Field experience has shown that these early estimates of coverage, especially of toilets and hand hygiene stations, were far too high compared to conditions on the ground.

The latest international coverage estimates were revealed in 2019 in the first official HCF WASH report under the auspices of the JMP. It reported service coverage results by Sustainable Development Region (SDR), a grouping system that includes ‘regions’ based on both geography and country characteristics.[5] The JMP also provided service level coverage estimates by country where data was available.

Estimated coverage of basic water service among HCFs in the Least Developed Countries (LDCs) SDR was 55%. Coverage among HCFs in Landlocked Developing Countries (LLDCs) was 46%, the lowest of any SDR ‘region’ of countries (JMP, 2019). In the sub-Saharan Africa (SSA) geographic SDR, basic water service coverage was estimated at 51%. The JMP lacked sufficient data for the Central and Southern Asia (CSA) region to provide a full assessment of water service levels there, but estimated that 10% of HCFs in the region had no water service (JMP, 2019).

[5] SDG Regions of Interest: Afghanistan is a member of the Central and Southern Asia (CSA) region. Uganda is a member of the Sub-Saharan Africa (SSA) region. Afghanistan and Uganda are both members of two regions based on development characteristics: “Least Developed Countries” and “Landlocked Developing Countries” (JMP, 2019).

In Afghanistan, 49% of HCFs had basic water service, 26% had limited water service, and 25% had no water service. About 75% had an improved water source and 49% had an improved water source on premises. In Uganda, 31% of HCFs had basic water service, 65% had limited water service, and 4% had no water service. Approximately 96% had an improved water source, but only 36% had an improved source on premises (JMP, 2019).[6]

Hand hygiene service level coverage estimates in the JMP's 2019 report were incomplete for all regions of interest to this study. It reported that 42% of HCFs in the CSA region had no hand hygiene service, but basic and limited service levels were not estimated. In the SSA region, coverage of hand hygiene at points of care was estimated at 84% among hospitals and 64% among lower-level HCFs (JMP, 2019). Estimated coverage of hand hygiene "at points of care" – this study's indicator of interest – was reported for 55 countries, ranging from 100% in 10 countries to only 15% in one country The JMP noted that the availability of hand hygiene materials at points of care seemed to vary widely both within and between regions, with most regions having at least one country with < 50% coverage and at least one country with ≥ 90% coverage of hand hygiene at points of care (JMP, 2019).

Hand hygiene estimates were incomplete for both countries of interest in the JMP report. Approximately 28% of HCFs in Afghanistan had hand hygiene facilities near toilets, but the JMP did not estimate coverage of hand hygiene at points of care. About 84% of HCFs in Uganda were said to have hand hygiene at points of care, and an estimated 1% had no hygiene service (JMP, 2019). The JMP definition of hand hygiene coverage at points of care required only one point of care observed.

[6] Data from Afghanistan was from 2013. Data from Uganda was from 2016.

In terms of sanitation service, 23% of HCFs in SSA were estimated to have basic sanitation service, 48% had limited service, and 29% had no service. In the CSA region, coverage of limited service and basic service were not estimated, but 40% of HCFs were said to have no sanitation service at all. Among the LLDC group, 42% of HCFs had basic sanitation service, 44% had limited service, and 14% had no service (JMP, 2019).

The JMP estimated 37% of HCFs in Afghanistan had no sanitation service. The remaining 63% had an improved sanitation facility of some kind, but more data was needed to determine which improved facilities would meet the criteria for basic sanitation services. In Uganda, 12% of HCFs had basic sanitation services, 79% had limited service, and 9% had no service. An estimated 91% of HCFs had an improved sanitation facility of some kind, and 88% had an improved and useable sanitation facility (JMP, 2019).

In addition to the JMP and Cronk large-scale reviews, there have also been smaller-scale studies of WASH access in HCFs in one or more LMICs. A primary study of rural HCFs in six countries in SSA estimated that fewer than half of HCFs studied had access to all three WASH services, defined as an improved water source on premises, functional improved sanitation, and soap and water for handwashing. The proportions of rural HCFs with all three ranged from 50% in Rwanda (95% CL: 0.43-0.57) to 7% in Ethiopia (95% CL: 0.05-0.09) (Guo et al., 2017). In Uganda, an estimated 97% of rural HCFs had an improved water source (95% CL: 0.95-0.99), but only 76% had the source on premises (95% CL: 0.72-0.81). All studied HCFs (100%) were required to store water. Approximately 91% had improved, functional sanitation (95% CL: 0.88-0.94). About 82% had at least one handwashing station (95% CL: 0.78-0.86) but only 60% always had water for handwashing (95% CL: 0.54-0.65) and only 48% always had soap or ash for handwashing (95% CL: 0.42-0.54), for a combined 34% that always had both handwash components (95% CL: 0.29-0.40). Handwashing seemed to be the limiting factor for Uganda, as only 30% had access to all three services – water, sanitation, and hand hygiene (95% CL: 0.24-0.35) (Guo et al., 2017).

Government survey data from 701 HCFs in Liberia found that only 45% had access to an improved water source in 2015 (Abrampah et al., 2017). A 2012 review of infrastructure and infection controls among HCFs in five African countries found "dramatically low" proportions of HCFs with adequate basic infrastructure, ranging from 1% of HCFs in Ghana to 28% of HCFs in Rwanda (Hsia, Mbembati, Macfarlane, & Kruk, 2012). (Adequacy of basic physical infrastructure constituted all of the following: at least one functioning latrine, a "basic level of cleanliness," year-round water supplied by a source within 500 meters, routinely available electricity during service hours, and a protected waiting area.) In another study, 0% of health centers and less than 5% of hospitals studied in Uganda had adequate infection prevention controls (Hsia et al., 2012), where adequacy of infection prevention controls was defined by the presence of soap, running water, disinfectant, latex gloves, and a designated sharps waste disposal box.

L&D wards and other maternal and neonatal settings within HCFs have especially high need for access to safe WASH. In the mid-2000s, WHO outlined "Six Cleans" that define safe birth practices in any setting: (1) Clean hands of birthing attendant(s), (2) Clean birthing surface, (3) Clean blade, (4) Clean cord tie, (5) Clean towels for the newborn, and (6) Clean cloth to wrap the mother (WHO, 2006). Though the Six Cleans are not direct WASH measures, they are directly related to WASH (Velleman et al., 2014): clean hands require access to clean water and soap (or hand sanitizer, if both clean water and soap are not available), and the other five Cleans require access to specific hygienic materials, including disinfectants or sterilizing equipment for surfaces, blades, and cord ties/clamps, and some means by which to launder and disinfect cloth and towels. The overt focus of the Six Cleans framework is hygiene, but in reality, safe water service and safe sanitation are also directly related to achieving the Six Cleans.

A primary study of newborn care in HCFs and households in Cambodia showed that access all the Six Cleans was virtually nonexistent in both settings due to failures of infection prevention controls and water storage (A. N. T. Bazzano, L.; Oberhelman, R.A.; Var, C., 2016). In an earlier primary study of rural HCFs conducting deliveries in Cambodia, nine of 10 studied HCFs did not have handwashing stations at points of care, and six of 10 lacked handwashing stations at toilets (A. N. Bazzano, Oberhelman, Potts, Gordon, & Var, 2015), signaling a high risk of unclean hands among birth attendants. A primary study in Zanzibar found that only 49% of HCFS had the infrastructure required to enable clean hands (Gon et al., 2017). In the same study, 54% of HCFs had at least one worker who could demonstrate the knowledge required to ensure a clean delivery surface, but only 14% of HCFs actually had clean delivery surfaces when tested (Gon et al., 2017). About 66% of HCFs met the infrastructure requirements that would indicate an ability to provide clean cord ties or cord clamps (Gon et al., 2017).

The Cronk 2018 review, in addition to its findings on standard WASH services, reported various other deficits that impair the ability of HCFs to provide the Six Cleans: 73% of LMIC HCFs lacked sterilization equipment, 39% lacked infectious waste disposal, 59% lacked reliable electricity, and 74% lacked guidelines for standard infection prevention precautions (Cronk, 2018). These statistics were measured at the HCF level, and access rates within L&D wards could be even lower than the rates described.

Despite these concerns over HCFs' ability to provide the Six Cleans of safe delivery, multiple reviews indicated that home births were still more dangerous than HCF births, attributing this risk difference at least in part to less-hygienic environments in households. Implementing clean birth practices in HCFs seemed to yield greater reductions in neonatal mortality than implementing clean birth practices at homes (Benova et al., 2014; Blencowe et al., 2011). This evidence has furthered global efforts to encourage HCF births, making it all the more imperative that HCFs are able to fulfill the promise of safe births by providing access to WASH and the Six Cleans in L&D wards.

3.2. Potential Drivers of Variation in Access to WASH Services

The literature strongly indicates disparities in access to WASH services at HCFs, including variation both between and within countries. Even countries with generally high rates of access may have districts or types of HCFs where coverage rates are far lower than the national averages (WHO, 2015). To test the determinants of low coverage of basic water service, the landmark Cronk study in 2018 assessed nationally-representative data from six LMICs, finding statistically significant variations in basic water service coverage based on four factors: managing authority (e.g., public/private), HCF type (also known as Level of Care; e.g., hospital/clinic), geographic setting (rural/urban), and sub-national administrative unit (e.g., different districts or provinces) (Cronk, 2018). In all five countries that distinguished between rural and urban geographic settings, rural HCFs were significantly less likely to have basic water service than their urban counterparts (Cronk, 2018). Hospitals were often significantly more likely than other types of HCFs to have basic water coverage (Cronk, 2018). The availability of inpatient services was significantly associated with basic water service coverage in univariable analysis, but the association was not significant in multivariable analysis.

Cronk's findings on level of care as a determinant of access to basic water service echoed results from a smaller 2014 review of Demographic and Health Survey (DHS) data on HCFs in Tanzania. That study found that only 39% (95% CL: 0.36-0.42) of HCF types at the lowest levels of care met the study's definition of "WATSAN-safe", whereas 90% of HCFs at the highest levels of care (hospitals) were found WATSAN-safe (95% CL: 0.78-0.95) (Benova, Cumming, Gordon, Magoma, & Campbell, 2014b). In the context of this study, WATSAN-safe meant that the HCF had access to improved water within 500 meters and improved sanitation.

Most literature on WASH in HCFs examines access to WASH services at the HCF level or generalized to the HCF level. The limited data available suggests variation in access rates at different points of care in an HCF, including possibly differential access between Labor and Delivery (L&D) wards and other points of care (Benova et al., 2014b; Cronk, 2018; WHO, 2015). Research shows that HCF-level results do not always hold true across all points of care: in the 2014 review of DHS data in Tanzania, all reviewed HCFs conducted deliveries, and 43.8% were WATSAN-safe at the HCF level, but only 23.6% actually had WATSAN-safe L&D rooms (Benova et al., 2014b). This result held true at all levels of care, from the lowest-level primary care facilities to the highest-level hospitals (Benova et al., 2014b). Evidence also suggests that access to water within an HCF does not mean access for all. A 2017 study of HCFs with piped water found that, generally, patient-accessible water points were at toilets or outdoors, not at the piped sinks (Huttinger et al., 2017). Even if the water at such access points was potable, most patients might think twice about drinking water provided near a toilet. This evidence supports the existence of ward-based and role-based variation in WASH conditions within an HCF and raises questions about the sufficiency of monitoring WASH at the HCF level.

3.3. Access vs. Safety in Practice

Although this review focuses largely on access, it is important to note that access to WASH service does not guarantee safe WASH practices. Especially with regard to hygiene, access does not equal habitual use. Noncompliance with recommended hand washing and environmental cleaning procedures is commonplace. Poor hand hygiene practices have been frequently identified as a challenge to implementation of comprehensive infection controls – i.e., even when adequate hand-washing supplies are present, they are not always used effectively (Abrampah et al., 2017; Dondorp, Limmathurotsakul, & Ashley, 2018). A 2015 primary study in Mali found baseline hand hygiene compliance of only 8%, which the authors attributed in part to infrastructural deficiencies – but after an intensive intervention that included full provision of hand-washing materials, intensive training, reminders, and performance feedback, hand-washing compliance only increased to 21.8% (Allegranzi et al., 2010). A review of handwashing in industrialized-nation HCFs showed that even in HCFs characterized by ample, engrained access to handwashing materials and messaging on handwashing importance, overall median handwashing compliance was only 40%, and physician compliance was only 32% (Erasmus et al., 2010). Similarly, even when an HCF has adequate materials for surface cleaning, compliance with cleaning practices is uneven (Dancer, 2009). In sum, the literature shows that access to appropriate hygiene materials is a necessary but insufficient component of safe hygiene, and to observe only access is to ignore a large behavioral component that is critical to the "theory of change" underlying hygiene interventions.

Likewise, mere access to water – even an improved source on premises – does not guarantee that the water is safe to drink or to use for medical purposes (JMP, 2018; Shaheed et al., 2014). Water can become contaminated at many points in the system: at the source, during distribution (through contaminated pipes, taps, faucets, sink trap reservoirs, or drains), during storage, or while accessing water (through improper accessing of stored water, or through droplet dispersion from a contaminated sink reservoir or drain during faucet operation) (Kotay, Chai, Guilford, Barry, & Mathers, 2017). Contamination is far more likely to occur with an unimproved water source, but it is still possible with an improved source (Guo et al., 2017): a 2014 review covering 319 primary studies of fecal contamination in drinking water in LMICs found that more than 25% of samples from improved sources contained fecal contamination (Bain et al., 2014). Monitoring of water quality at HCFs is not included in any major international monitoring program, but water testing and treatment at point of use are vital to ensure access to *safe* water service, not just basic water service.

4. Water Quality in HCFs

Water quality tests for fecal contaminants can be either direct or indirect. Direct tests involve analyzing water samples for fecal indicator bacteria (e.g., *E. coli*, total coliforms) which, if detected, directly indicate contamination is present. Indirect tests involve testing water samples for residual levels of free chlorine. Detectable free chlorine in a sample is a marker of safety: if fecal or environmental microorganisms are present in the water, the free chlorine would react with them and inactivate them, and in doing so, it would cease to become 'free' chlorine. If turbidity is reasonably low (< 5 NTU), and if the chlorine has been in contact with the water for at least 30 minutes, then a detectable residual level of free chlorine is an assurance that the water is protected from most bacterial and viral contaminants, and that there remains some level of 'residual' chlorine available to react with more microorganisms if there is a subsequent contamination event. If there is no detectable FCR, that does not necessarily mean that the water is contaminated, but simply that it is not protected from contamination.

4.1. Rates of Detection of Fecal Contamination in HCF Water Samples

There is limited primary evidence available on water quality in HCFs in LMICs, as testing for water quality in HCFs is relatively rare. A 2017 primary study among rural HCFs in Rwanda found that only three of 18 drinking water samples tested met all three WHO guidelines for drinking water (<1 coliform/100mL, <1 *E. coli*/100mL, and FCR of ≥ 0.2mg/L) (Huttinger et al., 2017). By design, this study was limited to HCFs with piped water and power supply – but even among these relatively well-equipped HCFs, less than 20% of samples met water safety standards. The limiting factor appeared to be chlorination: 15 of 16 samples tested for *E. coli* met the *E. coli* guideline (93%), six of 16 samples tested for coliforms met the coliform guideline (37%), but only three of 18 samples tested for chlorine (17%) met the guideline for FCR (Huttinger et al., 2017).

There is some evidence that stored water at HCFs may be at heightened risk of contamination. A 2017 cross-sectional study of rural HCFs in six African countries included microbiological water quality testing of stored water in two of the six countries, Uganda and Mozambique: 15% of samples from rural HCFs in Uganda and 30% of samples from rural HCFs in Mozambique tested positive for *E. coli* (>1 MPN/100 mL) (Guo et al., 2017). Among 10 rural HCFs in Cambodia that conduct deliveries, Bazzano et al. observed that stored water at "many" HCFs was contaminated with visible debris or had a murky or cloudy color, indicating high turbidity and a high likelihood of microbiological contamination, although no laboratory testing of water quality was conducted (A. N. Bazzano et al., 2015). A 2014 meta-analysis of drinking-water quality in LMICs found that stored water was more likely to be contaminated than water taken from the source (OR=2.09, CI: 1.16-3.78), though this finding was not specific to HCFs (Bain et al., 2014).

Two assessments in Kenya, seeking to evaluate the effectiveness of prior WASH interventions, tested stored HCF water for free chlorine but not for microbiological contaminants. The first tested stored water at drinking water stations and handwashing stations at 30 of 53 HCFs that had received the intervention. The study tested only for FCR, finding that only 23.3% of HCFs had one or more storage containers with a detectable FCR (>0.0 mg/L) (Rajasingham, Leso, Ombeki, Ayers, & Quick, 2018). There was a large discrepancy between reported and confirmed use of water treatment products: 28 of 30 HCFs studied (93.3%) were observed to have supplies of free water treatment sachets on hand, and respondents at 25 of 30 HCFs (83.3%) self-reported using the sachets to treat drinking water at the HCF, yet only 7 of 30 HCFs (23.3%) had even one storage container that showed signs of sachet use (Rajasingham et al., 2018). The second assessment evaluated 30 of 109 HCFs that received a second WASH intervention. It found that 17 of 30 HCFs tested (59%) had at least one container where FCR was detectable, or 30 (32%) of 94 tested containers. Again there was a discrepancy between reported and confirmed water treatment, with 100% of HCFs reporting treating their drinking water (Sreenivasan et al., 2015). Neither study reported whether the FCRs detected were greater than 0.2 mg/L, the WHO's minimum recommendation for free chlorine in drinking water.

4.2. Potential Drivers of Variation

No known studies have explored potential drivers of variation in rates of water quality violations specifically within HCFs. Bain and Cronk's 2014 meta-analysis of studies of fecal contamination in household and other drinking water in LMICs found significantly higher odds of contamination in rural areas compared to urban areas (OR=2.37, CI: 1.47-3.81) (Bain et al., 2014). It also found country income level to be a significant determinant of water quality, with greater odds of contamination in drinking water among low-income countries than among wealthier countries (OR=2.37, CI: 1.52-3.72). However, the authors noted that this wealth difference was not significant when piped water sources were considered separately from other improved sources (Bain et al., 2014). Discontinuous service and inadequate storage processes have also been identified as potential drivers of increased odds of contamination and poor water quality (Guo et al., 2017).

5. Consequences of Unsafe WASH in HCFs

5.1. Health Care-Associated Infections (HCAI)

Any infection contracted within an HCF (i.e., not present upon arrival) is considered an HCAI. HCAIs can include outbreaks of communicable diseases, such as the 2014 – 2016 Ebola outbreak in West Africa, in which unsafe WASH and weak infection prevention and control (IPC) practices at HCFs in Liberia enabled the virus to spread rapidly through both patients and staff (Abrampah et al., 2017). More than 11,300 people in three countries died in this epidemic, including 8% of Liberia's entire healthcare workforce (CDC, 2017), prompting changes to WASH and IPC policies and procedures at HCFs throughout the region. However, despite their high profile, contagions like Ebola represent only a small percentage of all HCAIs. Maternal and infant sepsis, surgical site infections (SSIs), soft tissue infections, and communicable bacterial, viral, or fungal diseases, including respiratory and diarrheal disease, are far more common examples of HCAIs. Although these infections draw relatively little attention compared to an outbreak, over time they cause greater morbidity and mortality than most outbreak situations. Even when they are non-communicable and non-fatal, the pernicious effects of HCAIs extend beyond the individuals who become infected in an HCF. HCAIs of all types have a chilling effect on care-seeking behavior, discouraging care-seeking behavior and weakening health systems (WHO, 2015).

Most HCAIs are not transmitted directly from patient to patient, but rather are spread through a wide variety of transmission routes within an HCF. Evidence suggests that if contamination exists in an HCF, it often leads to HCAIs through one mechanism or another. A systematic review pertaining to waterborne infections in HCFs worldwide found that, among persons exposed to certain bacteria in HCF water, about 12% became infected (median "attack rate" of 12.1%; interquartile range 11 - 27.2%) (Li et al., 2017). Notably, not all of these 'waterborne' infections were transmitted through direct contact with water – many exposure routes contributed to the overall attack rate. Non-sterile handling of wounds, surgical sites, and births; contact with contaminated water, surfaces, or drains; and use of contaminated catheters, ventilators, and other medical devices and supplies, all spread the bacteria living in the water system, combining to increase the overall burden of HCAIs (Li et al., 2017; Moffa et al., 2017; WHO, 2015).

Lack of access to water, unsafe water quality, lack of basic sanitation, and lack of soap and disinfection materials have all been identified as causal factors for HCAIs (Allegranzi et al., 2011; Bartram & Platt, 2010; Zaidi et al., 2005), especially maternal and neonatal infections. Unsafe hygiene during delivery is a significant and well-established contributor to both maternal and neonatal mortality (Ganatra, Stoll, & Zaidi, 2010; Velleman et al., 2014). Poor hand hygiene was recognized as a causal factor for HCAIs as far back as the 1700s, when it was observed to be a risk factor for postpartum sepsis (Benova et al., 2014b). A more recent study of global causes of maternal mortality revealed that around 11% of all maternal deaths in the study's data collection period (2003 – 2009) were due to sepsis, a complication of birth and many surgeries that can be largely prevented with safe WASH and good IPC practices (Say et al., 2014). Sepsis is also a grave concern for newborns, especially in LMICs, where it caused an estimated 16% of neonatal deaths between 2000 and 2013 (Oza, Lawn, Hogan, Mathers, & Cousens, 2015). Poor water quality has been shown to be significantly associated with maternal mortality (OR=1.50, CI: 1.10-2.10), while "poor sanitation environments" were associated with three times higher odds of maternal mortality (OR 3.07, CI: 1.72 - 5.49), in a meta-analysis that reviewed studies in both household and HCF environments (Benova et al., 2014). A household-level review in Afghanistan found that women in households with unimproved water had nearly twice the odds of pregnancy-related mortality (OR=1.91, 95%CI 1.11-3.30) compared with women in households with improved water (Gon, Monzon-Llamas, Benova, Willey, & Campbell, 2014). There are many potential mechanisms for these associations, both direct and indirect: a groundbreaking 2014 framework examined the role of WASH in maternal and reproductive health and identified 77 unique risk mechanisms linking WASH deficiencies with negative outcomes in maternal and perinatal health (Campbell, Benova, Gon, Afsana, & Cumming, 2014).

The literature establishes that lack of access to safe WASH can cause negative health outcomes, and conversely, it establishes that safe WASH and IPC – especially the practice of safe hand hygiene – can interrupt transmission pathways and prevent these unnecessary infections. A 2013 systemic review concerning prevention of HCAIs in developing countries found hand hygiene to be the most effective measure at reducing infection rates (Murni et al., 2013). Another study found that the most effective measures for preventing HCAI transmission included increased attention to alternate forms of hand disinfection (e.g., hand rubs) and cleaning or replacing high-risk physical infrastructure, like faucets (Moffa et al., 2017).

5.2. Disparities in HCAI Risk

There is strong evidence of inequalities in rates of HCAIs between low-income, less-developed countries and higher-income, more-developed countries. A review limited to high-quality studies of HCAIs in low-income countries found an average HCAI prevalence of nearly 16% (15.5 per 100 patients) (Allegranzi et al., 2011; Li et al., 2017), compared with only 7.1% in Europe and 4.5% in the United States (Allegranzi et al., 2011; Wasswa et al., 2015). The risks associated with Intensive Care Units (ICUs) were especially high in the developing world: ICU patients in developing countries were 3.5 times more likely to acquire an infection than ICU patients in the US (pooled density of 47.9 HCAIs per 1000 patient-days in developing-country ICUs, compared to 13.6 HCAIs per 1000 patient-days in United States ICUs) (Allegranzi et al., 2011; Wasswa et al., 2015). Rates of SSIs were also reportedly twice as high in developing countries as they were in the U.S. and Europe (Allegranzi et al., 2011; Wasswa et al., 2015). Some reviews suggested that the SSA region had especially high rates of HCAIs, even compared to other parts of the developing world, but these studies also emphasized the absence of high-quality evidence on the true burden of HCAIs in developing areas (Bagheri Nejad, Allegranzi, Syed, Ellis, & Pittet, 2011; Rothe, Schlaich, & Thompson, 2013). Aside from level of development, there may be other factors that correspond with increased or decreased odds of HCAIs. Studies in Nigeria and Zimbabwe have shown that the more deliveries an HCF conducts, generally, the lower their maternal mortality ratios (Galadanci et al., 2011).

Vulnerable populations, including the young, the old, and the immunocompromised, are at the highest risk of HCAIs. The disease burden from HCAIs is especially severe for newborns, whose fledgling immune systems can be easily overwhelmed by infection (Oza et al., 2015; WHO, 2015). As with other HCAIs, the health burden of neonatal HCAIs is most pronounced in the developing world. A 2005 systematic review showed that rates of neonatal HCAIs in developing-world HCFs were between 3 and 20 times higher than in rates of neonatal HCAIs among HCFs in industrialized nations (Zaidi et al., 2005). And, as observed for HCAIs generally, neonatal infections and neonatal mortality associated with HCFs have an insidious effect on care-seeking behavior, fostering negative attitudes toward HCFs among mothers (Zaidi et al., 2005) and impeding efforts to increase rates of births at HCFs.

5.3. Anti-Microbial Resistance (AMR)

Many pathogens that cause HCAIs are becoming known for their emerging resistance to antibiotics (Li et al., 2017). Many multi-drug resistant organisms (MDROs) are opportunistic, preying on the vulnerable populations of patients within HCFs, but they can also cause serious illness even in healthy individuals (Quinn et al., 2015). Overuse of antibiotics is one factor in the global increase in AMR, but another major factor is the failure of safe sanitation and hygiene at HCFs, resulting in the proliferation of MDROs both inside the HCF and outside in the surrounding environment.

Waste from HCFs often has elevated levels of antibiotics, resistant pathogens, and pieces of the genetic material that codes for drug resistance (JMP, 2019). Bacteria have the ability to share genetic material, which leads to rapid spread of resistant genes through bacterial populations in soil and water. If HCF waste is not safely contained with safe sanitation, and eliminated within an HCF with safe hygiene, then those pathogens become a global risk. While a full review of the impacts of AMR is outside the scope of this study, AMR and HCAIs are closely related, and AMR is one of the most pressing issues associated with unsafe WASH in HCFs.

6. Conclusion: Summary and Need for this Study

When the UN affirmed the SDGs in 2015, it enshrined the pursuit of clean and safe WASH as an urgent international priority. Since then, it has demonstrated the understanding that this pursuit is especially vital at HCFs. In an HCF, the first rule must be to “do no harm” – and unsafe HCF WASH has been shown to cause harm to patients, staff, and entire health systems (Abrampah et al., 2017; CDC, 2017).

The consequences of unsafe WASH in HCFs – and the life-saving benefits of safe WASH in HCFs – have been well-documented. The literature has shown that safe WASH is an absolute precondition for providing adequate care and preventing harm in a health care setting. Governments and non-governmental organizations (NGOs) are making progress on ensuring access to safe WASH – but there remain issues of grave concern, and regions where we know very little about the realities of WASH conditions, practices, and risks. In March of 2018, the U.N. Secretary-General used a major speech about water action to call for improving WASH in HCFs (Guterres, 2018). Yet, despite increased attention to the consequences, primary research on WASH in HCFs has yet to catch up with public interest, and there remains a relative lack of primary data with which to parse, prioritize, and confront these problems.

This study helps bridge this evidence gap by describing and analyzing newly collected primary data on WASH in HCFs in two developing countries, Afghanistan and Uganda. Both countries are members of the UN's LDC and LLDC SDG regions, and in both countries, the HCFs assessed are in sub-national regions known for especially high risk and low development. Although the study is only sub-nationally representative in each country, the areas assessed could be considered representative of 'least-developed' and low-resource settings generally. This analytic study uses the data from HCFs in high-risk areas within Afghanistan and Uganda to build country-specific multivariable models that estimate the crude and adjusted risks of unsafe WASH conditions associated with certain HCF characteristics, including sub-national region, geographic setting, and level of care. The results of this research will empower governments, NGOs, and other stakeholders to prioritize the areas of highest need and implement improvements to WASH services in the assessed areas and similar settings.

Chapter II. Thesis Objectives and Rationale

1. Introduction

Basic water, sanitation, and hygiene (WASH) – together, basic WASH – is a prerequisite for provision of adequate health care service. Inadequate WASH infrastructure, services, and practices in health care facilities (HCFs) can cause serious individual and community harm. Unsafe HCF WASH can facilitate the transmission of health care-associated infections (HCAIs), including maternal and newborn sepsis, surgical site infections, diarrheal disease, and other major contributors to morbidity and mortality worldwide. HCF WASH deficiencies also deter care-seeking behavior, weaken health systems, and accelerate the global emergence and spread of anti-microbial resistant (AMR) microorganisms. Due to the global nature of these effects, no one is safe until all are safe. No individual or community is truly isolated from the effects of unsafe HCF WASH until WASH conditions are satisfactory at all HCFs. While the consequences of unsafe WASH in HCFs are well-understood in theory, we still know very little about actual WASH conditions and practices in HCFs globally. International monitoring of WASH in HCFs is still in early stages, but early findings suggest that WASH conditions in HCFs are often quite poor, especially in low-income countries (LICs) and other low-resource settings (JMP, 2019). In 2016, Emory University's Center for Global Safe WASH (CGSW) introduced a data collection tool to provide HCFs in low- and middle-income countries with a "broad assessment" of their own "WASH conditions, infrastructure, and resources" .

2. Problem Statement

Despite the high health and human costs of unsafe WASH in HCFs, very little data exists to help public health professionals understand and correct HCF WASH deficiencies, especially in the least-developed areas of the world. This knowledge gap stymies the design and implementation of HCF WASH interventions in low-development and/or high-risk settings – interventions that would decrease disease transmission and avert preventable deaths, especially maternal and neonatal deaths. To achieve these goals, there is an urgent need to describe HCF WASH access and HCF water quality, and to analyze their respective determinants in the context of high-risk and low-development settings, giving the international health care community the necessary tools to craft effective HCF WASH interventions in the places that need them the most.

3. Purpose Statement

The purpose of this study was to describe WASH conditions and practices among HCFs in certain high-risk and/or low-development regions in Afghanistan and Uganda, and to analyze the predictors of four key WASH outcomes among this population of HCFs.

4. Research Questions

Pursuant to the study's purpose, this thesis investigated research questions (RQ) in two research domains: 1. HCF WASH Access, and 2. HCF Water Quality. The first research question under each domain was descriptive in nature, and subsequent research questions under each domain were observational-relational (analytic) in nature.

4.1. Domain 1: HCF WASH Access (RQ 1.00, 1.01, 1.02, 1.03)

1. Among HCFs in certain high-risk regions of Afghanistan and Uganda,

00. …what are the reported and observed rates of access to various WASH services? *(RQ 1.00: Descriptive)*

01. …what are the predictors of having Basic Water Service? *(RQ 1.01: Analytic)*

02. …what are the predictors of having functional hand hygiene facilities available at one or more points of care? *(RQ 1.02: Analytic)*

03. …what are the predictors of having access to all of the "Six Cleans" for safe delivery in the labor and delivery ward? *(RQ 1.03: Analytic)*

4.2. Domain 2: HCF Water Quality (RQ 2.00, 2.01)

2. Among HCFs in certain high-risk regions of Afghanistan and Uganda,

00. …what are the rates of detection of *E. coli* and free chlorine in HCF water samples? *(RQ 2.00: Descriptive)*

01. …what are the predictors of detecting *E. coli* in one or more HCF water samples? *(RQ 2.01: Analytic)*

5. Significance Statement

Basic WASH and safe water quality in HCFs are critical for public health and provision of quality health services. The first step to improving WASH services and water quality at HCFs is understanding where safe conditions exist and where they do not. The second step is seeking to understand the determinants of these conditions. This study will contribute to both of these efforts: understanding WASH conditions, and predicting variation in WASH conditions.

First, this study will describe new primary data on WASH outcomes at HCFs in high-risk sub-national regions of two of the world's least-developed countries, Afghanistan and Uganda. Second, it will analyze these data to understand what factors predict these outcomes. These insights into HCF WASH conditions, and drivers of variance in these conditions, will constitute new and important findings that will enable health care researchers and practitioners to design and implement interventions that will reduce mortality, especially maternal and neonatal mortality; contain the global menace of resistant pathogens; reduce disparities in HCF WASH access and safety, and inspire a positive feedback loop of community trust and investment in health systems.

6. Key Terms

Health care facilities (HCFs): HCFs are clinics and hospitals providing health care services, ranging from low-level primary care to high-level hospital care and specialty care. In Afghanistan, these included all formal levels of care, including Sub Health Centers (SHCs), Basic Health Centers (BHCs), Comprehensive Health Centers (CHCs), District Hospitals (DHs), Provincial Hospitals (PHs), Regional Hospitals (RHs), and Special/National Hospitals (SHs). (AMoPH, 2012). In Uganda, health care facilities for the purposes of this study included Health Center IIIs (HC IIIs), Health Center IVs (HC IVs), General Hospitals (GHs), Regional Referral Hospitals (RRHs), and National Referral Hospitals (NRHs) (UMoH, 2010).

WASHCon Assessment Tool: The WASHCon Assessment is a data collection tool that enables HCFs and third-parties to assess HCF WASH conditions through structured interviews, observation checklists, and lab testing of HCF water samples (CGSW, 2018a). This tool provided the data analyzed in this study. A detailed overview of the WASHCon tool, as well as the text of the survey, observation, and testing forms used to capture data, are contained in Appendices.

Level of care: HCFs selected for assessment were grouped into two overarching categories of care: “High” level of care, which included all of the hospitals and highest-level health clinics, and “Low” level of care, which included all other primary care health centers and clinics. In Uganda, HC IIIs were categorized as “Low”, and HC IVs and hospitals were designated “High”. In Afghanistan, SHCs and BHCs were categorized as “Low”, while CHCs and all Hospitals were considered “High”.

Subregions: This study assessed HCFs from two sub-national regions in Uganda, known within the country as ‘subregions’, and three sub-national regions in Afghanistan, known within the country as ‘provinces’ but referred to here as ‘subregions’ for consistency. The studied subregions in Uganda were Karamoja and West Nile. The studied subregions in Afghanistan were Badghis, Ghor, and Herat provinces.

Functional hand hygiene facilities:: This study defines functional hand hygiene facilities as “the availability of soap and water, or alcohol-based hand rub, at locations where patients receive care,” to be consistent with the JMP’s definition (JMP, 2019). For the purposes of global and national monitoring, the JMP also considers alcohol-based hand rub alone to count as a hand hygiene facility – i.e., it deems that hand sanitizer alone can suffice as a hand hygiene facility at a point of care, even if the point of care does not have water. To collect the data used to assess access to hand hygiene facilities, enumerators were instructed to “observe a functional hand hygiene facility” and mark the materials present (for the full text of the ward observation form, see **Appendix C**). Enumerators verified during the course of their observations that the hand hygiene materials marked in response to this question were, in fact, functional. Thus, the terms ‘hand hygiene facility’ and ‘functional hand hygiene facility’ are used interchangeably here.

Reported accessibility of water: Reported accessibility of water refers to equity of access to water between staff and patients. In other words, this metric explores who can access water assuming that water is available at the HCF. In this case, “access” does not guarantee that water is, in fact, always available in the event of an outage or shortage.

Reported accessibility of soap: In the context of soap, reported accessibility for patients or staff means that the respondent answered ‘yes’ instead of ‘sometimes’ or ‘never’ when asked if the HCF provides soap to this group. In this case, access does imply availability.

The Six Cleans: The Six Cleans that define safe birth practices in any setting are: (1) clean hands of birthing attendant(s), (2) clean birthing surface, (3) clean blade, (4) clean cord tie, (5) clean towels for the newborn, and (6) clean cloth to wrap the mother (WHO, 2006). For the purposes of this study, “Clean hands” was indicated by the presence of a functional hand hygiene facility observed in the labor and delivery (L&D) ward. The presence of gloves was not sufficient to achieve “Clean hands”. No microbiological testing was done for any surfaces or tools; cleanliness was assessed visually. Additionally, during the WASHCon deployments that produced the data for this study (2017-2018), the observation checklist only included one option for clean towels. When clean towels were present, it was assumed that they were available for both mother and newborn. Thus, in this study, the Six Cleans in fact measures the presence of five unique items in an HCF’s L&D ward, because towels were allowed to represent both (5) clean towels for the newborn and (6) clean cloth to wrap the mother.

Ward and **point of care**: A ward is a point of care. The terms “ward” and “point of care” are used interchangeably throughout this text. Examples of ward types of particular interest include labor and delivery (L&D) wards, surgical wards, and emergency wards. Wards were observed and ward-level data was collected using the Ward observation form (**Appendix C**).

Rural and **urban** (**geographic setting**): Definitions of rural and urban settings differed by country. In Afghanistan, subject matter experts categorized each studied HCF as rural or urban based on their knowledge of the HCFs and the surrounding areas. In Uganda, subject matter expertise was not available, and categorizations of studied HCFs as rural or urban were made according to the Ugandan Bureau of Statistics' definition of urban and rural areas. Uganda's 2014 Census "defined urban areas to include only the gazette urban centres (City, Municipalities, Town Councils and Town Boards)" (UBoS, 2017). Using a list of our studied HCFs by their subcounty, we found all HCFs located in a "City", "Municipality", "Town Council", or "Town Board" subcounty and designated them as Urban. All others were designated Rural.

Chapter III. Manuscript

Water, sanitation and hygiene at health care facilities in Afghanistan and Uganda: an analysis of access, quality, and predictors of disparity

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A R T I C L E I N F O

Keywords:
Water
Hygiene
Hand Hygiene
Handwashing
Sanitation
Health care facilities
Hospitals
Clinics
Access
Quality
Basic water service
Water quality
E. coli
Free chlorine
Point of care
Six Cleans
Maternal health
Safe delivery

A B S T R A C T

Background: Basic water, sanitation, and hygiene (WASH) in health care facilities (HCFs) are critical for infection prevention and control, containment of anti-microbial resistance, and provision of quality health care. Data on HCF WASH conditions remain scarce, and there is a need for field assessments and identifying determinants of WASH among HCFs in low-development/high-risk areas.

Methods: Primary survey, observation, and microbiological water quality data were collected from >250 HCFs in selected regions of Afghanistan and Uganda through the WASH Conditions (WASHCon) Assessment Tool. This report describes the WASH conditions and uses country-specific multivariable logistic regressions to identify determinants of 4 key outcomes: 1) basic water service; 2) hand hygiene facilities; 3) Six Cleans for safe delivery, and 4) microbiological water quality.

Results and Conclusions: Among HCFs assessed in Afghanistan and Uganda, respectively: 70% / 60% had basic water service; 86% / 74% had hand hygiene facilities at ≥1 point of care; 23% / 33% had all of the Six Cleans; and 21% in both countries had *E. coli* detected in ≥1 100mL water sample. Differences in coverage estimates emerged from small changes to indicator definitions, indicating need for careful consideration of these definitions. Private HCFs were more likely to have basic water service, access to hand hygiene facilities, and superior water quality compared to public HCFs in Uganda. Sub-national region was associated with hand hygiene access and water quality in both countries and Six Cleans access in Uganda. Higher levels of care were associated with basic water service in Uganda but poorer water quality in Afghanistan. Main water source type was the strongest predictor of *E. coli* detection in ≥ 1 water sample among HCFs in both countries. These analyses support development of evidence-based WASH interventions for HCFs and provide a roadmap for future research on the determinants of HCF WASH conditions.

1. Introduction

Safely managed water, sanitation, and hygiene (collectively, WASH) are critical to the provision of health care services. Access to safe WASH at health care facilities (HCFs) plays a central role in enabling an HCF to be a place for disease treatment instead of a place for disease transmission. Access to safe WASH and high-quality water are necessary for multiple purposes in HCFs, from routine daily needs to medical uses. Safe WASH in HCFs prevents healthcare-associated infections (HCAIs) (Oza et al., 2015; WHO, 2015), reduces the spread of antimicrobial resistance (AMR), and substantially decreases mortality, especially maternal and neonatal mortality (Say et al., 2014).

Despite the importance, preliminary evidence suggests that many HCFs, especially in low- and middle-income countries (LMICs), function with very poor access to WASH. The first-ever landscape report on HCF WASH access in LMICs reported in 2015 that only about 62% of LMIC HCFs had access to an improved water source within 500 meters (m) of the premises, about 65% had access to soap, and about 81% had access to improved sanitation (WHO, 2015). A subsequent peer-reviewed study of LMIC HCFs reported slightly higher coverage of improved water within 500m (71%), but slightly lower access to soap (61%) and sanitation (65%) (Cronk, 2018). Specific to L&D settings, in 2006, the WHO defined six "Cleans" that must be present to enable safe births: (1) Clean hands of the birthing attendant, (2) Clean birthing surface, (3) Clean blade, (4) Clean cord tie, (5) Clean towels to dry and wrap the newborn, and (6) Clean cloth to wrap the mother (WHO, 2006). There is still little data about the capacity for HCFs to provide the Six Cleans, and the consensus on what constitutes "essential" WASH services in L&D settings is still evolving, but the limited available evidence suggests a pervasive lack of necessary infrastructure and policies to provide safe birth conditions at HCFs, including in labor and delivery (L&D) wards (A. N. T. Bazzano, L.; Oberhelman, R.A.; Var, C., 2016; Cronk, 2018; Gon et al., 2017). Recent assessments of delivery room conditions in several countries leave no doubt that many women face serious risks of infection due to inadequate WASH services in L&D settings (JMP, 2019).

In 2019, the Joint Monitoring Programme (JMP) published its first global baseline HCF WASH service coverage estimates for SDG6. The report included “service ladders” that outlined the definitions of Basic Service, Limited Service, and No Service in five WASH service areas: Water, Sanitation, Hygiene, Environmental Cleaning, and Waste Management. The JMP estimated that 64% percent of HCFs globally had achieved Basic Water Service, where “Basic” service meant an HCF had water available from an improved source on the premises (JMP, 2019). None of the other service areas had sufficient data for the JMP to produce global estimates of the service levels, but based on the partial data available, the report found HCF WASH services to be “sub-standard” in every global region and noted substantial variation both within and between regions (JMP, 2019).

To understand their WASH service conditions, HCFs are advised to conduct regular WASH conditions assessments and take action as needed to remediate deficiencies (WHO, 2018). However, without standardized questions and measurement techniques, the HCF WASH self-assessment process can be daunting both for staff to design and administer and for third parties to interpret and aggregate. To address this problem, the Center for Global Safe Water, Sanitation, and Hygiene (CGSW) at Emory University developed the **WASH Conditions (WASHCon) Assessment Tool**, a suite of structured interview survey questionnaires, observation checklists, and water quality testing protocols designed to help LMIC HCFs understand their unique WASH conditions and risks, and to help government and NGOs better target programs and resources to improve WASH in HCFs. The results from these assessments help international organizations (WHO and UNICEF) and researchers form a more comprehensive picture of HCF WASH conditions and risks around the world (CGSW, 2018a). In partnership with local and international organizations with existing relationships with HCFs, the CGSW has conducted WASHCon assessments at hundreds of HCFs in more than a dozen countries since the WASHCon tool's inception in 2015. A full synopsis of the WASHCon tool, along with the enumerators' guide and the full text of the relevant WASHCon data collection forms, can be found in this study's Appendices.[7]

This study examines WASHCon data from two countries, Afghanistan and Uganda, where WASHCon assessments were deployed in 2017 and 2018. Using these country-specific WASHCon data sets, this study explores a variety of research questions (RQs) in two research domains: HCF WASH Access and HCF Water Quality (**Fig. 2**). First, we report descriptive statistics related to outcomes of interest in each research domain (RQ 1.00 and RQ 2.00). Second, we analyze and report potential predictors for four key HCF WASH outcomes of interest: having Basic Water Service (RQ 1.01), having functional hand hygiene facilities at ≥ 1 point of care (RQ 1.02), having access to the Six Cleans required for safe births in the L&D ward (RQ 1.03); and detecting *E. coli* in one or more water samples at an HCF (RQ 2.01).

[7] **Appendix A** contains a two-page brief reviewing the purpose of the WASHCon assessment tool and how it fits with broader WHO guidance for assessing WASH conditions in HCFs. **Appendix B** contains the enumerators' guide for use of the WASHCon tool. **Appendix C** contains the full text of the WASHCon data collection forms relevant to this study.

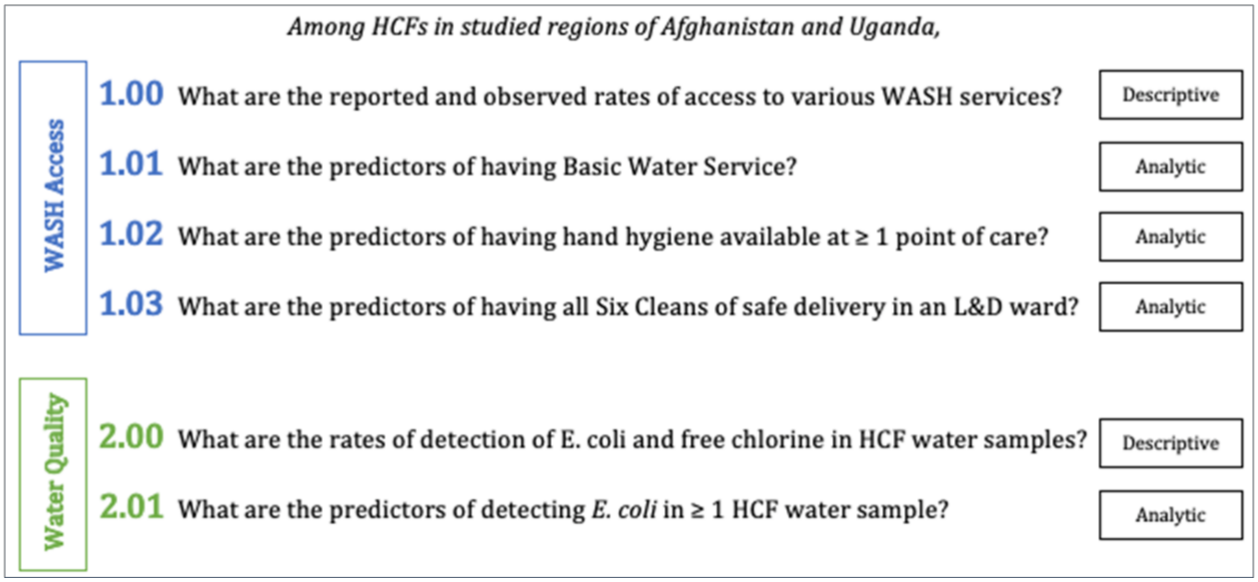


Figure 2. *Summary of the study's research questions*

2. Methods

2.1. Data set and study design

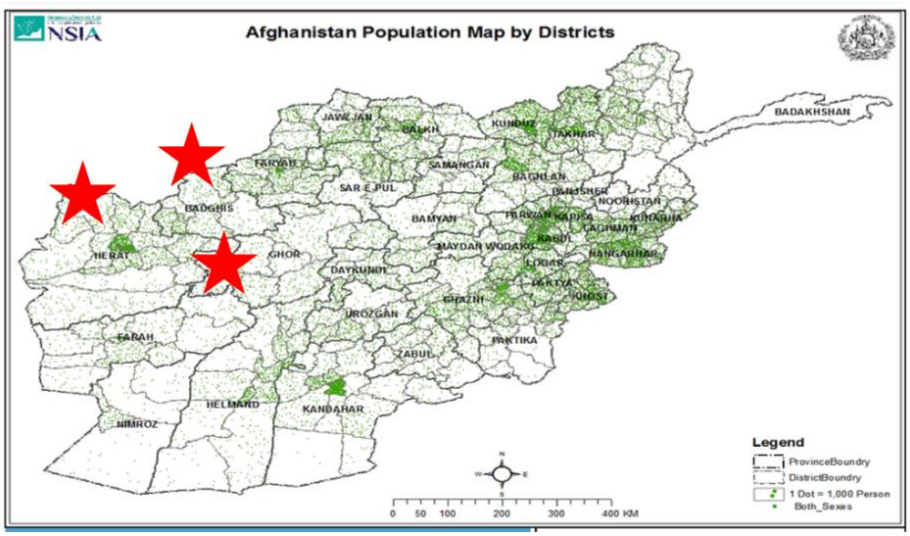
The data for this study was collected from HCFs surveyed through WASHCon in two countries, Afghanistan and Uganda. At each studied HCF, a WASHCon enumerator collected survey and observational data focused on both the HCF as a whole and specific points of care (wards) within it, and collected water samples to obtain quantitative data about the microbiological quality of the HCF's water (**Table 1**).

Table 1. *Study data set by country*

	Afghanistan				Uganda			
		per HCF				*per HCF*		
	n	mean	median	range	n	mean	median	range
Subregions (Provinces)	3				2			
HCFs	104				148			
Points of care	497	4.9	4	1 – 19 *	422	2.9	3	1 – 6
Water samples	190	1.8	2	1 – 6	285	2.1	2	1 – 7

*Two HCFs in Afghanistan were missing data for points of care (i.e., no "ward" forms were attached to these HCFs). The data were set to missing, so the range here appears as 1 – 19 instead of 0 – 19.

These two countries presented a desired regional contrast, with one being located in sub-Saharan Africa (SSA) and one in the Middle East in the JMP's Central and Southern Asia (CSA) region. Data collection was limited to a subset of HCFs in a few subregions in each country. In Afghanistan, HCFs were selected in Badghis, Ghor, and Herat provinces (subregions) (**Fig. 3**), and in Uganda, HCFs were selected from the West Nile and Karamoja subregions (**Fig. 4**). The studied subregions were not considered to be nationally representative in either country. In Uganda, these two subregions were chosen by UNICEF collaborators because they had higher-than-average rates of child mortality and were considered areas of special concern in the country. In Afghanistan, the three subregions were chosen because World Vision collaborators were already working in these areas. Two of the three, Badghis and Ghor provinces, are known for severe chronic water shortages and underdevelopment. Herat province has a much larger population and higher level of development than Badghis or Ghor, but it is heavily impacted by drought.



(ANSIA, 2018)

Figure 3. *Map of Afghanistan with studied subregions starred*

(UBoS, 2017)

Figure 4. *Map of Uganda with studied subregions starred*

Health systems in both Afghanistan and Uganda operate on a referral system, wherein patients at lower levels of care are referred to higher levels of care as needed. In Afghanistan, mobile community health workers are generally the first line of defense, followed by a hierarchy of primary care clinics: Sub Health Centers (SHCs) at the lowest level, followed by Basic Health Centers (BHCs), followed by Comprehensive Health Centers (CHCs). From there, patients may enter the hospital system, beginning with District Hospitals (DHs), then Provincial Hospitals (PHs), Regional Hospitals (RHs), and finally, Special or National Hospitals (SHs) (AMoPH, 2012). Structurally, Uganda's health care system looks very similar, with a hierarchy of clinics (HC I – HC IV) and hospitals. HC Is are informal village teams, similar to the mobile health workers in Afghanistan. HC IIs (analogous to SHCs) are the first formal interaction point between patients and the health care system, providing low-level primary care. (Note: no HC IIs were assessed in this study: **Table 2**.) HC IIs are followed by HC IIIs (analogous to BHCs), and finally HC IVs, which provide comprehensive care to entire counties, and are intended to function like small hospitals (Kavuma, 2009; UMoH, 2010). Finally, Uganda's hospital system consists of General Hospitals (GHs), Regional Referral Hospitals (RRHs), and its two National Referral Hospitals (NRHs) (UMoH, 2010).

HCFs selected for assessment included HCFs in Afghanistan ranging from SHCs (low-level primary) to hospitals, and included HCFs in Uganda ranged from HC IIIs (mid-level primary) to hospitals. In each subregion, between 32% and 64% of all known HCFs in the area were selected for data collection. For the purposes of this analysis, HCFs were grouped into two categories by level of care: "Low" level of care, including SHCs and BHCs from Afghanistan and HC IIIs from Uganda, and "High" level of care, including Afghan CHCs, Ugandan HC IVs, and all hospitals sampled in both countries (**Table 2**).

Table 2. HCFs selected for assessment and sample frames by region and level of care

Level of Care		Afghanistan n (%)				Uganda n (%)		
		Badghis	Ghor	Herat	**Total**	Karamoja	West Nile	**Total**
Low	Low-level primary	SHC *				HC II *		
	All	14	20	25	59	89	158	247
	Sampled	9 (64)	1 (5)	7 (28)	17 (29)	0 (0)	0 (0)	0 (0)
	Mid-level primary	BHC				HC III		
	All	24	21	38	83	44	129	173
	Sampled	15 (63)	12 (57)	23 (61)	50 (60)	40 (91)	83 (64)	123 (71)
High	High-level primary	CHC				HC IV		
	All	3	8	25	36	4	11	15
	Sampled	2 (67)	7 (88)	17 (68)	26 (72)	4 (100)	8 (73)	12 (80)
	Hospitals	DH, PH, RH, SH				GH, RRH, NRH		
	All	2	3	5	10	5	13	18
	Sampled	1 (50)	2 (67)	5 (100)	8 (80)	5 (100)	8 (62)	13 (72)
	Other / Specialty	Other / Specialty Services				Other / Specialty Services		
	All	1	2	3	6	0	1	1
	Sampled	1 (100)	1 (50)	1 (33)	3 (50)	0 (n/a)	0 (0)	0 (0)
	Total HCF	44	54	96	194	142	312	454
	Total Sampled	28 (64)	23 (43)	53 (55)	104 (54)	49 (35)	99 (32)	148 (33)

*Clinic and Hospital abbreviations: Afghanistan - Sub Health Center (SHC), Basic Health Center (BHC), Comprehensive Health Center (CHC), District Hospital (DH), Provincial Hospital (PH), Regional Hospital (RH), Special or National Hospital (SH). Uganda: Health Clinic II (HC II), Health Clinic III (HC III), Health Clinic IV (HC IV), General Hospital (GH), Regional Referral Hospital (RRH), National Referral Hospital (NRH).

Sources: Estimated sample frames ("All") – Badghis, Ghor, Herat: Afghanistan Ministry of Public Health (AMoPH, 2012), Karamoja, West Nile: Uganda Ministry of Health (UMoH, 2018).

While the data set consisted of HCFs, it was also important to consider the human populations in their catchment areas – the presumed users of these HCFs – and assess whether the HCF sample in each subregion was generally proportionate to how and where those people lived (**Table 3**). Generally, the number and distribution of the facilities was approximately proportionate to the populations in each subregion. More than half of sampled Afghan HCFs were in Herat, as Herat has more than twice the population of Badghis and Ghor combined. Similarly, in Uganda, the HCF sample size in West Nile was about twice the size of the sample in Karamoja, reflecting the regions' respective population sizes. All five subregions had majority-rural populations, and the study's samples reflected that as well, with rural HCFs constituting between 79% and 93% of each region's HCF sample (**Table 3**).

Table 3. *HCFs sampled and their estimated catchment area populations by region and geographic setting*

	Afghanistan			Uganda	
	Badghis	Ghor	Herat	Karamoja	West Nile
HCFs sampled n	28	23	53	49	99
% Rural HCFs	89	91	79	86	93
Catchment area population n	0.5 M *	0.7 M	2.0 M	1.0 M	2.1 M
% Rural population	97	99	71	87	88

M = Million. Sources: Sample Size and Rural Sample %: Study data. Population: Badghis, Ghor, Herat – Afghanistan Central Statistics Organization (ACSO, 2018), West Nile – Uganda Bureau of Statistics (UBoS, 2019). Rural Population %: Afghanistan Central Statistics Organization (ACSO, 2018), Uganda Bureau of Statistics (UBoS, 2017).*

2.2. Data Collection and Sample Testing

2.2.1. WASHCon Survey Methods

Enumerators for the WASHCon assessment visited each HCF in person. They used a GPS device to record each HCF's location. While at the HCF, enumerators used a variety of structured interview survey forms and observation checklists on a mobile device to collect both interview data and observational data onsite. Finally, if water was available, the enumerators collected water samples for water quality analysis. Water quality testing methods differed between Afghanistan and Uganda, and the methods used in each country are described in detail in the following section (**Methods**). The enumerator or a lab technician recorded the results of each water sample's tests in an individual sample water quality assessment form, and after water quality testing was complete for all samples taken from an HCF, they completed an HCF-level water quality form summarizing the water quality testing results from all samples at that HCF.

In total, there were nine WASHCon forms (**Table 4**). Data from five of the forms were relevant to the research objectives of this analytic study: GPS, Director, Administrative, Ward (Point of Care), and Individual Water Quality forms (**Table 4**, shaded in bold).

Table 4. *WASHCon data collection survey forms and descriptions*

Survey Form	Description
1) GPS form	**One per HCF. Recorded the location of the HCF, to which other demographic variables were later added, including geographic setting (rural or urban); HCF type (the basis for categorizing Level of Care); and HCF ownership.**
2) Director form	**One per HCF. Recorded results of a structured interview with the HCF's director or his/her designee.**
3) Management form	One per HCF. Recorded results of a structured interview with the HCF's director, designee, or other management.
4) Administrative (Background) form	**One per HCF. Recorded administrative data about the HCF from records or from a reliable source.**
5) Ward observation checklist form	**Multiple per HCF. One per point of care observed. Recorded enumerator's observations for that point of care.**
6) Toilet facility observation checklist form	Multiple per HCF. One per toilet facility observed.
7) Sanitary inspection form	One per HCF. Recorded sanitary conditions observed at the HCF.
8) Water Quality - individual form	**Multiple per HCF. One per water sample. Recorded results of water quality testing for that sample.**
9) Water Quality – aggregate form*	One per HCF. Recorded aggregated results of individual sample-level Water Quality forms.

The forms shaded in bold provided the data for this analytic study. For further information, please see Appendices: **Appendix C** contains the full text of the survey forms relevant to this study, including answer options and skip logic. **Appendix B** contains the WASHCon Enumerator's Guide.

*There were nine HCFs in Uganda for which Aggregated water quality forms were available but not Individual water quality forms. We requested and received the Aggregated water quality form results for these nine HCFs, but for no other HCFs. As appropriate, these results were used for HCF-level questions related to water quality, but these nine HCFs were excluded from any analysis requiring sample-level results since sample-level results were not available.

Sources: WASHCon Enumerator's Guide (CGSW, 2018b); WASHCon Unifying Document (CGSW, 2018c)

2.2.2. WASHCon Water Quality Testing Methods

2.2.2.1. Water Testing Methods in Afghanistan

In Afghanistan, initial tests for free chlorine and pH were conducted at the HCF immediately after each water sample was collected. Enumerators collected water from taps into collection tubes, added a Palintest DPD1 reagent, and used the SP610 Palintest PoolTester Chlorine & pH Visual Kit (Palintest, Gateshead, Tyne and Wear, UK) to visually gauge chlorine and pH results on site. Enumerators were tested for color-blindness and received practical training on visually matching the color of the water after adding the reagent to the color on the Palintest PoolTester reference screen. Duplicate samples were collected using 207 mL Whirl-Pak sterile sampling bags (Nasco, Fort Atkinson, WI, USA) for multi-parameter testing in the lab. (In some cases, 500mL polypropylene bottles were used to collect supplementary samples for additional physical-chemical tests.) Samples were held in long-range vaccine carrier cold boxes of unknown manufacture (borrowed from Afghanistan's Ministry of Public Health) with ice packs for storage and transportation. All samples were tested within 24 hours, most within 6 to 16 hours.

In the lab, technicians tested water samples for turbidity, free chlorine, and microbiological water quality (*E. coli* and coliforms) using the Palintest Wagtech Potatest+ (C) kit (Palintest, Gateshead, Tyne and Wear, UK). All consumables used in the lab were also purchased through Palintest. Turbidity was tested with the kit's Turbidimeter Plus, following the ISO 7027 standard, and results were reported in Nephelometric Turbidity Units (NTU). Lab testing for free chlorine used the Photometer in the Potatest+ (C) kit. However, the free chlorine results provided for this analysis were those from the SP610 Palintest PoolTester Visual Kit tests, not from the Potatest+ (C) kit's Photometer. After establishing this understanding in the analysis phase, the free chlorine results were rounded down to the nearest decimal place measurable by the PoolTester kit at the manufacturer's intended level of sensitivity (Palintest, 2019). [8]

E. coli was tested in the lab using a membrane filtration method and Palintest's Membrane Lauryl Sulphate Broth (MLSB) powdered culture media. Occasionally, a pre-prepared Nutridisk media was used instead of the MLSB powdered media. In two of the three provinces, Herat and Ghor, the volumes filtered through the membrane were all 100mL. In the third province, Badghis, 70% of the samples were diluted such that 50 mL of sample was combined with 50 mL of distilled water before being filtered through the membrane. The exact incubation times and temperatures are not known. After incubation, concentrations of *E. coli* were estimated using Colony Forming Units (CFU) per 100mL. Limits of detection were 1 CFU to 200 CFU, and any results equal to or above 200 CFU were marked Too Numerous to Count (TNTC).

2.2.2.2. Water Testing Methods in Uganda

In Uganda, all tests for free chlorine, total chlorine, and turbidity were conducted at the HCF immediately after each water sample was collected. Enumerators used a portable colorimeter and DPD reagent (HACH, Loveland, CO, USA) to test for free and total chlorine,

[8] The PoolTester kit is marketed as a tool to test swimming pool water, allowing users to visually assess free chlorine levels by observing the color of a water sample as it reacts to a reagent tablet. The kit's visual matrix enables comparison at 0.1, 0.3, 0.4, 0.5, 0.6, 0.7, 0.8, and 1.0 mg/L, skipping 0.2 mg/L and 0.9 mg/L, and continuing in larger intervals to 6.0 mg/L (Palintest, 2019). Results from this test kit would be expected only in those intervals to avoid guesswork., but initially our results were reported to two decimal places with observations ranging from 0.00 to 0.45. The study team confirmed that these observations had been taken with the PoolTester and not the more sensitive Photometer, stating that enumerators had "received practical training to ensure focus and concentration for finding matching colors on the result screen" and that "due to very low concentrations of free chlorine in samples (almost zero), they did put a decimal number which still could be guess[ed] as zero (0.05, 0.04, 0.01, 0.02…)" (Haqmal, 2019). To bring results in line with the level of sensitivity dictated by the testing instrument, we rounded down each reported observation to the nearest interval specified by the PoolTester. I.e.: results between 0.01 and 0.09 inclusive were rounded down to 0.00 mg/L. Results between 0.11 and 0.29 inclusive were all rounded down to 0.1 mg/L, since 0.2 was not measurable by the PoolTester kit. Results between 0.31 and 0.39 were rounded down to 0.3 mg/L, and between 0.41 and 0.45 (the largest) to 0.4 mg/L.

and results were reported in mg/L to one decimal place. Chlorine testing was only conducted in HCFs with a chlorinated municipal water source or a water source that was chlorinated on site. If the HCF reported having no access to chlorinated water, chlorine testing was not conducted, and free and total chlorine were each reported as 0 mg/L. Turbidity was tested using a portable turbidimeter (HACH, Loveland, CO, USA), and results were reported in Nephelometric Turbidity Units (NTU). For both chlorine and turbidity tests, water samples were collected directly into the instruments' testing tubes, and aseptic techniques were used to avoid contamination of samples.

Water samples to be tested for *E. coli* and total coliforms were collected using Whirl-Pak sterile sampling bags (Nasco, Fort Atkinson, WI, USA), and sodium thiosulphate was added to neutralize any remaining free chlorine and preserve the samples for microbiological testing. Samples were stored in a cooler on ice and tested within six hours of collection. Undiluted 100 mL samples were tested for *E. coli* and total coliforms using the IDEXX Quanti-Tray/2000 system and Colilert 18 reagent (IDEXX, Westbrook, ME, USA). The exact incubation times and temperatures are not known. After incubation, concentrations of *E. coli* and total coliforms were estimated in Most Probable Number (MPN) per 100 mL according to the IDEXX Quanti-Tray/2000 MPN Table. Limits of detection were 1 to 2419.6 *E. coli* or total coliforms per 100 mL.

2.2.2.3. Use of Water Quality Data Sets to Estimate Water Service Levels by Country

For an HCF to meet the JMP definition of Basic Water Service, it needed to have water available*(1), from an improved source**(2), on the premises***(3). For this study, the indication of whether an HCF's main water source was an improved source, and the indication of whether the main water source was on-premises, were both from the Director interview, measured on the Director survey form. The indication of whether an HCF had water available at the time of the survey was the presence of at least one Water Quality form indicating that a water sample had been taken from the HCF. However, the Water Quality forms did not ask whether each sample was drawn from the Main Water Source described in the Director interview. The data collected in Water Quality forms was different by country, but neither country's Water Quality forms established whether a given sample was from the HCF's Main Water Source. (For a review of Water Quality data fields by country, see **Appendix C.5**). Thus, the WASHCon data in both countries could establish each individual requirement for basic water service – whether water was available, whether the HCF's main water source was improved, and whether the HCF's main water source was on-premises – but it could not establish that the water available on the day of the survey was from the HCF's main water source. Given this limitation, for the purposes of classifying Water Service Level, we made the baseline assumption that if the Main Water Source type was improved, then the samples from that facility were from an improved source, and if the Main Water Source type was unimproved, then the samples from that facility were from an unimproved source.

In Afghanistan, additional information was available to supplement the baseline assumption. Water Quality data in Afghanistan noted the type of water source from which each sample was drawn. Sometimes the sampled source type differed from the HCF's stated Main Water Source type on the Director form, and often multiple water sources were tested within the same facility. This additional information, available only in Afghanistan, complicated the baseline assumption that all of an HCF's water samples were from its Main Water Source or a comparable (improved or unimproved) source, because the source types listed did not always match the Main Water Source type. Thus, for Afghanistan only, we amended the water service level categorization methodology as follows: if the Main Water Source was reportedly an improved source but water was available only from unimproved sources at the time of the survey, the facility was deemed not to have attained the Basic Water Service level. In Uganda, data on the sources of water samples tested was not available, so all water service level designations relied on the baseline assumption that the water tested came from the Main Water Source or a comparable (improved or unimproved) source, despite the fact that this was not always true in Afghanistan.

JMP guidance allows reasonable assumptions where perfect monitoring data is not available (JMP, 2019). After defining our assumptions in each country, we proceeded with estimation of water service levels for HCFs in both countries. Our results are always reported stratified by country so as not to conflate results that rely on different assumptions.

2.2.3. WASHCon Deployment Differences

WASHCon assessments were deployed in Uganda in three phases in 2017 (n=9, n=98, and n=41), and were deployed in Afghanistan in one phase in 2018 (n=104). Generally, the data from the five forms relevant to this study in both countries aligned with the standardized WASHCon survey questions in the current Data Dictionary (**Appendix C**). However, some of the WASHCon survey questions and their response options changed between these four phases of deployment (**Appendix D**). As a result, the data set outputs from the five WASHCon forms were not identical between the two countries, nor were they always internally consistent within each country. There were certain variables for which results had been collected in one country but not the other, and certain shared variables where the answer options differed by country or by deployment within the same country.

These changes were largely harmonized during data cleaning to allow appropriate comparisons both within and between countries (**Appendix E**). If harmonization was not possible for a certain indicator, data from that indicator was not used in analysis.

2.3. Data Unification

All data manipulation, variable synthesis, and data set merging was conducted using SAS software, version 9.4 of the SAS System for Windows (SAS Institute Inc., Cary, NC, USA). The goal of the data unification process was to create one integrated data set that would allow comparison of HCF variables, ward variables, and water quality variables both within and between countries. An initial HCF data set was created by merging the three HCF-level forms (GPS, Director, and Administrative forms) such that each HCF assessed was represented by one observation row that included all variables from each of the three forms. Subsequently, the Ward and Water Quality data sets were analyzed, and variables were created to summarize the Ward and Water Quality results at each HCF (e.g., percentage of wards at the HCF where hand hygiene was observed; percentage of water samples at the HCF that tested positive for *E. coli*; etc.). These summary variables were merged into the HCF data set such that the final data set still had only one observation row per HCF but contained variables drawn from all five relevant forms.

2.4. Data Analysis

2.4.1. Outcomes

After data cleaning and harmonization was complete and a unified HCF data set was created, four key outcomes of interest were defined (**Table 5**) corresponding to the study's four analytic research questions (**Fig. 2**). Descriptive statistics (**Tables 6-7**) were calculated and reported for these key outcomes and various other outcomes of interest to explore this study's two descriptive research questions (**Fig. 2**).

Table 5. *Outcome variables, levels, and definitions for each analytic research question*

RQ	Outcome Variable	Levels	Definition	Variable Name
1.01	**Basic Water Service**	Yes, No	"Yes" response required all of the following: (1) Main water source was improved; (2) Main water source was on premises; (3) Water was available at the time of the survey from an improved source.* Service level assignments in Uganda relied on the assumption that water sampled was from the Main water source or similar.	jmp_basic__water
1.02	**Staff Access to a Functional Hand Hygiene Facility Observed at One or More Points of Care**	Yes, No, Missing	"Yes" response required that a functional hand hygiene station (water and soap together, or an alcohol-based hand sanitizer with or without any other supplies) was observed in at least one point of care in the facility on the day of the survey.	poc_handwash_ any
1.03	**Staff Access to the "Six Cleans" Observed in the L&D Ward**	Yes, No, Missing	"Yes" response required that all of the following were visually observed in the HCF's L&D ward on the day of the survey: a functional hand hygiene station (1: "Clean Hands"); a clean delivery service (2: "Clean Surface"); a clean blade for cutting (3: "Clean Blade"); a clean cord for tying (4: "Clean Cord"); and clean towels for wrapping the baby and cleaning and wrapping the mother (5 and 6: "Clean Towels" counting for both mother and baby).	sixcl_all
2.01	**≥ 1 *E coli* Detected in One or More 100 mL Water Samples at HCF**	Yes, No, Missing	"Yes" response occurred if one or more water samples at the HCF tested positive for *E. coli* in laboratory testing. A "missing" response indicates that no water was available to test.	hcf_ecoli_viol

*An improved source, "by nature of [its] design and construction, [has] the potential to deliver safe water." As of 2019, WHO guidance on improved sources include piped water, boreholes or tube wells, protected dug wells, protected springs, rainwater, and packaged or delivered water as improved sources (JMP, 2019).

Exploratory chi-square tests of association were performed between outcome variables and relevant categorical variables, first using combined (two-country) data and subsequently using data stratified by country. Observing that associations often diverged by country, it was determined that subsequent analyses should be stratified by country.

2.4.2. Predictors

A set of independent variables was identified for exploration as potential predictors of variation in outcome variables, using regression modeling. Descriptive statistics were produced for those predictor variables (**Tables 9-10**).[9] Some of these potential predictors displayed relatively imbalanced frequencies – for example, 142 HCFs in Uganda offered inpatient services, and only 6 did not. Variables with such imbalanced frequencies were noted as potentially problematic for modeling. However, the two variables with the highest imbalances – inpatient services and rural/urban geographic setting – were of interest despite their frequencies because they had been found significant in previous studies, so they were retained and tested in the regression models. Some predictor variables were missing data for certain HCFs. The number of data points (n) for each predictor is included in the predictor variables' descriptive statistics tables (**Tables 9-10**).

2.4.3. Univariable Analyses

All univariable analyses for this paper were completed using SAS software, version 9.4 of the SAS System for Windows (SAS Institute Inc., Cary, NC, USA). After the dependent (outcome) variables and independent (predictor) variables were chosen, the four outcome variables were analyzed using univariable regressions with the predictor variables, i.e., each outcome was assessed against each potential predictor one at a time. Conducting multiple comparisons like this results in an inflation of the Type I error rate (multiplicity), such that the 'familywise' error rate is much higher than the error rate specified for each individual test (α=0.05). For this study, there was no prespecified method for controlling for

[9] The Variable Reference Table in **Appendix F** contains a complete list of predictor (independent) variables, outcome (dependent) variables, and supplementary variables. It includes variable names, types, levels, labels in data sets, and derivation details for composite variables created from original WASHCon variables. See also **Appendix C** for definitions of original WASHCon variables.

multiplicity prior to conducting the analyses. In keeping with the latest guidance on statistical reporting (Harrington et al., 2019), point-estimates and 95% confidence intervals are reported for all analysis, but p-values have been omitted for univariable analyses. The guidance emphasizes that p-values related to univariable results present high risk for misinterpretation (Harrington et al., 2019), especially when many univariable analyses have been undertaken, as was the case in this study.

Quasi-complete separation of data occurs when not all outcome levels are observed in each predictor level in a univariable regression analysis. This can occur when sample sizes are small or when an event is relatively rare (i.e., when frequencies are imbalanced), or when a predictor and an outcome are strongly associated. This message is displayed in lieu of an odds ratio because the SAS software is not able to calculate accurate odds ratios under this circumstance. This circumstance prevents the predictor in question from being included in multivariable analysis, although this warning can in fact be a sign that the variable in question would be a strong predictor for the dependent variable if studied in a large enough data set.

2.4.4. Multivariable Analyses

Multivariable logistic regression models were used to assess associations between each outcome and a predictor while controlling for the effects of other modeled predictors. All multivariable analyses for this paper were completed using SAS software, version 9.4 of the SAS System for Windows (SAS Institute Inc., Cary, NC, USA). All multivariable models were generated using backward selection, and a significance level of 0.2 was required for a variable to stay in any multivariable model (i.e., $p < 0.2$ after controlling for the effects of other modeled variables). All confidence limits and p-values were estimated using the Profile Likelihood method. All confidence intervals reported are 95% confidence intervals.

Before conducting multivariable modeling, correlations between pairs of predictors were examined to prevent multicollinearity in the models. Correlation coefficients were calculated for each pair of predictors by country.[10] No variables with greater than 60% correlation were entered in the same model unless suggested by prior research, and very highly correlated pairs (>90%) were never included in the same model. **Appendix G** contains the complete list of correlation coefficients for each pairs of predictors in each country.

Variables for each model were chosen based on a combination of their significance and effect size in univariable modeling, their significance and effect size in prior research, their n, and their correlates. In both countries, many of the continuous variables were strongly correlated with each other, and one variable among the correlates was chosen as representative in each model. The n for each predictor was an especially important consideration because the SAS software automatically dropped any HCFs that were missing data for any variables included in the model. To maintain each model's power, predictors with high n were generally prioritized over predictors with lower n.

Each multivariable logistic regression model controlled for the effects of other variables included in the model but did not control for the inflation of the Type I error rate caused by conducting more than one test (multiplicity). Because only four multivariable models were produced, the issue of multiplicity in the multivariable models was not as problematic as it

[10] Pearson correlation coefficients were used to assess almost all pairs of predictors (continuous-continuous, dichotomous-continuous, and dichotomous-dichotomous pairs). Non-dichotomous categorical variables, including subregion and main water source, were evaluated for correlation with the other categorical variables using chi-square tests of association (Cramer's V statistic, cutoff = 0.6), and with the continuous variables using multiple logistic regression (cutoff $p < 0.05$) stratified by country.

was for univariable analyses, so *p*-values are reported for multivariable models. However, it is important to note that even these adjusted *p*-values must be considered in the context of the effect size, the width of the confidence interval, consistency with findings of other studies, etc., and a reported *p*-value should not be considered a "bright line" for a result's significance.

2.5. Reporting of Results

In this study's tables, '**HCF n**' represents the total number of HCFs contributing data to a given indicator or predictor variable. In tables featuring categorical variables, '**%**' represents the percentage of HCFs in each level of the variable. For example, if 104 HCFs in Afghanistan contributed data about water service level and 17 of them had No Service, '**HCF n**' would be 104 and '**%**' would be 16.4 (17 / 104 HCFs = 16.4% with no service).

In the results of the regression analyses, slashes (**/**) indicate the variable was not included in the multivariable model. Dashes (**--**), along with a value in the '**HCF n**' column, indicate that the variable was included as a potential predictor in the multivariable model but was eliminated by the SAS software because its adjusted p-value did not reach the significance level required to remain ($p < 0.2$). One asterisk (*) next to a result in a multivariable model indicates significance at the $\alpha = 0.05$ level (95% confidence). Two asterisks (**) indicate significance at the $\alpha = 0.01$ level (99% confidence).

3. Results

3.1. **Descriptive Results**

3.1.1. Access to HCF WASH (RQ 1.00)

About 70% of HCFs assessed in Afghanistan and 60% in Uganda met the JMP requirements for Basic water service (**Table 6**). Despite greater overall access to basic water service, HCFs in Afghanistan were less likely than HCFs in Uganda to have a piped water source on premises (17.3% vs 31.1%, **Table 6**).

Approximately 86% of HCFs in Afghanistan had at least one functional hand hygiene facility observed at a point of care (i.e., at least one ward at those HCFs was observed to have water and soap, or hand sanitizer, or both), but only 27% of Afghan HCFs had functional hand hygiene facilities observed at *all* points of care assessed. This contrast was nearly as strong in Uganda, where 74% of HCFs were observed to have a functional hand hygiene facility in at least one ward (point of care), but only 28% of HCFs had functional hand hygiene facilities at *all* points of care observed. In both countries, these large gaps highlight the importance of precision in terminology and demonstrate the value of observing multiple points of care per HCF.

In this study, "reported" access to hand hygiene materials is based on the interview with the HCF's director or designated senior staff member about the presence of soap and water. "Observed" access to a functional hand hygiene facility also counted the presence or absence of alcohol-based hand sanitizer as a functional hand hygiene facility. Understanding this difference in measurement criteria between reported and observed access to hand hygiene facilities, one might in fact expect to see observed rates that are *higher* than reported rates – and indeed, observed rates of access to hand hygiene facilities in ≥ 1 ward are higher than reported rates of access to "both soap and water" at an HCF (in Afghanistan, 82.7% and 86.3% respectively: **Table 6**). However, the data from multiple points of care (wards) within an HCF provide different results: about 39% of HCFs in Afghanistan and 36% of HCFs in Uganda reported that soap and water were accessible to patients, but only 22% and 19%

respectively had functional hand hygiene facilities for patients at all points of care observed (**Table 6**).

There were also strong contrasts between access to hand hygiene facilities for staff and hand hygiene access for patients. In Afghanistan, more than 88% of HCFs reported that soap was accessible to staff, but only 42% reported that soap was accessible to patients. In Uganda, those rates were 75% and 45% respectively. Those general trends held true in observations of hand hygiene facilities at points of care, with observed access to hand hygiene facilities at points of care generally 5 to 20 points lower for patients than for staff. For example, 86% of HCFs in Afghanistan had hand hygiene facilities for staff observed at one or more points of care, but less than 78% had them for patients. In Uganda, those figures were 74% and 56%, respectively (**Table 6**).

Only about 23% of HCFs in Afghanistan and 33% of HCFs in Uganda had access to all six of the WHO's "Six Cleans" for safe delivery in their labor and delivery (L&D) wards (**Table 6**). Many HCFs lacked access to clean towels in both countries, suggesting that soft goods could be a common limiting factor for Six Cleans access. Many HCFs in both countries reported intermittent access to water, with about 49% in Afghanistan and almost 85% in Uganda stating that their main source was unavailable at times (**Table 6**). The reasons for an HCF's main water source being unavailable included power outages, equipment malfunctions, and seasonal effects (**Table 6A**). A majority of HCFs studied in both Afghanistan and Uganda lacked reliable electricity, with 56% in Afghanistan and nearly 80% in Uganda reporting power outages of more than 2 hours on at least "several" days during the month leading up to the survey. (Included in those figures are 9% of HCFs in Afghanistan and 2% in Uganda that reported having no power source at all: **Table 6B**).

Table 6. *Descriptive statistics for indicators of access to various WASH services by country*

		Afghanistan		Uganda	
RQ	Indicator	HCF n	%	HCF n	%
—	Estimated JMP Water Service Level	104	/	148	/
—	No water service	104	16.4	148	18.9
—	Limited water service	104	13.5	148	21.0
1.01	Basic water service	104	70.2	148	60.1
—	Improved main water source	104	89.4	148	92.6
—	Piped	104	25.0	148	36.5
—	Borehole or tube well	104	36.5	148	45.9
—	Other improved	104	27.9	148	10.1
—	Unimproved main water source, or no main water source	104	10.9	148	7.4
—	Improved main water source within 500m	104	83.7	148	81.1
—	Piped main water source on premises	104	17.3	148	31.1
—	Reliable electricity reported *	100	44.0	148	20.3
—	Main water source reported unavailable at times	103	48.5	143	84.6
—	Water reported accessible to staff, when available	104	92.3	148	85.1
—	Water reported accessible to patients, when available	104	83.7	148	83.1
—	Soap reported available and accessible to staff	104	88.5	148	75.0
—	Soap reported available and accessible to patients	104	42.3	147	44.9
—	Both soap and water (when avail.) reported accessible to staff	104	82.7	148	64.2
—	Both soap and water (when avail.) reported accessible to patients	104	39.4	147	36.1
1.02	Hand hygiene facilities for staff observed at ≥ 1 ward(s) assessed	102	86.3	148	73.7
—	Hand hygiene facilities for patients observed at ≥ 1 ward(s) assessed	102	77.5	139	56.1
—	Hand hygiene facilities for staff observed at ≥ 50% of wards assessed	102	73.5	148	56.8
—	Hand hygiene facilities for patients observed at ≥ 50% of wards assessed	102	55.9	140	39.6
—	Hand hygiene facilities for staff observed at 100% of wards assessed	102	26.5	148	27.7
—	Hand hygiene facilities for patients observed at 100% of wards assessed	102	21.6	140	19.4
1.03	All of the Six Cleans of safe delivery observed in the HCF's L&D ward**	96	23.0	127	33.1
—	Clean hands (hand hygiene facility for staff)	96	74.0	127	59.8
—	Clean delivery surface	97	57.7	126	75.4
—	Clean blade	97	60.8	126	83.3
—	Clean cord or tie	97	55.7	126	76.2
—	Clean towels (for both baby and mother)	97	30.9	126	61.1
—	Client toilet observed at 100% of points of care assessed	102	60.8	148	84.5

*For this study, electricity was designated "unreliable" if an HCF reported that its electricity had been interrupted for more than 2 hours at a time on at least "several" days in the month immediately prior to the survey.
**The indicator "All of the Six Cleans" is reported at the HCF level. One HCF in Afghanistan (Guzarad District Hospital) had two L&D wards observed, one with access to all Six Cleans and the other without. This HCF was classified as having access to the Six Cleans despite what were, in fact, mixed results. The individual Cleans are reported at the ward level.

Many HCFs reported a lack of access to their main water source at times. In Afghanistan, 19% of all HCFs reported that their main water source was sometimes unavailable because of power outages (**Table 6A**). In Uganda, 52% of all HCFs reported issues with main water source availability stemming from equipment malfunctions (**Table 6A**).

***Table 6A**. Reasons reported for Main water source being unavailable by country*

	Afghanistan		Uganda	
	HCF n	%	HCF n	%
Main water source reported unavailable at times	103	48.5	143	84.6
Reason(s) for main water source being unavailable:				
Power outage	104	19.2	148	6.1
Water rationing or shortage	104	6.7	148	4.1
Equipment malfunction (e.g., broken pump)	104	12.5	148	52.0
Season	104	15.4	148	27.0
Pipe breakage	104	12.5	148	7.4
Problems at the water provider	104	6.7	148	8.9
Other	104	1.9	148	3.4

Although only 6% of HCFs in Uganda cited power outages as the direct reason for a lack of access to their water source, power outages were shown to be relatively frequent in that country (**Table 6B**), with nearly 47% of HCFs reporting outages of 2+ hours "most days", and an additional 18.2% reporting such outages "every day". It is possible that a lack of electricity may be an underlying cause of equipment malfunction, the most frequently cited reason for water source unavailability in Uganda. About 9% of HCFs in Afghanistan and 2% in Uganda lacked any power source at all (**Table 6B**).

***Table 6B**. Frequency of power outages by country*

		Afghanistan		Uganda	
		HCF n	%	HCF n	%
In the previous month, electricity was out for more than 2 hours:					
Not Reliable	No power source [Always out]	100	9.0	148	2.0
	Every day	100	15.0	148	18.2
	Most days	100	14.0	148	46.6
	Several days	100	18.0	148	12.8
Reliable	Once	100	13.0	148	3.4
	Never	100	31.0	148	16.9

3.1.2. HCF Water Quality (RQ 2.00)

About 37% of HCFs surveyed in each country reported their water was chlorinated. However, of the HCFs with water available for testing, most samples tested from HCFs in both countries (93% of HCFs in Afghanistan and 81% of HCFs in Uganda) did not meet the WHO standard for free chlorine residual in drinking water [≥ 0.2 mg/L] (**Table 7**).

Table 7. *Descriptive statistics for indicators of HCF water quality by country*

		Afghanistan		Uganda	
RQ	Indicator	HCF n	%	HCF n	%
—	Chlorinated water reported at HCF	100	37.0	140	37.1
—	Water chlorination reported to occur on-site at HCF	100	32.0	140	8.6
—	Free chlorine detected [≥ 0.1 mg/L] in 1 or more water samples at HCF	104	67.3	128	21.1
—	Free chlorine sufficient to meet WHO standard [≥ 0.2 mg/L] detected in 1 or more water samples at HCF *	104	6.7	137	19.0
—	Free chlorine sufficient to meet WHO standard [≥ 0.2 mg/L] detected in 100% of water samples at HCF *	104	2.9	137	8.0
2.01	*E coli* detected in one or more water samples at HCF	104	21.2	137	21.2
—	By Main Water Source type:	104		137	
—	Improved: Piped	/	3.9	/	20.7
—	Improved: Borehole or tube well	/	21.1	/	24.2
—	Improved: Other	/	20.7	/	28.6
—	Unimproved or None	/	63.6	/	36.4

*In Afghanistan, only results ≥ 0.3 mg/L were able to be counted as ≥ 0.2 mg/L (see: **Water Quality Methods**).

Of the HCFs with water available to test, about 21% of HCFs in each country had *E. coli* detected in one or more water samples. In Uganda, about 7% of the HCFs did not have any water to test (**Fig. 5**).

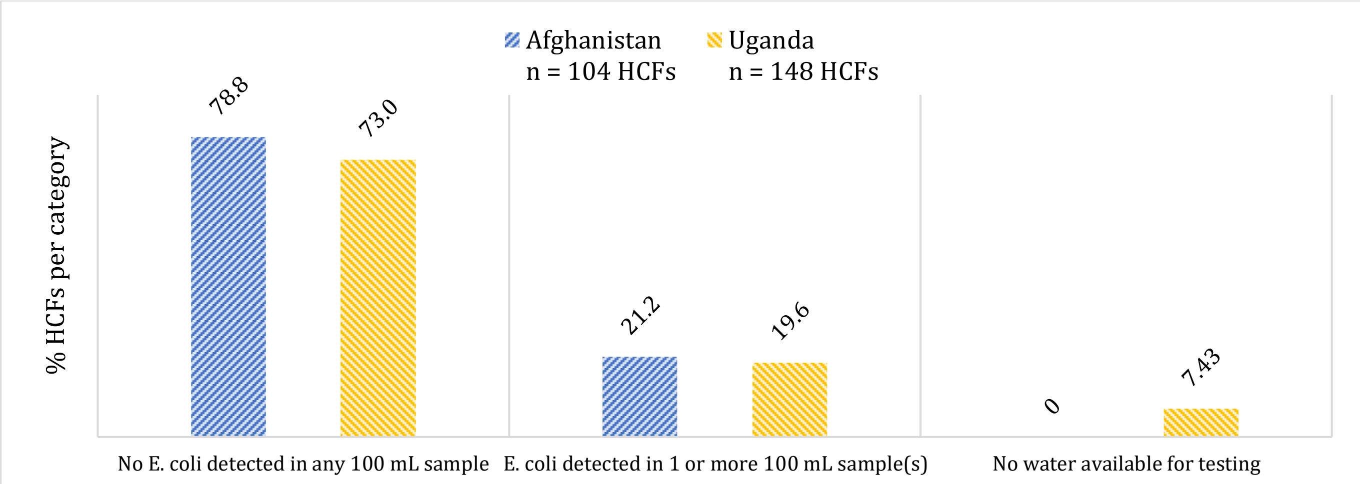


Figure 5. *Percentages of HCFs with and without E. coli detected in water samples, and without water available for analyses*

Between 36% and 64% of HCFs with unimproved main water sources had one or more water samples with ≥ 1 *E. coli* / 100mL (**Fig. 6**).

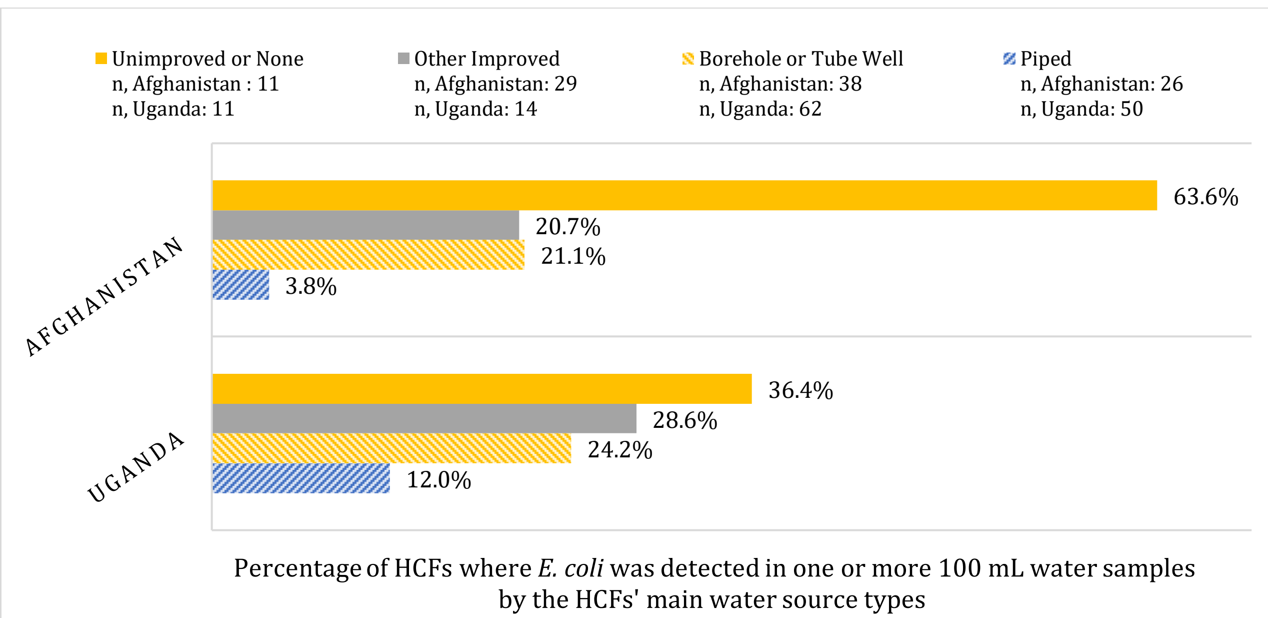


Figure 6. *Percentages of HCFs with E. coli detected in ≥ 1 water sample by HCF main water source type*

In Uganda, sample-level data about water source type was not available. We assumed that each water sample taken at an HCF was taken from the HCF's main water source or a source of the same type. In Afghanistan, however, sample-level data about the water source type was available (**Table 8**), and generally reinforced the trends observed in HCF-level data (**Fig. 6**), especially the very high rate of contamination in water from unimproved sources.

Table 8. *Water samples with E. coli detected by sampled water source type (Afghanistan only)*

Afghanistan only: sample-level results	Water Samples n	Water Samples with ≥ 1 *E. coli* / 100 mL n (%)
All	190	33 (17.4)
By Sampled Water Source Type:		
Improved: Piped	39	3 (7.7)
Improved: Borehole or Tube Well	112	11 (9.8)
Improved: Other	17	3 (17.7)
Unimproved or None	22	16 (72.7)

Of the 466 water samples evaluated from HCFs in both countries for this study, nearly 6% of water samples collected from HCFs in Afghanistan and more than 2% of water samples collected from HCFs in Uganda fell into the WHO's highest-risk category of microbial water quality, with ≥ 100 *E. coli* (MPN or CFU) per 100 mL (**Fig. 7**).[11]

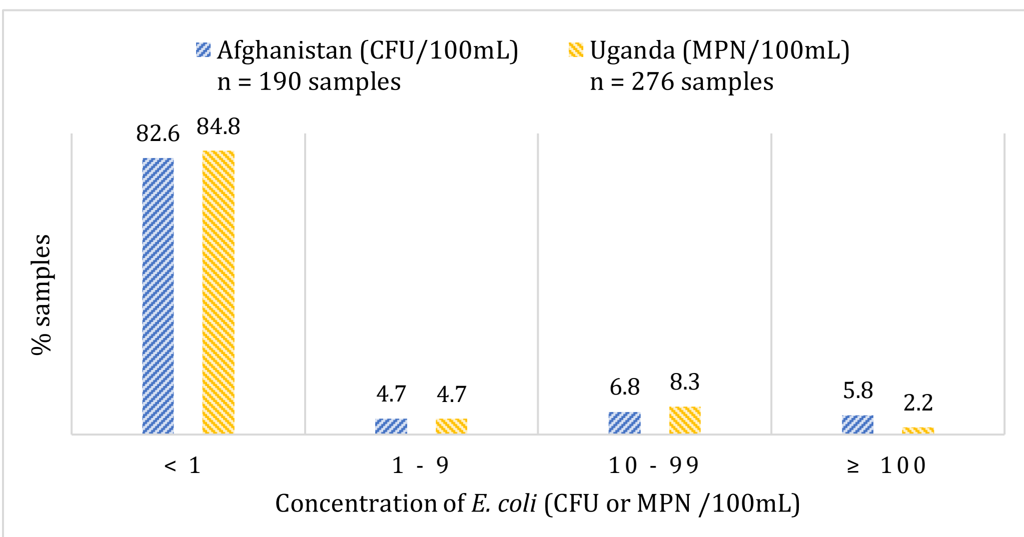


Figure 7. *Concentrations of E. coli in individual water samples taken from HCFs by country*

We also explored the relationship between the concentrations of free chlorine (mg/L) and *E. coli* (MPN or CFU/100mL) detected in each 100mL water sample by country (**Fig 8.**).

11 Results are shown in either CFU/100mL or MPN/100mL based on the testing methods used by country.

In Uganda, there was no free chlorine detected in any of the 42 water samples that tested positive for *E. coli* (≥ 1 MPN/100mL). (It is possible that some of these samples were not tested for chlorine: enumerators in Uganda did not test any water samples for free chlorine at HCFs where staff did not believe they had access to chlorinated water.) In Afghanistan, 9 of the 33 water samples that tested positive for *E. coli* (≥ 1 CFU / 100mL) also tested positive for free chlorine ≥ 0.1 mg/L (**Fig. 8**).

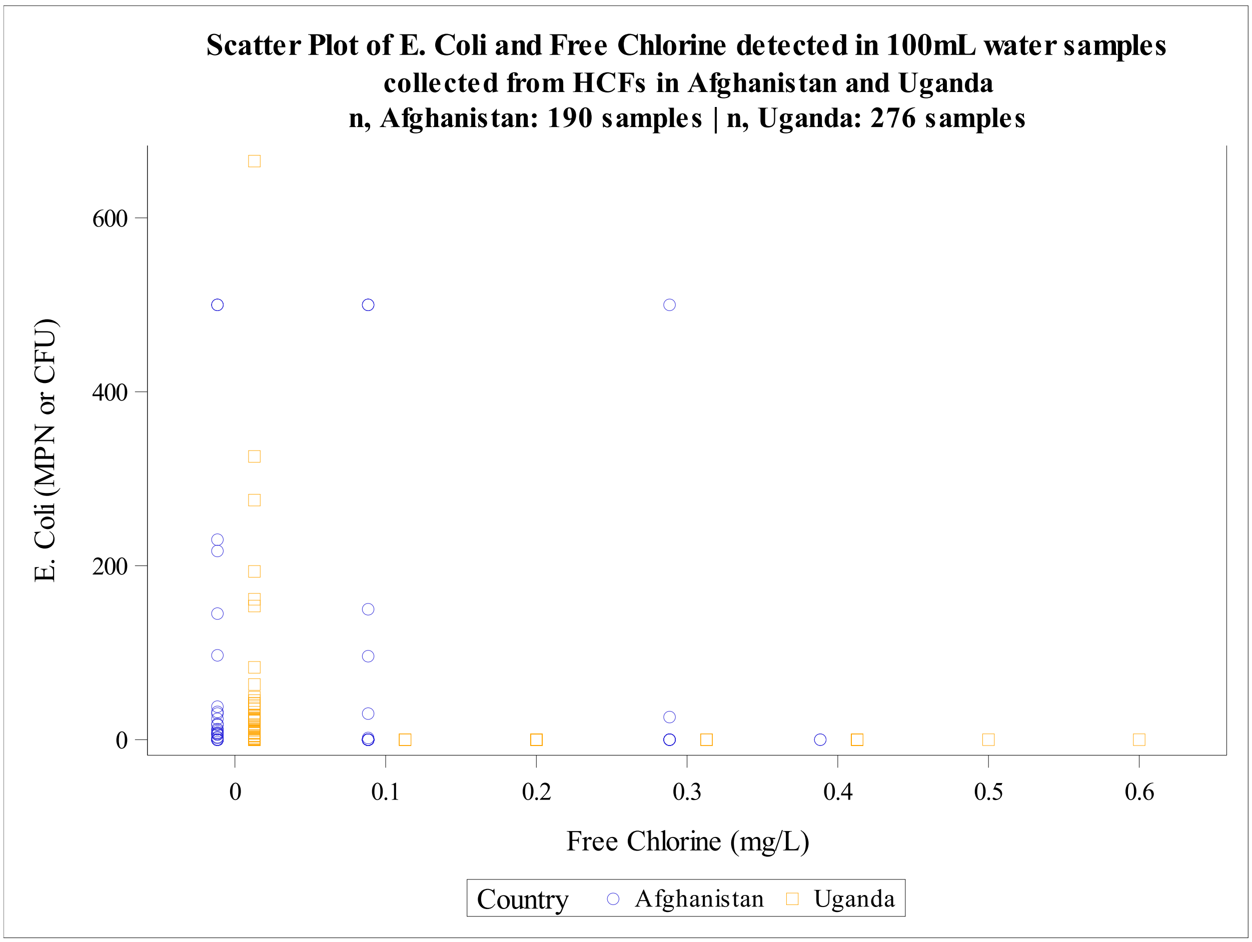


Figure 8. *Relationship between free chlorine and E. coli detected in 100 mL water samples from HCFs in Afghanistan and Uganda*

After reviewing the descriptive results, four key outcomes were analyzed against a set of independent predictor variables to identify factors associated with variation in these four outcomes. Of the four key indicators chosen for analysis, three were related to WASH access (**Table 6**) and one was related to water quality (**Table 7**).

3.1.3. Predictor Variables Tested in Analytic Modeling

Descriptive statistics were calculated for all variables that were tested as potential predictors in analytical models (**Tables 9-10). Table 9** outlines descriptive statistics for categorical predictor variables. For binary variables with yes/no levels, only 'yes' is reported unless otherwise indicated.

Many of the demographic variables exhibited imbalanced frequencies in one or both countries. About 10% of HCFs assessed in Uganda and 18% of HCFs assessed in Afghanistan were classified as being located in an urban setting. About 17% of HCFs assessed in Uganda and 36% in Afghanistan provided high levels of care, with the remainder classified as providing low levels of care. Inpatient services were only available at about 28% of Afghan HCFs assessed, but were available at nearly 96% of Ugandan HCFs assessed. Generally, these frequencies indicate that our sample of HCFs in Uganda was slightly more homogenous, with higher proportions of HCFs tending to cluster together in one level of a given variable, leaving low sample sizes for the other level(s) of these variables. A notable exception is ownership, where the Afghanistan sample was more homogenous: about 21% of HCFs assessed in Uganda were under private ownership, compared with 0% of HCFs assessed in Afghanistan.

Table 9. *Descriptive statistics for categorical predictor variables by country*

Predictor	Afghanistan HCF n	Afghanistan %	Uganda HCF n	Uganda %
Subregion	104		148	
Badghis	104	26.9		
Ghor	104	22.1		
Herat	104	51.0		
Karamoja			148	33.1
West Nile			148	66.9
Geographic Setting	104		148	
Rural	104	81.7	148	90.5
Urban	104	18.3	148	9.5
Ownership *	104		147	
Private	104	0.0	147	21.1
Public	104	100.0	147	78.9
Level of Care	104		148	
Low	104	64.4	148	83.1
High	104	35.6	148	16.9
Reliable electricity reported **	100	44.0	148	20.3
Inpatient services available	102	28.4	148	95.9
Surgical Services available	102	19.6	148	74.3
At least one MD on staff	102	72.5	148	20.9
Main Water Source Type	104		148	
Improved.: Piped	104	25.0	148	36.5
Improved.: Borehole / Tube Well	104	36.5	148	45.9
Improved.: Other	104	27.9	148	10.1
Unimproved or None	104	10.6	148	7.4
Distance to Main Water Source	104		148	
On premises	104	75.0	148	68.9
Within 500m	104	17.3	148	18.2
Off premises	104	7.7	148	9.64
Unknown	104	0.0	148	3.38
JMP Service Level	104		148	
Basic Service	104	70.2	148	60.1
Limited Service	104	13.5	148	20.9
No Service	104	16.3	148	18.9
Basic Water Service not attained	104	29.8	148	39.9
Water reported chlorinated	100	37.0	140	37.1
Water reported chlorinated onsite	100	32.0	140	8.6

*All facilities in Afghanistan were public, so the ownership variable was not included as a predictor in Afghanistan models.
** For this study, electricity was designated “unreliable” if an HCF reported that its electricity had been interrupted for more than 2 hours at a time on at least “several” days in the month immediately prior to the survey.

Table 10 shows the descriptive statistics for continuous and discrete predictor variables, including each variable's mean, median, and standard deviation.

Table 10. *Descriptive statistics for continuous and discrete predictor variables by country*

	Afghanistan				Uganda			
Predictor	HCF n	Mean	Median	Std. Dev.	HCF n	Mean	Median	Std. Dev.
Water Use per Day (L)	98	4,475	500	16,353	148	1,162	200	4,281
Water Storage Capacity (L)	104	2,666	1,000	4,878	134	33,328	10,000	178,607
Water Samples at HCF with Free Chlorine ≥ 0.1 mg/L (%)	104	57	67	44	128	15	0	32
Outpatients per Month	102	2,136	1,500	2,286	148	1,457	1,112	1,720
Inpatients per Month	102	118	0	499	148	175	68	402
Total Patients per Month	102	2,254	1,500	2,410	148	1,633	1,209	1,952
Surgeries per Month	102	29	0	209	148	23	0	100
Deliveries per Month	102	61	10	300	148	43	27	75
C-Sections per Month	102	5	0	30	148	3	0	15
Clinical Staff	102	14	6	51	148	18	10	31
MD Staff	102	5	1	30	148	1	0	2
Nonclinical Staff	102	11	5	37	148	7	5	5
Cleaning Staff	102	4	2	16	148	3	2	2
Total Staff	102	25	9	87	148	24	15	33
Inpatient Beds	102	13	0	66	148	33	19	46
Wards Observed per HCF	102	5	4	3	148	3	3	1
Samples Tested per HCF	104	2	2	1	137	2	2	1

3.2. Analytic Results

3.2.1. Access to Basic Water Service (RQ 1.01)

A greater percentage of HCFs in Afghanistan achieved basic water service than in Uganda (70.2% vs. 60.1%, respectively: **Table 6**). When testing which factors were associated with an HCF's access to basic water service, the adjusted significance level for variables to remain in the multivariable model was $p < 0.2$, with a few exceptions (footnotes, **Table 11**).

3.2.1.1. Predictors of basic water service in Afghanistan

In Afghanistan, univariable analysis of the determinants of basic water service indicated that many factors were positively associated with basic water service coverage: having reliable electricity, providing inpatient or surgical services, having at least one medical doctor (MD) on staff, having higher water storage capacity, and being located in Herat province were all significant predictors of an HCF having basic water service (**Table 11**). Four factors remained in the multivariable model – subregion, setting, level of care, and inpatient services – but only the availability of inpatient services remained a significant predictor at the 95% confidence level. After adjusting for the other three factors that remained in the multivariable model, HCFs that provided inpatient services had 6 times higher odds of having basic water service than HCFs without inpatient services, though the confidence interval was relatively wide (aOR 6.251, 95% CL 1.062-45.912).

Geographic setting and level of care were included in the model because they had been identified as significant determinants of basic water service in prior research among HCFs in other LMICs (Cronk, 2018), so the SAS software was instructed to retain them regardless of their adjusted significance levels. Had we not "forced" their inclusion, both would have exited the multivariable model, as their significance levels were both $p > 0.2$. There was some evidence that subregion was a relevant predictor, especially for Ghor province, though its effect after adjusting for the other three modeled variables did not quite reach significance with 95% confidence (aOR Ghor vs. Herat 0.296, 95% CL 0.084-1.019). Subregion was initially suspected to be an effect modifier, but tested interaction terms between subregion and other modeled variables were not significant.

3.2.1.2. Predictors of basic water service in Uganda

In Uganda, only one variable was significantly associated with basic water service in univariable analysis (number of non-clinical staff), but after controlling for opposite-direction effects in multivariable analyses, four variables were significantly predictive of basic water service coverage: ownership (i.e., whether the HCF was a public government HCF or private HCF), level of care, geographic setting, and average daily water use (**Table 11**). After adjusting for the effects of the other modeled variables, private HCFs were 3 times more likely than public HCFs to have basic water service (aOR 3.035, 95% CL 1.194-8.739). HCFs at the "High" level of care were almost 4.6 times more likely than HCFs at the "Low" level of care to have basic water service (aOR 4.594, 95% CL: 1.425-18.719). Interestingly, though the effect size was small, HCFs that reported using more water were significantly less likely to have basic water service than those that reported using less water, after adjusting for the effects of ownership, level of care, and setting. For each additional 100 liters (L) of average water use per day reported, odds of basic water service dropped by about 1.2% (aOR 0.988, 95% CL: 0.961, 0.995). The variable for water use may in effect be standing in as a measure of the HCF's size: the number of outpatients per month at a given HCF was included in the multivariable model as a direct measure of an HCF's size, but this factor exited the model as it did not reach the significance threshold of $p < 0.2$.

Unexpectedly, rural HCFs were more likely than urban HCFs in Uganda to have basic water service after controlling for ownership, level of care, and water use (aOR:0.263, 95% CL: 0.065, 0.977). This association was explored further by examining the three components that comprise basic water service: improved source, on premises, and water available at the time of the survey. Testing associations between those three factors and geographic setting in Uganda revealed that the 'on premises' criterion of the JMP definition was not met by 43% of the urban HCFs. Urban HCFs were slightly more likely than rural HCFs to have an improved source and to have water available at the time of the survey, although these differences were not significant. Urban HCFs were less likely than rural HCFs to meet the "on-premises" portion of the criteria for basic water service.

The SAS software was instructed to include the variables for geographic setting, ownership, and level of care regardless of their significance levels because the effects of these variables had been identified in prior research as significant determinants of basic water service (Cronk, 2018). However, in Uganda, all three were significant at $p < 0.05$ and would have remained in the model even without intervention.

Table 11. *Crude and adjusted odds ratios (OR) of having* ***access to Basic Water Service*** *at HCFs in Afghanistan and Uganda*

Country Models: **Basic Water Service** 12	Afghanistan HCF n	Crude OR (95% CL)	HCF n	Adjusted OR 13 (95% CL)	*p*	Uganda HCF n	Crude OR (95% CL)	HCF n	Adjusted OR 14 (95% CL)	*p*
Sub-Region										
Badghis (vs. Herat)	**104**	**0.237 (0.079, 0.673)**	98	0.400 (0.121, 1.288)	0.1240	/	/	/	/	/
Ghor (vs. Herat)	**104**	**0.194 (0.061, 0.579)**	98	0.296 (0.084, 1.019)	0.0535	/	/	/	/	/
Karamoja (vs. West Nile)	/	/	/	/	/	148	0.942 (0.470, 1.908)	147	--	--
Setting: Urban	104	1.746 (0.570, 6.566)	98	0.671 (0.129, 3.560)	0.6294	148	0.634 (0.206, 1.952)	**147**	**0.263 (0.065, 0.977)**	**0.0461 ***
Ownership: Private	/	/	/	/	/	147	2.178 (0.930, 5.565)	**147**	**3.035 (1.194, 8.739)**	**0.0187 ***
Level of Care: High	104	1.521 (0.627, 3.912)	98	0.526 (0.099, 2.589)	0.4296	148	1.883 (0.760, 5.145)	147	**4.594 (1.425, 18.719)**	**0.0092 ***
Reliable Electricity: Yes	**100**	**2.500 (1.003, 6.713)**	98	--	--	148	0.993 (0.441, 2.295)	147	--	--
Inpatient Services: Available	**102**	**5.087 (1.595, 22.738)**	**98**	**6.251 (1.062, 45.912)**	**0.0425 ***	148	3.164 (0.597, 23.366)	/	/	/
Surgical Services: Available	**102**	**10.393 (1.994, 191.423)**	/	/	/	148	1.750 (0.829, 3.707)	/	/	/
At least one MD on staff: Yes	**102**	**3.625 (1.444, 9.285)**	/	/	/	148	1.513 (0.668, 3.620)	/	/	/
Water Use per Day (+ 100 L)	98	1.007 (1.000, 1.026)	/	/	/	148	0.992 (0.977, 1.002)	147	**0.988 (0.969, 0.998)**	**0.0136 ***
Storage Capacity (+ 100 L)	**104**	**1.032 (1.008, 1.066)**	98	--	--	134	1.000 (1.000, 1.001)	/	/	/
Outpatients per Month (+ 100)	102	1.010 (0.990, 1.035)	/	/	/	148	0.986 (0.962, 1.005)	147	--	--
Inpatients per Month (+ 100)	102	1.082 (0.962, 1.433)	98	--	--	148	1.028 (0.944, 1.164)	/	/	/
Total Patients per Month (+ 100)	102	1.011 (0.992, 1.036)	/	/	/	148	0.990 (0.971, 1.007)	/	/	/

12 For Basic water service multivariable modeling, SAS software was instructed to include the following variables regardless of their significance: geographic setting, ownership (applicable in Uganda only), and level of care. These were significant determinants of basic water service in prior research in six LMICs (Cronk, 2018). For all other variables, the significance level required to stay in the model remained p < 0.2.
13 Adjusted Odds Ratios (aORs) in **Afghanistan** are adjusted for: subregion, geographic setting, level of care, and availability of inpatient services. Two of these (geographic setting and level of care) remained in the model only because the SAS software was instructed to include them.
14 Adjusted Odds Ratios (aORs) in **Uganda** are adjusted for: geographic setting, ownership, level of care, and average reported water use per day.

Country Models: **Basic Water Service** [12]	Afghanistan					Uganda				
	HCF n	Crude OR (95% CL)	HC F n	Adjusted OR [13] (95% CL)	*p*	HCF n	Crude OR (95% CL)	HCF n	Adjusted OR [14] (95% CL)	*p*
Surgeries per Month (+ 10)	102	1.112 (0.992, 1.550)	/	/	/	148	1.011 (0.977, 1.071)	/	/	/
Deliveries per Month (+ 10)	102	1.050 (0.995, 1.180)	/	/	/	148	1.007 (0.963, 1.006)	/	/	/
C-Sections per Month (+ 1)	102	1.115 (0.999, 1.499)	/	/	/	148	0.993 (0.967, 1.016)	/	/	/
Clinical Staff (+ 1)	102	1.014 (0.996, 1.068)	/	/	/	148	0.999 (0.988, 1.011)	/	/	/
MD Staff (+1)	102	1.136 (0.996, 1.533)	/	/	/	148	0.975 (0.802, 1.193)	/	/	/
Nonclinical Staff (+1)	102	1.004 (0.992, 1.039)	/	/	/	**148**	**1.089 (1.015, 1.184)**	**/**	**/**	**/**
Cleaning Staff (+ 1)	102	1.000 (0.980, 1.075)	/	/	/	148	1.136 (0.969, 1.373)	/	/	/
Total Staff (+ 1)	102	1.004 (0.997, 1.027)	/	/	/	148	1.001 (0.991, 1.013)	/	/	/
Inpatient Beds (+10)	102	1.126 (0.971, 1.687)	/	/	/	148	1.016 (0.945, 1.102)	/	/	/

3.2.2. **Access to a Functional Hand Hygiene Facility at ≥ 1 Point of Care (RQ 1.02)**

The WASHCon observation form for wards (points of care) required enumerators to look for a "functional hand hygiene facility" in each studied ward and mark which materials were present (full text of the ward observation form: **Appendix C.**). For this study, a "functional hand hygiene facility" required the presence of soap and water (together), or hand sanitizer, or both. Functionality requirements were not specifically defined in the form, but the form asked enumerators to observe a "functional" hand hygiene facility, and the field supervisors instructed the enumerators to turn on the taps and verify that there was running water at each sink.

About 86% of HCFs in Afghanistan and 74% of HCFs in Uganda were observed to have functional hand hygiene facilities located at one or more points of care. In the univariable analyses in both countries, increasing the number of wards assessed at an HCF was a significant predictor of increased odds of finding at least one functional hand hygiene facility at that HCF. Given this result, the multivariable models for both countries were set to include the number of wards observed as a predictor, regardless of significance level, to ensure that the final results would be adjusted for the number of opportunities an HCF was given to demonstrate a functional hand hygiene station. In fact, this variable was significant in the models for both countries, and would have remained in both multivariable models even without this forced inclusion.

3.2.2.1. Predictors of access to a hand hygiene facility in Afghanistan

In the multivariable analysis, three factors remained in the model, and two factors were significantly predictive of an HCF having access to hand hygiene facilities at ≥ 1 point of care with 95% confidence: subregion, and the presence of at least one MD at the HCF (**Table 12**).

HCFs with at least one MD on staff were greater than 5 times more likely than HCFs with no MDs on staff to have hand hygiene access at one or more points of care (aOR 5.343, 95% CL 1.247-26.235) after adjusting for subregion and the number of wards observed. HCFs in Badghis had only about 17% the odds of HCFs in Herat of having access to hand hygiene at one or more points of care (aOR 0.166, 95% CL 0.021-0.914), after adjusting for the presence of an MD on staff and the number of wards observed.

Many variables that had appeared significant in univariable analysis were included in the multivariable model but failed to meet the $p < 0.2$ threshold to remain. High level of care, increased water storage capacity, increased numbers of outpatients per month, and increased numbers of MD staff were all significant predictors of access to hand hygiene facilities in Afghan HCFs in univariable analyses, but all were rendered insignificant after controlling for the number of wards observed, presence of at least one MD, and subregion.

3.2.2.2. Predictors of access to a hand hygiene facility in Uganda

In Uganda, multivariable analysis revealed three predictors of access to hand hygiene at ≥ 1 point of care that were significant at the 95% confidence level: number of outpatients per month, ownership, and subregion (**Table 12**). Number of wards observed also remained in the multivariable model and was a significant predictor at the 90% confidence level.

For each additional 100 outpatients an HCF reported seeing in an average month, its odds of having at least one functional hand hygiene station at a point of care rose by nearly 21% after controlling for the effects of ownership, subregion, and the number of wards observed (aOR 1.205, 95% CL 1.086-1.360). HCFs in Karamoja had only 16% the odds of HCFs in West Nile of having a hand hygiene station observed, after controlling for the effects of ownership, number of outpatients per month, and number of wards observed (aOR 0.159, 95% CL

0.063-0.381). Finally, privately-owned HCFs were 5 times more likely than public HCFs to have a functional hand hygiene station in at least one point of care, after adjusting for the effects of the other modeled factors, though the confidence interval for this effect was relatively wide (aOR 5.371, 95% CL:1.554, 21.469).

Table 12. *Crude and adjusted odds ratios (OR) of a functional* ***hand hygiene facility observed*** *at one or more points of care at HCFs in Afghanistan and Uganda*

Country Models: **Hand Hygiene Facility Observed at ≥ One Point of Care** [15]	Afghanistan HCF n	Afghanistan Crude OR (95% CL)	Afghanistan HCF n	Afghanistan Adjusted OR [16] (95% CL)	Afghanistan *p*	Uganda HC F n	Uganda Crude OR (95% CL)	Uganda HCF n	Uganda Adjusted OR [17] (95% CL)	Uganda *p*
Sub-Region										
Badghis (vs. Herat)	102	0.074 (0.011, 0.321)	100	**0.166 (0.021, 0.914)**	**0.0389 ***	/	/	/	/	/
Ghor (vs. Herat)	102	0.261 (0.033, 1,688)	100	0.339 (0.027, 3.438)	0.3604	/	/	/	/	/
Karamoja (vs. West Nile)	/	/	/	/	/	148	0.158 (0.070, 0.345)	147	**0.159 (0.063, 0.381)**	**<.0001 ****
Setting: Urban	102	*quasi-complete data separation*	/	/	/	148	1.347 (0.394, 6.202)	/	/	/
Ownership: Private	/	/	/	/	/	147	1.657 (0.656, 4.784)	147	**5.371 (1.554, 21.469)**	**0.0070 ****
Level of Care: High	102	**8.997 (1.677, 167.055)**	100	--	--	148	3.034 (0.973, 13.377)	147	--	--
Reliable Electricity: Yes	99	1.526 (0.485, 5.318)	/	/	/	148	1.223 (0.497, 3.328)	/	/	/
Inpatient Services: Available	102	**6.276 (1.159, 116.807)**	/	/	/	148	0.547 (0.028, 3.539)	/	/	/
Surgical Services: Available	100	1.588 (0.386, 10.794)	/	/	/	148	**2.751 (1.241, 6.090)**	147	--	--
At least one MD on staff: Yes	100	**10.147 (3.010, 40.772)**	100	**5.343 (1.247, 26.235)**	**0.0236 ***	148	**2.881 (1.031, 10.282)**	147	--	--
Water Use per Day (+ 100 L)	96	1.104 (0.999, 1.063)	/	/	/	148	**1.093 (1.017, 1.275)**	147	**--**	**--**
Storage Capacity (+ 100 L)	102	**1.0880 (1.019, 1.181)**	100	--	--	134	1.001 (1.000, 1.004)	/	/	/
Outpatients per Month (+ 100)	100	**1.061 (1.012, 1.133)**	100	--	--	148	**1.125 (1.052, 1.218)**	147	**1.205 (1.086, 1.360)**	**<.0001 ****
Inpatients per Month (+ 100)	100	1.492 (0.962, 12.246)	/	/	/	148	**2.060 (1.307, 3.810)**	147	--	--
Total Patients per Month (+ 100)	100	**1.066 (1.016, 1.139)**	/	/	/	148	**1.126 (1.055, 1.216)**	/	/	/

[15] For modeling access to a functional hand hygiene station, SAS software was instructed to include the variable for 'Number of Wards Observed' in the multivariable model regardless of its significance level to control for the fact that some HCFs that had more points of care observed than others. For all other variables, the significance level required to stay in the model remained p < 0.2.
[16] Adjusted Odds Ratios (aORs) in **Afghanistan** are adjusted for: number of wards observed, subregion, and presence of at least one MD on staff.
[17] Adjusted Odds Ratios (aORs) in **Uganda** are adjusted for: number of wards observed, subregion, ownership, and number of outpatients seen per month.

Country Models: **Hand Hygiene Facility Observed at ≥ One Point of Care** [15]	Afghanistan HCF n	Afghanistan Crude OR (95% CL)	Afghanistan HCF n	Afghanistan Adjusted OR [16] (95% CL)	Afghanistan *p*	Uganda HC F n	Uganda Crude OR (95% CL)	Uganda HCF n	Uganda Adjusted OR [17] (95% CL)	Uganda *p*
Surgeries per Month (+ 10)	100	1.403 (0.990, 5.346)	/	/	/	148	**1.284 (1.030, 1.908)**	/	/	/
Deliveries per Month (+ 10)	100	**1.364 (1.017, 2.599)**	/	/	/	148	**1.161 (1.020, 1.381)**	/	/	/
C-Sections per Month (+ 1)	100	1.172 (0.993, 2.684)	/	/	/	148	**1.113 (1.006, 1.547)**	/	/	/
Clinical Staff (+ 1)	100	1.073 (0.997, 1.238)	/	/	/	148	**1.036 (1.003, 1.093)**	/	/	/
MD Staff (+1)	100	**4.719 (1.917, 14.814)**	100	--	--	148	**1.569 (1.053, 3.081)**	/	/	/
Nonclinical Staff (+1)	100	**1.171 (1.002, 1.475)**	/	/	/	148	1.059 (0.983, 1.161)	/	/	/
Cleaning Staff (+ 1)	100	1.342 (0.990, 2.623)	/	/	/	148	1.020 (0.871, 1.228)	/	/	/
Total Staff (+ 1)	100	1.071 (1.000, 1.196)	/	/	/	148	**1.026 (1.003, 1.065)**	/	/	/
Inpatient Beds (+10)	100	2.206 (0.984, 29.140)	/	/	/	148	**1.225 (1.041, 1.576)**	/	/	/
Wards Observed (+1)	102	**1.517 (1.136, 2.160)**	100	1.387 (0.948, 2.290)	0.1073	148	**1.554 (1.045, 2.394)**	147	1.565 (0.945, 2.681)	0.0825

3.2.3. **Access to the Six Cleans for Safe Delivery (RQ 1.03)**

About 21% of HCFs assessed in Afghanistan and 33% of HCFs assessed in Uganda had L&D wards where all of the Six Cleans required for safe delivery were observed. Of the Six Cleans – hands, delivery surface, blade, cord or tie, and towels (counting twice, for the mother and for the baby) – towels were a limiting factor in both countries, with only 31% of L&D wards observed in Afghanistan having clean towels, and 61% in Uganda. Access to a functional hand hygiene facility in the L&D ward was another limiting factor in Uganda at around 60% coverage, but all other factors had coverage rates of 75% or greater in Uganda. In Afghanistan, only 56% of L&D wards had a clean cord or tie, 58% had a clean delivery surface, and 61% had a clean blade. Access to a hand hygiene facility (the infrastructure needed for 'clean hands') had the highest coverage rate of all Six Cleans in Afghanistan (74%) and had the lowest coverage rate of all Six Cleans in Uganda (59%).

3.2.3.1. Predictors of Six Cleans access in Afghanistan

In Afghanistan, having access to reliable electricity was a significant predictor of access to the Six Cleans (aOR: 2.999, 95% CL: 1.005, 9.815), after adjusting for the number of surgeries performed at the HCF per month (**Table 13**). The odds of Six Cleans access also improved as the number of surgeries per month increased (aOR per each additional 10 surgeries/month was 1.176, 95% CL 1.003-1.463), after adjusting for whether or not the HCF had reliable electricity. Urban versus rural setting, which had been significant in univariable analysis, dropped out of the model in multivariable analysis as it did not meet the $p < 0.2$ threshold to remain. Subregion was not included in the multivariable model due to quasi-complete separation of data points observed in univariable analysis. This particular warning, "quasi-complete separation of data points," indicates that the outcome variable has separated the predictor variable almost completely, preventing a determination of the maximum likelihood estimate for this variable. (In this case, the message appeared because one subregion, Badghis, had zero HCFs with access to all Six Cleans.) Although we could not include subregion in the multivariable model, this warning implies that subregion might be a statistically significant predictor if we had a larger data set with enough variation to enable the logistic regression model to make accurate predictions.

3.2.3.2. Predictors of Six Cleans access in Uganda

Three factors remained in Uganda's multivariable model, two of which were significantly associated with Six Cleans access at the 95% confidence level, although these associations were significant in opposite directions (**Table 13**). For each additional 100 inpatients seen per month, adjusted odds of Six Cleans access rose by 45% (aOR 1.447, 95% CL 1.081-2.201). But for each additional 10 deliveries per month, adjusted odds of Six Cleans access fell by about 14% (aOR 0.861, 95% CL 0.727-0.976) after controlling for the effects of the other two modeled variables. Subregion was the third effect that remained in the multivariable model. It had been a significant predictor of Six Cleans access in univariable analysis – HCFs in Karamoja had significantly lower crude odds of Six Cleans access than HCFs in West Nile – but it did not quite reach 95% significance after adjusting for the number of inpatients per month and the number of deliveries per month (aOR Karamoja vs. West Nile 0.446, 95% CL 0.169, 1.094).

Table 13. *Crude and adjusted odds ratios (OR) of* ***access to the Six Cleans for safe delivery*** *at HCFs in Afghanistan and Uganda*

Country Models: **Six Cleans Access**	**Afghanistan**					**Uganda**				
	HCF n	Crude OR (95% CL)	HCF n	Adjusted OR [18] (95% CL)	*P*	HCF n	Crude OR (95% CL)	HCF n	Adjusted OR [19] (95% CL)	*p*
Sub-Region										
Badghis (vs. Herat)	96	*quasi-complete data separation*	/	/	/	/	/	/	/	/
Ghor (vs. Herat)	96	0.964 (0.297, 2.892)	/	/	/	/	/	/	/	/
Karamoja (vs. West Nile)	/	/	/	/	/	127	**0.354 (0.144, 0.805)**	114	0.446 (0.169, 1.094)	0.0785
Setting: Urban	96	**3.643 (1.057, 12.214)**	91	--	--	127	1.301 (0.371, 4.175)	114	--	--
Ownership: Private	/	/	/	/	/	127	1.383 (0.528, 3.485)	114	--	--
Level of Care: High	96	1.885 (0.677, 5.184)	91	--	--	127	0.620 (0.210, 1.627)	114	--	--
Reliable Electricity: Yes	93	**3.357 (1.169, 10.587)**	**91**	**2.999 (1.005, 9.815)**	**0.0489 ***	127	0.650 (0.236, 1.627)	/	/	/
Inpatient Services: Available	94	2.074 (0.714, 5.852	91	--	--	127	0.488 (0.019, 12.539)	/	/	/
Surgical Services: Available	94	1.429 (0.411, 4.422)	/	/	/	127	2.203 (0.903, 5.981)	114	--	--
At least one MD on staff: Yes	94	1.804 (0.584, 6.827)	/	/	/	127	0.886 (0.350, 2.117)	/	/	/
Water Use per Day (+ 100 L)	94	1.000 (1.000, 1.000)	/	/	/	127	0.999 (0.998, 1.007)	/	/	/
Storage Capacity (+ 100 L)	96	1.003 (0.987, 1.017)	/	/	/	114	**1.001 (1.000, 1.004)**	114	--	--
Outpatients per Month (+ 100)	94	1.015 (0.996, 1.036)	/	/	/	127	1.005 (0.984, 1.026)	/	/	/
Inpatients per Month (+ 100)	94	1.032 (0.934, 1.133)	/	/	/	127	1.078 (0.985, 1.231)	**114**	**1.447 (1.081, 2.201)**	**0.0036 ****
Total Patients per Month (+ 100)	94	1.015 (0.997, 1.035)	91	--	--	127	1.007 (0.989, 1.026)	/	/	/
Surgeries per Month (+ 10)	**94**	**1.161 (1.004, 1.441)**	**91**	**1.176 (1.003, 1.463)**	**0.0310 ***	127	0.995 (0.943, 1.030)	/	/	/

18 Adjusted Odds Ratios (aORs) in **Afghanistan** are adjusted for the presence of reliable electricity and the number of surgeries per month.
19 Adjusted Odds Ratios (aORs) in **Uganda** are adjusted for subregion, the number of inpatients seen per month, and the number of deliveries per month.

Country Models: **Six Cleans Access**	**Afghanistan**					**Uganda**				
	HCF n	Crude OR (95% CL)	HCF n	Adjusted OR [18] (95% CL)	*P*	HCF n	Crude OR (95% CL)	HCF n	Adjusted OR [19] (95% CL)	*p*
Deliveries per Month (+ 10)	**94**	**1.049 (1.002, 1.130)**	/	/	/	127	0.990 (0.925, 1.037)	**114**	**0.861 (0.727, 0.976)**	**0.0116 ***
C-Sections per Month (+ 1)	**94**	**1.032 (1.001, 1.102)**	/	/	/	127	1.005 (0.980, 1.029)	/	/	/
Clinical Staff (+ 1)	**94**	**1.030 (1.003, 1.079)**	/	/	/	127	1.000 (0.986, 1.011)	/	/	/
MD Staff (+1)	**94**	**1.151 (1.002, 1.440)**	/	/	/	127	1.020 (0.819, 1.240)	/	/	/
Nonclinical Staff (+1)	**94**	**1.023 (1.001, 1.076)**	/	/	/	127	1.023 (0.958, 1.090)	/	/	/
Cleaning Staff (+ 1)	**94**	**1.046 (1.004, 1.140)**	/	/	/	127	1.033 (0.879, 1.203)	/	/	/
Total Staff (+ 1)	**94**	**1.014 (1.001, 1.041)**	/	/	/	127	1.000 (0.988, 1.010)	/	/	/
Inpatient Beds (+10)	94	**1.143 (1.002, 1.503)**	/	/	/	127	1.031 (0.956, 1.110)	/	/	/

3.2.4. **Detection of *E. coli* in HCF Water Samples (RQ 2.01)**

About 21% of the HCFs assessed in each country had detectable *E. coli* in at least one water sample. In Afghanistan, 67% of the HCFs assessed had free chlorine (≥ 0.1 mg/L) detected in at least one water sample. In Uganda, this figure was only 21% among the studied HCFs with water available to test. However, in Uganda, 19% of studied HCFs with water available to test had at least one water sample that met the WHO standard for free chlorine (≥ 0.2 mg/L), compared with only 7% of HCFs assessed in Afghanistan.

This water quality-related regression model engages a number of water quality-specific predictors, including the HCF's main water source type, distance to the main water source, and both reported and observed measures of water chlorination, in addition to the predictors used in the access-related models. To assess the relationship between *E. coli* detection and free chlorine detection at the HCF level, we introduced a continuous variable describing the percentage of water samples at a given HCF where ≥ 0.1 mg/L of free chlorine was detected, ranging from 0% to 100% of that HCF's samples. To ensure that these models were not biased in favor of HCFs with fewer water samples taken (i.e., HCFs with fewer opportunities for *E. coli* detection), we set the models in both Afghanistan and Uganda to always adjust for the number of samples tested per HCF regardless of that factor's significance.

3.2.4.1. Predictors of *E. coli* detection in HCF water samples in Afghanistan

The strongest predictor of *E. coli* detection in one or more 100mL water samples at an HCF was the HCF's main water source type (**Table 14**). HCFs with boreholes or tube wells as their main water sources were >15 times more likely to have detectable *E. coli* in one or more water samples compared with HCFs that had piped main water sources (aOR 15.100, 95% CL 1.842-347.597), an effect that was significant with 99.99% confidence after adjusting for the effects of other modeled factors. HCFs with unimproved main water sources were 24 times more likely than HCFs with piped main water sources to have detectable *E. coli* in one or more water samples (aOR 24.074, 95% CL 1.591, 792.116), after controlling for the effects of the other modeled factors. Despite the statistical significance of these estimates, their confidence intervals were exceptionally wide, signaling high variability in the data.

The percentage of water samples at a given HCF with ≥ 0.1 mg/L free chlorine detected was another robust predictor of *E. coli* detection in one or more water samples among HCFs assessed in Afghanistan. HCFs with higher proportions of chlorinated water samples were significantly less likely to have one or more water samples with *E. coli* detected. For each 10% increase in the proportion of water samples with free chlorine detected, an HCF's odds of having at least one water sample with *E. coli* detected dropped by more than 22% (aOR +10%: 0.778, 95% CL 0.653-0.901), after adjusting for the effects of an HCF's main water source, subregion, level of care, water storage capacity, and the number of samples tested from an HCF.

Subregion and level of care were also significant predictors of *E. coli* detection in Afghanistan. The model results indicated that the odds of detecting *E. coli* in water samples at HCFs assessed in Badghis were 8 times higher than among HCFs assessed in Herat, after adjusting for the effects of other modeled factors (aOR Badghis vs. Herat 8.197, 95% CL 1.533-57.770). The model results indicated similar trends in Ghor, but those results were not significant at the 95% confidence level (aOR Ghor vs. Herat 3.198, 95% CL 0.401-24.647). Interestingly, HCFs at high levels of care in Afghanistan were significantly more likely than

HCFs at low levels of care to have *E. coli* detected in one or more water samples (aOR 6.480, 95% CL 1.250-43.192), after adjusting for the other modeled factors. The effect of subregion, present in initial versions of the model, was strengthened after controlling for the number of samples tested at an HCF and the other modeled factors.

Increasing water storage capacity seemed to have a protective effect on water quality in terms of lowering the odds of *E. coli* detection in any one or more water samples. After controlling for the effects of the other modeled factors, the adjusted odds of *E. coli* detection in one or more HCF water samples dropped by about 4.8% for each additional 100L of storage capacity at the HCF (aOR 0.952, 95% CL 0.901-0.989).

Finally, and unsurprisingly, the odds of *E. coli* detection in at least one water sample rose as the number of samples analyzed per HCF increased. After adjusting for the effects of the other modeled variables, the odds of detecting *E. coli* were 2.1 times greater for each additional sample tested by the WASHCon team (aOR +1 sample 2.118, 95% CL 0.991, 4.807).

Distance to the main water source and geographic setting were both tested in the multivariable model, but both failed to meet the significance threshold ($p < 0.2$) to remain in the final model. The final regression results are adjusted for the effects of six predictors: HCF main water source type, percentage of HCF water samples with ≥ 0.1 mg/L free chlorine detected, subregion, level of care, water storage capacity, and the number of samples tested.

3.2.4.2. Predictors of *E. coli* detection in HCF water samples in Uganda

Among the HCFs that were assessed in Uganda, five factors were associated with variation in odds of *E. coli* detection in one or more water samples: the HCF's main water source type, subregion, ownership, level of care, and the number of samples tested. The variable for the number of samples tested remained in the model only because the software was instructed to include it; ultimately its presence or absence made very little difference to the model's results. Of the other four factors, three of these were significant at the 95% confidence level (**Table 14**): main water source, subregion, and ownership. Level of care was significant enough to remain in the model without interference, but it did not reach statistical significance with 95% confidence.

As was the case in Afghanistan, an HCF's main water source type was the strongest predictor of *E. coli* detection in one or more water samples at HCFs assessed in Uganda. HCFs with boreholes or tube wells as main water sources were greater than 4 times more likely than HCFs with piped main water sources to have *E. coli* detected in one or more 100 mL water samples (aOR 4.229, 95% CL 1.290-15.782). HCFs with "other" types of improved sources (non-piped, non-borehole/tube well) were greater than 7 times more likely to have *E. coli* contamination detected in at least one water sample than HCFs with piped main water sources (aOR 7.170, 95% CL 1.247-41.850). Interestingly, the odds of detecting *E. coli* in water samples from HCFs with unimproved main water sources were *not* significantly different than the odds of detecting *E. coli* in water samples from HCFs with piped main water sources.

Studied HCFs in the Karamoja subregion had nearly 4 times higher odds of detecting ≥1 *E. coli* in at least one 100 mL water sample compared with HCFs in the West Nile subregion (aOR 4.066, 95% CL 1.274-13.804), after adjusting for the HCF's water source type, ownership, level of care, and number of samples tested. Finally, odds of detecting *E. coli* in one or more water samples at a privately-owned HCF were only about 23% the odds of detecting *E. coli* in one or more water samples at a publicly-owned HCF (aOR: 0.232, 95% CL: 0.034-0.928) after adjusting for the other modeled factors (**Table 14**).

The adjusted odds ratios for the models with Uganda data – like for Afghanistan – suggested that HCFs at higher levels of care were more likely to have *E. coli* detected in one or more water samples compared with HCFs at lower levels of care. In Uganda, this effect was significant enough to remain in the model ($p < 0.2$), but it did not reach statistical significance with 95% confidence (aOR 3.093, 95% CL 0.689-14.911). Unlike in Afghanistan's results, in Uganda's model the proportion of water samples at an HCF with ≥0.1 mg/L free chlorine detected was not a significant predictor of *E. coli* detection in one or more water samples and did not reach the level of significance needed to remain in the multivariable model after adjusting for the effects of the other modeled factors. Distance to the main water source and storage capacity were also tested in Uganda's multivariable model but were not significant enough to remain in the model after considering the effects of other modeled factors.

The only factor to remain in Uganda's model despite not attaining the required significance level to remain ($p < 0.2$) was the variable for the number of water samples taken at each HCF. While we felt it was appropriate to ensure that the multivariable results were adjusted for the number of samples taken at an HCF regardless of the impact, the effect of this added variable on the Uganda model's predictions was minimal.

Table 14. *Crude and adjusted odds ratios (OR) of detecting* ***E. coli in one or more 100mL water samples from*** *HCFs in Afghanistan and Uganda*

Country Models: ***E. Coli*** **detected in one or more HCF water samples**[20]	Afghanistan HCF n	Afghanistan Crude OR (95% CL)	Afghanistan HCF n	Afghanistan Adjusted OR [21] (95% CL)	Afghanistan *P*	Uganda HCF n	Uganda Crude OR (95% CL)	Uganda HCF n	Uganda Adjusted OR [22] (95% CL)	Uganda *p*
Main Water Source (vs. piped)										
Borehole or tube well	**104**	**6.664 (1.113, 127.970)**	**104**	**15.100 (1.842, 347.597)**	**< .0001****	137	2.340 (0.867, 7.056)	**122**	**4.229 (1.290, 15.782)**	**0.0165***
Other improved source	**104**	**6.519 (1.009, 128.072)**	104	3.661 (0.289, 98.009)	0.3264	137	2.933 (0.650, 12.370)	**122**	**7.170 (1.247, 41.850)**	**0.0279***
Unimproved or none	**104**	**43.735 (5.796, 945.912)**	**104**	**24.074 (1.591, 792.116)**	**0.0205***	137	4.190 (0.890, 18.942)	122	3.835 (0.609, 22.809)	0.1453
Distance to Main Water Source (vs. on premises)										
Off, but within 500 m	**104**	**4.00 (1.309, 12.204)**	104	--	--	137	2.469 (0.876, 6.676)	122	--	--
Off, further than 500m	**104**	0.714 (0.037, 4.523)	104	--	--	137	1.481 (0.307, 5.507)	122	--	--
Unknown	**104**	/	/	/	/	137	3.292 (0.409, 21.445)	122	--	--
JMP Service Level (vs. Basic service)										
Limited service	104	2.255 (0.544, 8.177)	/	/	/	137	2.923 (0.957, 8.550)	/	/	/
No service	**104**	**3.945 (1.213, 12.688)**	/	/	/	137	**2.293 (1.062, 7.892)**	/	/	/
Basic Water Service: <u>not</u> attained	**104**	**3.100 (1.165, 8.341)**	/	/	/	127	**2.923 (1.267, 6.879)**	/	/	/
Water Reported Chlorinated: Yes	100	0.966 (0.349, 2.541)	/	/	/	129	1.033 (0.417, 2.460)	/	/	/
Water Reported Chlorinated Onsite: Yes	100	0.750 (0.245, 2.064)	/	/	/	129	0.318 (0.017, 1.754)	/	/	/
Percentage of Water Samples at HCF with Free Chlorine ≥ 0.1 mg/L (+10%)	**104**	**0.981 (0.968, 0.992)**	**104**	**0.778 (0.653, 0.901)**	**0.0005****	**128**	**0.976 (0.944, 0.996)**	122	--	--

[20] For modeling detection of E. coli,, SAS software was instructed to include the variable for 'Number of Samples Taken in the multivariable model regardless of its significance level to control for the fact that some HCFs that had more points of care observed than others. For all other variables, the significance level required to stay in the model remained p < 0.2.
[21] Adjusted Odds Ratios (aORs) in **Afghanistan** are adjusted for: main water source type, percentage of water samples at HCF with free chlorine ≥ 0.1 mg/L, subregion, level of care, water storage capacity, and number of samples tested.
[22] Adjusted Odds Ratios (aORs) in **Uganda** are adjusted for: main water source type, subregion, ownership, level of care, and number of samples tested.

Country Models: ***E. Coli* detected in one or more HCF water samples**[20]	Afghanistan HCF n	Afghanistan Crude OR (95% CL)	Afghanistan HCF n	Afghanistan Adjusted OR[21] (95% CL)	Afghanistan *P*	Uganda HCF n	Uganda Crude OR (95% CL)	Uganda HCF n	Uganda Adjusted OR[22] (95% CL)	Uganda *p*
Sub-Region										
Badghis (vs. Herat)	104	**3.839 (1.143, 14.095)**	**104**	**8.197 (1.533, 57.770)**	**0.0131***	/	/	/	/	/
Ghor (vs. Herat)	104	**6.170 (1.836, 23.049)**	104	3.198 (0.441, 24.647)	0.2476	/	/	/	/	/
Karamoja (vs. West Nile)	/	/	/	/	/	137	1.250 (0.509, 2.942)	**122**	**4.066 (1.274, 13.804)**	**0.0178***
Setting: Urban	104	0.652 (0.141, 2.220)	104	--	--	137	0.654 (0.097, 2.626)	122	--	--
Ownership: Private	/	/	/	/	/	136	**0.219 (0.034, 0.801)**	**122**	**0.232 (0.034, 0.928)**	**0.0376***
Level of Care: High	104	1.335 (0.496, 3.484)	**104**	**6.480 (1.250, 43.192)**	**0.0253***	137	0.663 (0.181, 1.941)	122	3.093 (0.569, 16.085)	0.1837
Reliable Electricity: Yes	100	0.626 (0.215, 1.695)	/	/	/	137	0.770 (0.239, 2.107)	/	/	/
Inpatient Services: Available	102	0.527 (0.141, 1.599)	/	/	/	137	1.077 (0.152, 21.500)	/	/	/
Surgical Services: Available	102	0.956 (0.249, 3.023)	/	/	/	137	0.419 (0.174, 1.031)	/	/	/
At least one MD on staff: Yes	102	0.533 (0.195, 1.515)	/	/	/	137	0.692 (0.216, 1.879)	/	/	/
Water Use per Day (+ 100 L)	98	0.988 (0.955, 1.000)	/	/	/	137	0.999 (0.983, 1.008)	/	/	/
Storage Capacity (+ 100 L)	104	**0.970 (0.932, 0.995)**	**104**	**0.952 (0.901, 0.989)**	**0.0052***	123	1.000 (0.999, 1.000)	122	--	--
Outpatients per Month (+ 100)	102	1.005 (0.983, 1.024)	/	/	/	137	0.979 (0.932, 1.009)	/	/	/
Inpatients per Month (+ 100)	102	0.961 (0.748, 1.065)	/	/	/	137	1.039 (0.944, 1.141)	/	/	/
Total Patients per Month (+ 100)	102	1.003 (0.982, 1.022)	/	/	/	137	0.989 (0.955, 1.012)	/	/	/
Surgeries per Month (+ 10)	102	0.933 (0.658, 1.013)	/	/	/	137	1.019 (0.983, 1.063)	/	/	/
Deliveries per Month (+ 10)	102	0.993 (0.920, 1.011)	/	/	/	137	0.992 (0.914, 1.043)	/	/	/
C-Sections per Month (+ 1)	102	0.993 (0.914, 1.011)	/	/	/	137	0.999 (0.957, 1.023)	/	/	/

Country Models: ***E. Coli* detected in one or more HCF water samples**[20]	**Afghanistan**					**Uganda**				
	HCF n	Crude OR (95% CL)	HCF n	Adjusted OR [21] (95% CL)	*P*	HCF n	Crude OR (95% CL)	HCF n	Adjusted OR [22] (95% CL)	*p*
Clinical Staff (+ 1)	102	0.992 (0.943, 1.006)	/	/	/	137	0.997 (0.976, 1.010)	/	/	/
MD Staff (+1)	102	0.919 (0.671, 1.008)	/	/	/	137	0.878 (0.584, 1.131)	/	/	/
Nonclinical Staff (+1)	102	0.996 (0.954, 1.009)	/	/	/	137	0.939 (0.842, 1.022)	/	/	/
Cleaning Staff (+ 1)	102	0.994 (0.923, 1.023)	/	/	/	137	0.839 (0.630, 1.039)	/	/	/
Total Staff (+ 1)	102	0.997 (0.972, 1.004)	/	/	/	137	0.996 (0.976, 1.008)	/	/	/
Inpatient Beds (+10)	102	0.970 (0.726, 1.050)	/	/	/	137	1.005 (0.910, 1.087)	/	/	/
Samples Tested (+1)	104	1.297 (0.771, 2.151)	104	**2.118 (0.991, 4.807)**	*Not available*	137	1.164 (0.811, 1.660)	122	1.042 (0.649, 1.688)	0.8638

4. Discussion and Implications

This was a study of WASH-related data collected from more than 200 HCFs in two countries. Our objectives were to *describe* WASH access (1.00) and water quality (2.00) among these HCFs, and to *analyze* four key outcomes to identify demographic or other factors that may predict variation in these outcomes across HCFs. The four key outcomes studied were: access to basic water service (1.01), access to at least one functional hand hygiene facility at a point of care (1.02), access to the Six Cleans needed for safe delivery in a labor and delivery ward (1.03), and detection of *E. coli* (≥ 1 MPN or CFU / 100 mL) in one or more of an HCF's water samples (2.01). After examining coverage of various WASH services and water quality indicators among our studied population of HCFs, we performed logistic regression analyses on the four key outcomes, the findings of which are the primary focus of this discussion section.

For each of the four key outcomes, we created *two* multivariable logistic regression models, one in each country. In some cases, country-specific models were especially important because the outcome variables were based on assumptions that differed by country, due to differences in data collected and data collection methods. More generally, there were inevitable differences by country with respect to demographic predictor variables, which affected all four key outcomes. For example, classification of an HCF's geographic setting as "rural" or "urban" in Afghanistan was completed by experts from World Vision Afghanistan, but in Uganda, subject matter experts were not available and "rural"/"urban" classifications were based on the Ugandan Bureau of Statistics' definition of urban areas (UBoS, 2017). This type of country-specific context is important to keep in mind as we consider the results and conclusions of each analysis.

4.1. Access to Basic Water Service (RQ 1.01)

The JMP's 'basic' water service level is achieved when an HCF has water available*(1), from an improved source**(2), on the premises***(3).[23]

Given that the studied subregions were largely considered particularly high-risk or low-development regions of each country, it is surprising that the rates of access to basic water service measured in this study were *higher* than the JMP's 2019 national estimates in both countries. The JMP estimated that 49% of HCFs in Afghanistan had basic water service (JMP, 2019), whereas this study found basic water service among 52% of HCFs in Ghor, 57% of HCFs in Badghis, and 85% of HCFs in Herat, for overall coverage of 70% among HCFs in all three provinces (**Table 15**). It is notable that more than half of the HCF sample in Afghanistan was drawn from Herat, which has considerably more development than Badghis and Ghor, and somewhat lower risk of drought. The proportion of HCFs with access to basic water service measured through this study in Badghis and Ghor are more closely aligned with the JMP's national estimate for Afghanistan. Additionally, although the JMP report was published in 2019, the data used for the JMP's Afghanistan estimate was from 2013 and this study's WASHCon data was from 2018, which could also account for some of the discrepancy.

In Uganda, the JMP estimated that only 31% of HCFs had access to basic water service (JMP, 2019). This study observed 60% coverage: 59% coverage in Karamoja and 61% coverage in West Nile (**Table 15**). Variation between studied subregions was minimal, and

23 When we categorized water service levels for HCFs in Uganda, it was necessary to rely on the assumption that the water available for testing was from a source of the same type specified as the HCF's main water source, which may not have been true in all cases. It was not always true in the Afghanistan data set, where there was a variable at the sample level that specified each sample's water source type.

in this case the timing of data collection is also unlikely to explain this relatively large difference (Uganda's data in the JMP report was from 2016 and WASHCon data in Uganda was collected in 2017). It is possible that our study was biased towards certain types of HCFs that tended to have greater coverage of basic water service, like privately-owned HCFs and/or HCFs at higher levels of care. Some evidence supports the theory that our sample of HCF was skewed towards HCFs at higher levels of care: the lowest-level clinics assessed through WASHCon in Uganda were HC IIIs, with no representation of HC IIs. (HC Is, like Sub Health Centres [SHCs] in Afghanistan, are informal village teams and were also not assessed.)

In 4 of the 5 studied subregions, this study's findings on coverage of basic water service align relatively well with the JMP's estimates for Least Developed Countries (LDCs) and Landlocked Developing Countries (LLDCs), two UN SDG country groupings of which both Afghanistan and Uganda are members (**Table 15**).

Table 15. *Comparing previous coverage estimates of Basic Water Service with this study's results*

	Afghanistan			Uganda		LDCs	LLDCs
JMP 2019 (%)		49		31		55	46
This study's results (%)		70		60		/	/
By province (%)	57	52	85	59	61	/	/
	Badghis	Ghor	Herat	Karamoja	West Nile		

Sources: (JMP, 2019)

Despite higher-than-expected coverage of basic water service in studied regions, there was also a higher-than-expected percentage of HCFs in Uganda at the 'no service' level of the water service ladder. This study found 19% of HCFs assessed in the studied regions of Uganda to have no water service, whereas the JMP's 2019 estimate was only 4% (JMP,

2019) (**Table 16**). This is likely due, at least in part, to the 7% of HCFs in Uganda that did not have water available to test at the time of the survey. The converse was true in Afghanistan: initial reports estimated 44% of HCFs had no water service (Cronk, 2018; WHO, 2015); the JMP's estimate was 25% (JMP, 2019); and in this study, only 16% of HCFs assessed in the studied subregions had no water service. (It is also important to note that most HCF WASH assessments prior to the JMP 2019 report were based on data collected from large-scale general HCF assessments, not data collected specifically with HCF WASH in mind, so their results should be viewed with caution.)

Table 16. *Comparing previous coverage estimates of No Water Service with this study's results*

	Afghanistan			Uganda		LDCs	LLDCs
WHO 2015 (%)	44			34		/	/
Cronk 2018 (%)	44			18		/	/
JMP 2019 (%)	25			4		23	18
This study's results (%)	16			19		/	/
By province (%)	14	26	13	20	18	/	/
	Badghis	Ghor	Herat	Karamoja	West Nile		

Sources: (Cronk, 2018; JMP, 2019; WHO, 2015)

Only one previous study has attempted to analyze the predictors of access to basic water service (Cronk, 2018). This study's multivariable logistic regression results supported two of Cronk's findings, found one association to be significant that Cronk's adjusted results had not, and found one factor to be significantly predictive in the opposite direction (**Table 17**). (Cronk's analyses of the predictors of basic water service were specific to six other countries, and did not include data from Uganda or Afghanistan.) In Uganda, private ownership and high level of care were significantly positively associated with basic water service, supporting Cronk's findings on those factors. However, HCFs in urban settings were associated with significantly lower odds of basic water service whereas they had been associated with higher odds in Cronk's results.

Table 17. *Factors found to be predictive of basic water service in Cronk 2018 and in this study*

Factors associated with Basic Water Service	Cronk, 2018 Significant Associations (n of n countries studied) Unadjusted	Adjusted	This study, 2019 Significant Associations (n of n countries studied) Unadjusted	Adjusted *
Setting: Urban *vs. Rural*	Positively Associated (5 of 5)	Positively Associated (4 of 5)	Not Significant (2 of 2)	Negatively Associated (1 of 2: Ug.)
Ownership: Private *vs. Public*	Positively Associated (5 of 6)	Positively Associated (5 of 6)	Not Significant (1 of 1)	Positively Associated (1 of 1: Ug.)
Level of Care: High *vs. Low*	Positively Associated (6 of 6)	Positively Associated (5 of 6)	Not Significant (2 of 2)	Positively Associated (1 of 2: Ug.)
Inpatient service: Available *vs. Not available*	Positively Associated (2 of 6)	Not Significant (6 of 6)	Positively Associated (1 of 2: Af.)	Positively Associated ** (1 of 2: Af.)

*In this analysis, the SAS software was instructed to retain the three factors found significant in Cronk's adjusted results (setting, ownership, and level of care), regardless of their significance level in this study's model. This instruction was ultimately unnecessary in Uganda: all three factors would have remained in Uganda's model on their own strength, though the direction of one of the three associations was unexpected. In Afghanistan, ownership was not assessed because all HCFs were public, and the other two factors (setting and level of care) were insignificant and would have dropped out of Afghanistan's model had the SAS software not been instructed to retain them.
** Since inpatient service was not a significant predictor in any of Cronk's multivariable analyses, the SAS software was not instructed to force retention of this factor for our study. In Afghanistan, the factor was a significant predictor on its own strength without forced inclusion. In Uganda, it was not included in the multivariable model.

This study's much-smaller sample size could be the cause of differences in the results between this analysis and Cronk's study. Whether or not it is a valid finding, the inverse association that this study found between urban settings and basic water service in Uganda was primarily driven by the definitional requirement that an HCF's water source be on-premises, not the requirements that water be available from an improved source. Thirteen of 14 urban HCFs in Uganda (93%) had an improved water source, but only eight of 14 (57%) had their water source located on-premises, compared to 94 of 134 rural HCFs (70%). Five urban HCFs reported that their main water source was a borehole or tube well, and only one of those five was located on-premises, leading the study team to question the validity of categorizing these HCFs as “urban” and theorize that our reliance on the Ugandan Bureau of Statistics’ definition of “urban” may have resulted in some inexact classifications. Although this reliance on the government definitions was necessary in the absence of local expertise, it is easy to imagine how an HCF classified as urban on the basis of its sub-county’s title may not in fact qualify as urban in the judgment of local experts. This type of misclassification could have obscured the association between geographic setting and basic water service and may have contributed to this surprising result.

Alternately, we theorized that smaller premises and closer proximity of neighbors in urban environments could mean that urban HCFs are more likely than rural HCFs to use a convenient improved source located nearby but not on the premises, whereas a rural HCF with much larger premises may have a source “on-premises” that is even further away than the urban HCF’s “off-premises” source. A third theory is that some respondents may have misunderstood the question “Where is the main water source for the facility?” In survey data, 8 of the 14 urban HCFs in Uganda reported that their main water source was a piped improved source, but only 6 of these 8 reported that this piped water was located on-premises (1 reported their piped source was within 500m, and 1 reported their piped source was off-premises, further than 500m). While it is possible that these 2 HCFs were drawing water from off-site piped sources, carrying it back, and storing it onsite, it is also possible that these HCFs’ interviewees interpreted the question “Where is the main water source for the facility?” to mean “Where does this facility’s water come from?” and may have cited the municipal piped water as off-premises even if it was being piped into their

HCF. Still, this finding could simply be a consequence of low numbers of urban HCFs in the sample and might be insignificant if the sample size of urban HCFs was increased.

In Afghanistan's multivariable model, the availability of inpatient services was the only predictor of basic water service for which adjusted results were significant with 95% confidence. Level of care was included in the multivariable model because it was of particular interest due to Cronk's previous findings. However, the relatively high correlation between these two predictors (level of care and the availability of inpatient services had a correlation coefficient of 0.76: **Appendix G**) may have led to inflated variance for these two predictors, rendering unreliable estimates of regression coefficients for both factors. Although the model's overall predictive strength is not impacted by this collinearity, it does create some doubt as to the relative predictive power of the two coefficients. In other words, because of the collinear relationship between the two variables, it may be premature to conclude from these results whether availability of inpatient services or level of care is truly the stronger predictor – their effects are intertwined. Level of care may in fact be stronger than this model would seem to suggest (which would be in keeping with Cronk's findings), and availability of inpatient services may be less strong.

4.2. Access to a Functional Hand Hygiene Facility at ≥ 1 Point of Care (RQ 1.02)

A functional hand hygiene facility at a point of care is defined as "the availability of soap and water, or alcohol-based hand rub, at [a] location[…] where patients receive care," (JMP, 2019). The WASHCon ward observation form instructs enumerators to "observe a functional hand hygiene facility" in the ward and note which hand hygiene materials are present. Since the form does not provide specific instructions on what qualifies a component of a hand hygiene facility as "functional", this analysis adopts the assumption that any hand hygiene materials marked in response to this question are, in fact, functional for their intended purpose as the question assumes. Thus, the terms 'hand hygiene facility' and 'functional hand hygiene facility' are used interchangeably here.

About 86% of HCFs in Afghanistan and 74% of HCFs in Uganda were observed to have hand hygiene facilities in at least one point of care. These estimates appear to be in the mid-range for the countries' respective geographic regions according to the most recent JMP data on this indicator (**Table 18**). Access to hand hygiene facilities varied widely by subregion in both countries (**Table 18**).

The JMP focuses on access to a hand hygiene facility at ≥ 1 point of care as a monitoring indicator, allowing any single point of care at an HCF to represent the general "points of care" for its service levels (JMP, 2019). However, the WASHCon study provides rare insight into conditions at multiple points of care within a single HCF. The descriptive results indicate that access to hand hygiene at one point of care does *not* imply that an HCF has access to hand hygiene at most or all critical points of care. The WASHCon data show a large disparity between the proportion of HCFs that have hand hygiene facilities at "at least one" point of care (86% and 74% in Afghanistan and Uganda, respectively) and the proportion of HCFs that have hand hygiene facilities at **all** points of care observed (27% and 28% in Afghanistan and Uganda, respectively: **Table 18**). Understanding that global monitoring of WASH in HCFs is a serious challenge and that monitoring requirements must balance precision with feasibility and parsimony, it is still important to note that when a single point of care is considered representative of the conditions at a whole HCF, the JMP definition may be systematically over-estimating true rates of access to hand hygiene at points of care.

Table 18. *Hand hygiene coverage as measured at ≥ 1 point of care and as measured at all points of care*

Hand hygiene coverage rates when measured at ≥ 1 point of care and when measured at all points of care observed

	Afghanistan			Uganda		CSA *	SSA **
	Badghis	Ghor	Herat	Karamoja	West Nile		
JMP 2019 estimates: HCFs with hand hygiene at ≥ 1 point of care (%)	/			84		46 - 91	24 - 93
This study's results by country:						/	/
HCFs with hand hygiene at ≥ 1 observed point of care (%)	86			74			
HCFs with hand hygiene at all observed points of care (%)	26			28		/	/
This study's results by subregion:							
HCFs with hand hygiene at ≥ 1 point of care observed (%)	65	87	96	49	86	/	/
HCFs with hand hygiene at all points of care observed (%)	23	0	39	14	34	/	/

*Range of JMP coverage estimates from 4 countries in JMP's Central and Southern Asia (CSA) region *(JMP, 2019)*.
**Range of coverage estimates from 30 countries in JMP's Sub-Saharan Africa (SSA) region *(JMP, 2019).*

In Uganda, after adjusting for ownership and facility size in terms of outpatients per month, an HCF's subregion was the strongest predictor of hand hygiene access and had the largest effect size (aOR Karamoja vs. West Nile: 0.159, 95% CL 0.063 – 0.381). While subregion was similarly predictive in Afghanistan -- HCFs in Herat were about 6 times more likely than HCFs in Badghis to have access to a functional hand hygiene facility at ≥ 1 point of care (aOR Badghis vs. Herat 0.166, 95% CL 0.021-0.914), after adjusting for other modeled factors – the strongest predictor of access to hand hygiene facilities was the presence of at least one MD on staff. Level of care was not a significant predictor, indicating that presence or absence of an individual trained as an MD was a more important factor than an HCF's classification in a country's hierarchical health system. This result suggests that a focus on education and training to bring more experienced personnel to HCFs could boost access to hand hygiene.

4.3. Access to the Six Cleans of Safe Delivery (RQ 1.03)

The Six Cleans required for safe delivery in any birth setting are: (1) clean hands [of the birthing attendant(s)], (2) a clean birthing surface, (3) a clean blade, (4) a clean tie or clamp for the umbilical cord, (5) clean towels for the newborn, and (6) clean cloth to wrap the mother (WHO, 2006). For the purposes of this study, "Clean hands" was indicated by the presence of a hand hygiene facility in the labor and delivery (L&D) ward – the presence of gloves was not sufficient. During the data collection period in 2017-2018, the WASHCon observation form did not include an answer option for clean cloth, so towels were allowed to represent both items (5) and (6). Thus, in the context of this analysis, the Six Cleans in fact measures the presence of five unique elements in an HCF's L&D ward. During WASHCon observations of L&D wards, access to all Six Cleans was observed in 23% of HCFs assessed in Afghanistan and in 33.1% of HCFs assessed in Uganda.

All of the Six Cleans are necessary for a clean birth, and clean birth is critical for maternal and neonatal health. Unhygienic conditions during delivery (i.e., the lack of any or all of the Six Cleans in the delivery setting) contribute significantly to both maternal and neonatal morbidity and mortality (Ganatra et al., 2010; Oza et al., 2015; Velleman et al., 2014). Women who give birth without the clean environment represented by the Six Cleans framework face substantially higher risks of maternal sepsis, estimated to account for about 11% of all maternal mortality from 2003 to 2009 (Benova et al., 2014; Say et al., 2014). Newborns face even higher risks from the unhygienic conditions inherent in the absence of the Six Cleans, with neonatal sepsis accounting for about 16% of all neonatal mortality between 2000 and 2013 (Oza et al., 2015). The capacity of an HCF to provide the Six Cleans is especially critical in the context of encouraging facility births and building community trust in health care systems.

Prior research has pointed to hand hygiene infrastructure as a major limiting factor for Six Cleans access (A. N. Bazzano et al., 2015; Gon et al., 2017). In this study, access to a hand hygiene facility in the labor and delivery (L&D) ward was the top limiting factor to Six Cleans access in Uganda. Although L&D ward hand hygiene coverage rates were similar in both countries, hand hygiene did not appear to be as important a limiting factor in Afghanistan simply because other components of the Six Cleans were observed far less often in Afghanistan than were hand hygiene stations (**Table 6**).

In Afghanistan, reliable electricity and surgeries per month were the only significant predictors of Six Cleans access with 95% confidence. The odds of an HCF having Six Cleans access in its L&D ward rose significantly if the HCF had reliable electricity and also rose with the average number of surgeries per month performed at an HCF. Level of care and all other tested variables (geographic setting, availability of inpatient services, and total patients per month) failed to meet the $p < 0.2$ significance threshold to remain in the multivariable model of data from Afghanistan. The more specific markers of an HCF's size (surgeries per month) and infrastructure (reliable electricity) were better predictors than an HCF's position in the hierarchy of the Afghan health care system (level of care) or its position in relation to urban centers (geographic setting). Electricity, in particular, had the strongest effect size and seemed likely to be related to an HCF's ability to conduct the appropriate cleaning procedures necessary for the Six Cleans.

In Uganda, an HCF's odds of Six Cleans access tended to be significantly higher among HCFs that had more inpatients per month compared with HCFs that had fewer inpatients per month. We theorize that HCFs treating higher volumes of inpatients are likely to be more sophisticated and to have more resources than HCFs treating lower volumes of inpatients. However, after accounting for the effect of inpatient volume, the model found the inverse to be true for deliveries: odds of Six Cleans access fell as average number of deliveries per month rose. This finding may reflect overcrowding and resource limitations specific to L&D wards. Under resource-strained conditions, such as when an HCF is handling more deliveries than it is equipped to handle, an HCF's ability to provide clean 'reusables' like towels may be especially diminished. Previous research has demonstrated that sleep mats and other soft surfaces are among the most difficult items to clean at an HCF, and are often re-used between patients (Gon et al., 2017). Our descriptive findings support this theory: in both countries, clean towels did appear to be a limiting factor for having all of the Six Cleans in an L&D ward (**Table 6**).

These significant and oppositional effects of inpatients per month and deliveries per month paint a complex picture of HCF resource use and demands. Aside from these two factors, subregion was the only other predictor that stayed in Uganda's multivariable model, with weaker evidence. Setting, ownership, level of care, availability of surgical services, and water storage capacity were all dropped from the model because they were not statistically significant in adjusted results, which reinforces the sense that resource availability and resource needs are truly the driving factors behind access or lack of access to the Six Cleans.

It is also important to note that even where access existed, mere access to the Six Cleans resources (clean blades, clean towels, etc.) does not guarantee that these materials are being used perfectly or that safe deliveries are occurring in practice (Campbell et al., 2014). Observations in L&D wards have shown that there is a major behavioral component to safe birth practices, just as with many other hygiene practices (Buxton, 2019). Even among HCFs with the theoretical capability to provide a clean delivery surface, only a small percentage actually had a clean surface when tested (Gon et al., 2017). While this study's results estimate access to the Six Cleans, they cannot be said to estimate the true prevalence of safe delivery, since the study did not conduct observations of live births or any microbiological testing of surfaces or hands.

4.4. Detection of *E. coli* in HCF Water Samples (RQ 2.01) and Other Water Quality Results

In general, water quality in the HCFs that were assessed was found to be fair, though with some significant exceptions. About one-fifth of HCFs (21%) in each country had *E. coli* detected in one or more water samples, and certain water samples collected from HCFs in both countries contained high levels of contamination. Of the 466 water samples evaluated from HCFs in both countries, nearly 6% of those collected from HCFs in Afghanistan and more than 2% of those collected from HCFs in Uganda had ≥ 100 *E. coli* (MPN or CFU) per 100 mL, placing them in the WHO's highest-risk range for microbiological water quality (**Fig. 7).**

While overall *E. coli* detection rates were relatively comparable among HCFs in both countries, free chlorine detection rates differed considerably. About 37% of HCFs in both countries reported having chlorinated water. Surprisingly, 67% of HCFs in Afghanistan had ≥ 0.1 mg/L free chlorine detected in one or more water samples, but only about 8% had ≥ 0.2 mg/L free chlorine detected. This abrupt decrease can be partially attributed to measurement difficulties in that country, where the visual testing kit used to detect free chlorine was only able to distinguish results at 0.1 mg/L and at ≥ 0.3 mg/L, so only the results that appeared to have ≥ 0.3 mg/L of free chlorine were classified as having ≥ 0.2 mg/L of free chlorine (see: **Methods**). Compared with 8% of HCFs in Afghanistan, about 19% of HCFs in Uganda had one or more water samples that met the WHO standard for free chlorine in drinking water (≥ 0.2 mg/L). Only about 3% of HCFs in Afghanistan and 8% of HCFs in Uganda had ≥ 0.2 mg/L free chlorine detected in all tested water samples.

In both countries, after adjusting for other factors, an HCF's main water source type had a strong predictive effect on the odds of detecting *E. coli* in the HCF's water. In Afghanistan, HCFs with an unimproved main water source were 24 times more likely than HCFs with a piped main water source to have *E. coli* contamination detected in one or more water samples (aOR 24.074, 95% CL 1.591-792.116). In Afghanistan, even the HCFs whose main sources were boreholes or tube wells (also classified as improved sources) were still 15 times more likely than HCFs with piped water sources to have fecal contamination detected in water samples after adjusting for other modeled factors (aOR 15.100, 95% CL 1.842-347.597).[24] Confidence intervals on these estimates in Afghanistan were extremely wide. The trend was similar in Uganda, where HCFs with boreholes and tube wells were 4.2 times more likely to have *E. coli* detected in one or more water samples than HCFs with piped water (aOR 4.229, 95% CL 1.290-15.782), and HCFs with other kinds of improved sources were 7.2 times more likely than HCFs with piped water to have *E. coli* detected in at least one water sample (aOR 7.170, 95% CL 1.247-41.850).[25]

These results align well with the only other recent study of water quality among HCFs in a low-income country. Huttinger et al. tested water samples from rural HCFs in Rwanda with piped water and detected *E. coli* contamination in 1 of 16 samples (7%) from 1 of 10 HCFs

[24] Adjusted Odds Ratios (aORs) in Afghanistan are adjusted for all six modeled factors: main water source type, percentage of water samples at HCF with free chlorine ≥ 0.1 mg/L, subregion, level of care, water storage capacity, and number of samples tested.
[25] Adjusted Odds Ratios (aORs) in Uganda are adjusted for all four modeled factors: main water source type, subregion, ownership, level of care, and number of samples tested.

(10%) (Huttinger et al., 2017). If we consider only our most comparable subset of WASHCon data – rural HCFs in Uganda with piped water (n=46) – this study's results align very closely with Huttinger's: we detected *E. coli* contamination in 7 of 88 water samples (7%), impacting 5 of the 43 HCFs in this subset that had water available to test (12%). However, our results indicated that rural HCFs without piped water had a much greater chance of detecting fecal contamination in their water samples: among rural HCFs in Uganda lacking piped water (n= 88), *E. coli* contamination was detected in 31 of 164 samples taken (19%, compared to only 7% of samples from HCFs with piped sources), affecting 22 of 81 HCFs with water available to test (27%, compared to only 12% of HCFs with piped sources). This study did not find geographic setting (urban vs. rural) to be a significant predictor of water quality, although Bain's meta-analysis did find higher risk of contamination in rural areas compared to urban areas (OR: 2.37, 95% CL: 1.47 – 3.81) (Bain et al., 2014).

Subregion was the other predictor of water quality that was significant in adjusted results from both studied countries. In Afghanistan, HCFs in Badghis province were about 8 times more likely than HCFs in Herat to have *E. coli* detected in one or more water samples (aOR 8.197, 95% CL 1.533-57.770), and in Uganda, HCFs in Karamoja subregion were about 4 times more likely than HCFs in West Nile to have *E. coli* detected in one or more water samples (aOR 4.066, 95% CL 1.274-13.804), after adjusting for the other factors that were modeled in each country. Aside from water source type and subregion, three other factors were significantly predictive of *E. coli* detection among HCFs in Afghanistan: level of care, percentage of water samples with free chlorine detected, and water storage capacity. Only one other factor was significantly predictive of *E. coli* detection among HCFs in Uganda (public ownership).

There were 9 samples from HCFs in Afghanistan that had free chlorine ≥ 0.1 mg/L but also contained *E. coli* bacteria. These accounted for nearly one-third of the samples in Afghanistan in which *E. coli* was detected. Generally, when chlorinated water samples contain viable bacteria, the bacteria are attached to particles in the water (WHO, 2004). Five of the 9 samples in question also displayed turbidity well above the recommended maximum of 5 NTU. This result indicates that chlorination alone is not enough – water must also be filtered for particulate matter, and chlorine must be allowed ample time to interact with visibly-clean (non-turbid) water. The other 4 of the 9 contaminated samples in question had acceptable levels of turbidity and near-standard levels of free chlorine, despite being contaminated (two of the four in the highest-risk category, ≥ 100 CFU/mL). We theorize that the relative imprecision of the visual test kit used for free chlorine measurement in Afghanistan may have played a role in this surprising result.

Overall, the results of regression analyses of *E. coli* detection in both countries strongly suggest that piped water sources were significantly more likely to produce satisfactory water quality than other types of sources, even those considered improved. These findings are consistent with the findings of a major meta-analysis of the odds of detecting fecal contamination in drinking water in non-HCF settings, which found that piped water was significantly less likely to have fecal indicator bacteria detected than other improved water sources (OR, piped vs. all other improved sources: 0.53, 95% CL 0.32-0.89) (Bain et al., 2014). This study's results on piped water quality were also consistent with the results of the only other recent study of HCF water quality in a low-income country, which was focused exclusively on HCFs with piped water (Huttinger et al., 2017). Aside from the HCF's main water source, the only other factor that was a significant predictor of water quality in both countries was the HCF's subregion within the country.

These two commonalities across both countries – the significance of an HCF's main water source type, and of an HCF's subregion – are indicative of a sort of paradox of studying HCF WASH. First, the strength of the main water source type as a predictor in both countries suggests that there are certain things that are reliably true; factors that are determinative or predictive across contexts and continents. But, second, the fact that sub-national differences in both countries are also significantly predictive reminds us that no factor is truly universal, and that there is always an abundance of unknowns. Whether cultural, environmental, political, financial, or otherwise – the effect of some factors will always differ from one country to the next, from one sub-region to the next, and from one HCF to next. With this in mind, we believe it is important to focus on understanding the factors (like water source type, but unlike subregion) that are actually changeable for a given HCF, so that scientific research can be translated into action.

4.5. Strengths and Limitations

Until WASHCon Assessments began, the only available data on HCF wash came from large-scale general assessments such as the WHO's Service Availability and Readiness Assessment (SARA) or USAID's Service Provision Assessment (SPA). The WASHCon tool was created in response to a need for a WASH-specific assessment in HCFs, so one of its major strengths is that the HCF WASH data captured through WASHCon has exceptional depth and breadth. Another important strength is that WASHCon provides insights into HCF WASH at multiple points of care within each HCF, instead of just one.

Being uniquely designed for collection of HCF WASH data, WASHCon is one of the only HCF assessment tools that includes an option for direct measurement of water quality through chemical and microbiological water testing. Thus, this study is among the first of its kind to measure HCF water quality directly. Similar studies have been much smaller and more limited in the types of HCFs studied. We are only aware of one other study of HCF WASH that tested water samples from HCFs and described microbiological and free chlorine test results, and we are not aware of any others with sample sizes comparable to our sample size of more than 250 HCFs assessed across two countries.

This study is also one of the first to provide not only descriptive but analytic conclusions about HCF WASH, including assessment of which factors may predict or determine HCF WASH conditions. We are only aware of one other study of HCF WASH that offered analytic conclusions with regard to HCF water service levels, and we believe this is the first study that offers similar analyses for three other key HCF WASH outcomes: access to a hand hygiene facility, access to the Six Cleans necessary for safe delivery, and detection of *E. coli* in one or more 100 mL HCF water samples.

The limitations of this analytic study of WASHCon data are likely to include impacts of selection bias, information bias, and confounding. Selection bias may occur if non-participant HCFs in our chosen subregions are in some way systematically different from study participant HCFs in these subregions. It is possible that the HCFs that were reachable and that agreed to participate in this study may have been systematically different from the HCFs that were not reachable by the study team or would not agree to participate in an international study with "Western" partner organizations. This potential selection bias could have led to systematic overestimation of coverage rates and access, as it seems likely that the hardest-to-reach and most isolated HCFs would be the most challenging to include in the study and also the least likely to have access to the services and resources that the study attempts to measure.

Information bias may occur if responses or measurements are in some way systematically incorrect, whether differentially or non-differentially. Even with a largely standardized set of data collection instruments (the WASHCon forms), it is possible that both differential and non-differential misclassification may have occurred during data collection. Differential misclassification could have occurred especially by country. Data was collected by two different study teams in two different countries during two different time periods. When measuring water quality, the two country teams used different methodologies and instruments (see: **Methods**). These temporal, cultural, and methodological differences may have contributed to differential responses between the two countries. To mitigate this limitation, this study's results are always reported stratified by country.

Information bias can also be non-differential. Courtesy bias is one type of non-differential misclassification that could constitute a limitation for this study. Our reliance on data reported on the Director and Administrative forms from interviews with HCF staff may have led to systematic over-reporting of practices or infrastructure that respondents perceived as desirable (Rajasingham et al., 2018). The potential for courtesy bias in this study is supported by some evidence: for certain topic areas, such as hand hygiene availability for staff and patients or water source type(s) used at the HCF, we were able to link observational data collected through Ward observation checklists or Water Quality forms with interview data on the same topics collected through the Director and Administrative forms. Generally, assessments of "observed" vs. "reported" results supported the concept that respondents tended to minimize the negative and maximize the positive in their interviews. For example, interviewees often stated that hand hygiene was available at the HCF (as opposed to "sometimes" available or not available), but observations sometimes showed that hand hygiene facilities were not available on the day of the study, or were only available at a small fraction of points of care observed.

The final internal validity concern for this study is the potential for confounding. It is always challenging to uncover meaningful conclusions in observational studies, which do not have randomization to control for confounding variables. We did make efforts to control for possible confounding variables by including the suspected confounding variables as predictors in multivariable analysis, such that the adjusted results were controlling for the effects of the confounding variables. If an interaction or an effect modification was suspected, interaction terms were tested in the model. In all cases, interaction terms were eliminated from multivariable models as insignificant ($p > 0.2$). However, these interaction terms were not introduced in a formal or systematic way; i.e., there was no methodical testing of predictors for interaction, which may be a limitation. Other analysis-related biases may also be present: conclusions represented here may be false positives, a risk heightened by inflation of the Type I error rate (multiplicity) and confirmation bias.

There are also some limitations to the external validity of this study due to the study's delimited scope. The study regions were not considered nationally representative, so these results may not be wholly comparable with the results of nationally representative studies. Additionally, it is difficult to translate "service coverage at HCFs" into actual population service coverage. Weighting HCFs (e.g., by number of patients seen per month, number of deliveries per month, or number of beds) has been suggested as a way to improve estimates of actual human exposure to the WASH service levels at various HCFs (Cronk, 2018), but this analysis weighted each HCF equally in the study population regardless of the HCF's size or service area.

Lastly, there is a tremendously important behavioral component to all WASH research and WASH interventions that is not addressed in this study. This study measures access to HCF WASH services and quality of HCF water, which are both necessary but insufficient to prevent disease transmission and provide quality healthcare. The literature suggests that even if safe HCF WASH is accessible and the importance of compliance is strongly reinforced, only a small fraction of HCF staff perform the behaviors and infection prevention and control practices necessary to protect the health of patients, family, and staff (Buxton, 2019).

5. Conclusions

The purpose of this study was to describe WASH conditions and practices among HCFs in selected high-risk/low-development sub-national regions in Afghanistan and Uganda, and to analyze the predictors certain key outcomes among this population of HCFs. We reviewed data from >250 HCFs and explored research questions in two domains, HCF WASH Access and HCF Water Quality. We reported descriptive statistics related to the demographics and WASH outcomes reported and observed in the assessed HCFs. Using country-specific logistic regression models, we analyzed the determinants of four key WASH outcomes: having Basic Water Service, having a functional hand hygiene facility at ≥ 1 point of care, having access to the Six Cleans, and detecting *E. coli* in one or more 100mL water samples. Our results will help the public health community prioritize existing resources and support the design and development of future evidence-based HCF WASH interventions, policies, and procedures, as well as the ongoing refinement of HCF WASH monitoring indicators.

Perhaps the most important implication of the findings of this study is for how HCF WASH monitoring indicators are selected and defined. This study's findings on HCF water quality suggest that the type of water source used is a significant predictor of water quality, but the location of the water source is not a significant predictor. When the JMP water service level was tested as a predictor of water quality in univariable analysis, it was found to be significant – but when broken down to its component parts, the multivariable analysis shows that what drove its significance was entirely the water source type, not whether the water source was located on-premises. The findings also suggest that borehole and tube well water sources are significantly less safe than piped water sources, despite both being considered "improved". If the ultimate goal of measuring water service levels is to estimate the proportion of HCFs with reliable access to *safe* water, we should consider revising our definitions of water service to ensure that we are capturing the data with the closest relationship to the outcomes we truly wish to understand.

Similarly, this study's results suggest that counting HCFs with hand hygiene at "at least one" point of care paints a brighter picture of hand hygiene status at HCFs than does measuring the number of HCFs with HCFs at more than half of points of care, or all points of care. Not all data may be feasible to collect on a global scale today, but as data collection in this field continues to improve, we should keep these findings in mind and attempt to measure the factors that are truly most important.

The results also suggested that careful measurement of individual components of the Six Cleans of safe delivery is very important to understanding the most important and highest-risk disease transmission pathways for disease. For instance, functional hand hygiene facilities were the most-common of the Six Cleans observed in Afghanistan's L&D

wards, but were the least-common in Uganda's L&D wards. Similarly, access to clean towels or cloths is often categorized along with other tools (like access to a clean blade and a clean umbilical cord tie), but our results indicate that these soft goods may require special attention. These are important insights that may help HCFs and public health professionals design the most appropriate interventions for each unique risk factor.

Even where "interventions" for a given risk factor are not possible, our findings should enable HCFs and NGOs to prioritize attention and resources. For instance, although we cannot design an intervention around changing an HCF's location, we can identify which locations are at highest risk and focus attention in those areas. Our findings across the four key outcomes pointed to very stable sub-regional trends. Wherever subregion remained a predictor in any of the four multivariable models, the predictions were consistent in terms of risk level for each province. In Afghanistan, assessed HCFs in Badghis province were at highest risk of negative outcomes and HCFs in Herat province were at lowest risk, with Ghor HCFs between the two. In Uganda, HCFs in Karamoja were at higher risk than HCFs in West Nile. In designing and implementing HCF WASH interventions, partner organizations should prioritize HCFs in subregions with highest risk.

HCFs around the world are united by their promise to do no harm to their patients, and safe HCF WASH is a necessary precursor to keep this promise. As the field of HCF WASH continues to gain prominence, and as the global public health community works towards meeting SDG3 and SDG6, we are confident that the WASHCon Tool's importance as a leading-edge HCF WASH assessment tool will continue to grow, and that the results of this study can empower key stakeholders to improve HCF WASH for all.

Chapter IV. Conclusion and Recommendations

The first piece of improving HCF WASH conditions is understanding those conditions; and the second step understanding the trends and drivers of these conditions. This study has contributed to both of these efforts. In this final section, we review and summarize the key insights we have gained into HCF WASH conditions and the determinants of key outcomes.

1. Review of Key Descriptive Conclusions

The following table summarizes the major descriptive findings of WASHCon deployments in Afghanistan and Uganda (**Table 19**).

Table 19. *Summary of key descriptive conclusions*

Summary of key descriptive conclusions
• Approximately 70.2% of HCFs assessed in Afghanistan and 60.1% of HCFs assessed in Uganda met the JMP criteria for **basic water service**. In both countries, these proportions were higher than the JMPs estimated national averages, despite the fact that all HCFs assessed through this study were in certain sub-national regions of each country that are considered high-risk or low-development parts of these countries.
• In Afghanistan, 13.5% of HCFs assessed had **limited water service**, and 16.4% had **no water service** according to JMP criteria. In Uganda, these proportions were 21.0% and 18.9%, respectively.
• Only about 20% of HCFs assessed in Uganda and 44% in Afghanistan reported having **reliable electricity**. (Unreliable electricity was defined as having no access to power for 2 hours or more on at least "several" days in the month prior to the survey.)
• About 84.6% of HCFs in Uganda and 48.5% in Afghanistan reported that their **main water source was unavailable** at times. In Afghanistan, the most common reason cited for water loss was loss of electricity, while in Uganda, by far the most common reason cited was equipment malfunction.
• Measuring access to functional **hand hygiene** facilities observed at **≥ 1 point of care** led to coverage estimates that were 40 to 60 percentage points higher than coverage estimates measuring access to hand hygiene facilities at all observed points of care (Afghanistan: 86.3% and 26.5%, respectively; Uganda: 73.7% and 27.7%, respectively).
• Measuring access to **hand hygiene** facilities for **staff** led to coverage estimates that were 5 to 45 percentage points higher than coverage estimates measuring access for **patients**.
• Only about 23% of HCFs assessed in Afghanistan and 33% of HCFs assessed in Uganda had access to the **Six Cleans** for safe delivery in their labor and delivery wards. Clean towels were a major limiting factor in both countries, as was access to a functional hand hygiene facility in Uganda.
• In each country, about 21.2% of HCFs with water available to test had ***E. coli*** **detected** in one or more HCF water samples.

Summary of key descriptive conclusions
• Only about 2.9% of HCFs assessed in Afghanistan and 8.0% of HCFs assessed in Uganda had ≥ 0.2 mg/L free chlorine in all tested samples (the minimum amount required to meet the WHO's standard for free chlorine in drinking water).

2. Review of Significant Analytic Conclusions

The following tables summarize the analytic conclusions reached by this study (**Tables 20-22**). All conclusions reported here are the results of multivariable (not univariable) analysis and, where applicable, are represented by adjusted (not crude) odds ratios. Following these tables is a review of the study's general conclusions, recommendations for the public health community, and finally, recommendations for the WASHCon study team.

Table 20. *Summary of analytic conclusions applicable in both Afghanistan and Uganda*

Summary of study conclusions applicable in both Afghanistan and Uganda

- Subregion was a significant predictor of access to a functional **hand hygiene** facility among HCFs in both countries. Significant sub-national differences existed after accounting for the effects of other predictors.
- Subregion was also a significant predictor of **water quality** among HCFs in both countries. Significant sub-national differences existed after accounting for the effects of other predictors.
    - In both countries across both these outcomes, sub-regional trends were consistent in the adjusted results. In Afghanistan, Badghis province was highest-risk and Herat was lowest-risk, with Ghor in the middle. In Uganda, Karamoja was highest-risk and West Nile was lowest-risk.
- The type of main water source used by an HCF was a significant predictor of HCF **water quality** in both countries (odds of detecting *E. coli* contamination in one or more HCF water samples). HCFs with **piped water** in both countries had significantly lower odds of detecting *E. coli* in water samples than HCFs with water from boreholes and tube wells, even though these are also considered "improved" sources.

Table 21. *Summary of study results and conclusions in Afghanistan*

Summary of study results and conclusions in <u>Afghanistan</u>

- **Basic water service** was 6.3 times more likely among HCFs offering inpatient services than among HCFs offering only outpatient services (aOR 6.251, 95% CL 1.062-45.912), after adjusting for the effects of subregion, geographic setting, and level of care. Analogous measures of an HCF's general size and level of sophistication – level of care, availability of reliable electricity, and water storage capacity – were not significant predictors of basic water service in Afghanistan.
- Access to **hand hygiene** infrastructure at ≥ 1 point of care was 6 times <u>less</u> likely among HCFs in Badghis than among HCFs in Herat (aOR 0.166, 95% CL 0.021-0.914) after adjusting for the effects of having at least one MD on staff and the number of points of care observed.

Summary of study results and conclusions in Afghanistan

- Access to **hand hygiene** infrastructure at ≥ 1 point of care was 5.3 times more likely among HCFs with at least one MD on staff than among HCFs without any MDs on staff (aOR 5.343, 95% CL 1.247-26.235) after adjusting for the effects of subregion and the number of points of care observed. In addition to the technical expertise that MDs bring to their HCFs, increased access to hand hygiene could be a collateral benefit of having at least one MD on staff. Analogous measures of an HCF's general size and level of sophistication – level of care, storage capacity, and outpatients seen per month – were not significant predictors of hand hygiene access at ≥ 1 point of care in Afghanistan.
- **Six Cleans** access in the labor and delivery (L&D) ward was 3 times more likely among HCFs with reliable electricity than among HCFs without reliable electricity (aOR 2.999, 95% CL 1.005, 9.815), after adjusting for the average number of surgeries performed at the HCF per month.
- **Six Cleans** access in the L&D ward was more likely among HCFs that reported performing more surgeries per month than among HCFs that reported performing fewer surgeries per month, with adjusted odds rising about 17.6% for each additional 10 surgeries reported performed per month on average (aOR 1.176, 95% CL 1.003-1.463).
- Detection of ***E. coli* contamination** in ≥ 1 water sample was 15.1 times more likely among HCFs whose main water source was a borehole or tube well than among HCFs whose main water source was piped (aOR 15.100, 95% CL 1.842-347.597) after adjusting for the effects of subregion, level of care, water storage capacity, the percentage of water samples at the HCF that had free chlorine, and the number of water samples tested.
- Detection of ***E. coli* contamination** in ≥ 1 water sample was 24.1 times more likely among HCFs whose main water source was unimproved than among HCFs whose main water source was piped (aOR 24.074, 95% CL 1.591, 792.116) after adjusting for the effects of subregion, level of care, water storage capacity, the percentage of water samples at the HCF that had free chlorine, and the number of water samples tested.
- Detection of ***E. coli* contamination** in ≥ 1 water sample was less likely among HCFs with greater proportions of water samples containing ≥ 0.1 mg/L free chlorine than among HCFs with lower proportions of water samples containing ≥ 0.1 mg/L free chlorine, with odds of detection of *E. coli* dropping by about 22.2% for each additional 10% of an HCF's water samples with free chlorine (aOR +10%: 0.778, 95% CL 0.653-0.901), after adjusting for the effects of main water source type, subregion, level of care, water storage capacity, and the number of water samples tested.
- Detection of ***E. coli* contamination** in ≥ 1 water sample was 8.2 times more likely among HCFs in the Badghis subregion than among HCFs in the Herat subregion (aOR Badghis vs. Herat 8.197, 95% CL 1.533-57.770) after adjusting for the effects of main water source type, level of care, water storage capacity, the percentage of water samples at the HCF that had free chlorine, and the number of water samples tested.
- Detection of ***E. coli* contamination** in ≥ 1 water sample was 6.5 times more likely among HCFs at high levels of care than among HCFs at low levels of care (aOR 6.480, 95% CL 1.250-43.192) after adjusting for the effects of main water source type, subregion, water storage capacity, the percentage of water samples at the HCF that had free chlorine, and the number of water samples tested.
- Detection of ***E. coli* contamination** in ≥ 1 water sample was less likely among HCFs that reported having higher water storage capacity than among HCFs that reported having lower water storage capacity, with adjusted odds falling by about 4.8% for each additional 100L of storage capacity reported (aOR 0.952, 95% CL 0.901-0.989) after adjusting for the effects of main water source type, subregion, level of care, the percentage of water samples at the HCF that had free chlorine, and the number of water samples tested.

Table 22. Summary of study results and conclusions in Uganda

Summary of study results and conclusions in Uganda
• **Basic water service** was 4.6 times more likely among HCFs at high levels of care than among HCFs at low levels of care (aOR 4.594, 95% CL 1.425-18.719) after adjusting for the effects of geographic setting, ownership, and average water use per day.
• **Basic water service** was 3 times more likely among privately-owned HCFs than among publicly-owned HCFs (aOR 3.035, 95% CL 1.194-8.739) after adjusting for the effects of geographic setting, level of care, and average water use per day.
• **Basic water service** was 3.8 times less likely among urban HCFs than among rural HCFs (aOR 0.63, 95% CL 0.065-0.977) after adjusting for the effects of level of care, ownership, and average water use per day.
• **Basic water service** was less likely among HCFs that reported using more water per day than among HCFs that reported using less water per day, with adjusted odds falling by about 1.2% for each additional 100L of average reported water used per day (aOR 0.988, 95% CL 0.969-0.998) after adjusting for the effects of level of care, ownership, and geographic setting.
• Access to **hand hygiene** infrastructure at ≥ 1 point of care was 6.3 times less likely among HCFs in Karamoja than among HCFs in West Nile (aOR 0.159, 95% CL 0.063-0.381) after adjusting for the effects of ownership, average outpatients per month, and the number of points of care observed.
• Access to **hand hygiene** infrastructure at ≥ 1 point of care was 5.4 times more likely among privately-owned HCFs than among publicly-owned HCFs (aOR 5.371, 95% CL 1.554-21.469) after adjusting for the effects of subregion, average outpatients per month, and the number of points of care observed.
• Access to **hand hygiene** infrastructure at ≥ 1 point of care was more likely among HCFs that reported treating more outpatients per average month than among HCFs that reported treating fewer outpatients per average month, with adjusted odds rising by about 20.5% for each additional 100 outpatients treated per average month (aOR 1.205, 95% CL 1.086-1.360) after adjusting for the effects of subregion, ownership, and the number of points of care observed.
• **Six Cleans** access in the labor and delivery (L&D) ward was more likely among HCFs that reported treating more inpatients per average month than among HCFs that reported treating fewer inpatients per average month, with adjusted odds rising by about 44.7% for each additional 100 inpatients treated per average month (aOR 1.447, 95% CL 1.081-2.201) after adjusting for the effects of subregion and average number of deliveries per month.
• **Six Cleans** access in the L&D ward was less likely among HCFs that reported more deliveries per month than among HCFs that reported fewer deliveries per month, with adjusted odds falling by about 13.9% for each additional 10 deliveries reported per average month (aOR 0.861, 95% CL 0.727-0.976) after adjusting for the effects of subregion and average number of inpatients per month.
• Detection of ***E. coli* contamination** in ≥ 1 water sample was 4.2 times more likely among HCFs whose main water source was a borehole or tube well compared with HCFs whose main water source was piped (aOR 4.229, 95% CL 1.290-15.782) after adjusting for the effects of subregion, ownership, level of care, and the number of water samples tested.
• Detection of ***E. coli* contamination** in ≥ 1 water sample was 7.2 times more likely among HCFs whose main water source was an “other” improved source (including: protected springs, rainwater, or tanker truck water) than among HCFs whose main water source was piped (aOR 7.170, 95% CL 1.247-41.850) after adjusting for the effects of subregion, ownership, level of care, and the number of water samples tested.
• Detection of ***E. coli* contamination** in ≥ 1 water sample was 4.1 times more likely among HCFs in Karamoja than among HCFs in West Nile (aOR 4.066, 95% CL 1.274-13.804) after adjusting for the effects of main water source, ownership, level of care, and the number of water samples tested.

Summary of study results and conclusions in Uganda
• Detection of ***E. coli*** **contamination** in ≥ 1 water sample was 4.3 times less likely among privately-owned HCFs than among publicly-owned HCFs (aOR private vs. public 0.232, 95% CL 0.034-0.928) after adjusting for the effects of main water source, subregion, level of care, and the number of water samples tested.

3. General Conclusions and Recommendations for the Public Health Community

As refinement of the JMP service ladders continues, we recommend that the JMP review each requirement of its service level classifications at least annually. With regard to **water**, the results of this study's analyses on basic water service and on water quality have led us to examine the role of "distance to main water source" in the JMP water service definitions. Our *E. coli* detection model showed that an HCF's main water source type was a significant predictor of water quality, but that the location of that water source was *not* a significant predictor of water quality. We acknowledge that having a water source 'on-premises' may be correlated to water *quantity*, another critical consideration, or may simply be a de facto requirement for a designation of basic service for reasons unrelated to water quality. We also acknowledge that distance may be an important consideration even for water quality, because off-site water requires storage, which is a known risk factor for contamination (Bain et al., 2014), and this study did not examine the role of water storage. Still, the results suggested that the criterion of "on-premises" may have differential impacts for different groups of HCFs, potentially resulting in a biased understanding of service levels. The results suggested (though with very small sample size) that rural HCFs could be more likely than urban HCFs to have their water source located "on-premises," which raises issues about the varying nature of HCFs' premises and the very different space constraints imposed on urban versus rural HCFs; high-level versus low-level HCFs; etc. It may be more practical or more equitable to ask whether an HCF has an improved water source, say, "within 50 meters of a point of care" – which could be on-premises for a rural HCF and off-premises for an urban HCF, or could be on-premises for a large hospital but off-premises for a small clinic. If the ultimate goal of assigning service levels is to understand how many HCFs are likely to have reliable access to safe water, we argue that there may be ways to frame the consideration of "distance to an HCF's water source" that are more informative than whether HCF's main water source is technically located on the HCF's premises.

With specific regard to **water quality,** we understand that microbiological and chemical analysis of HCF water samples is simply not possible for most monitoring programs. However, our results lead us to caution against the sole use of "improved" versus "unimproved" as proxy measures for "safe" and "unsafe" water. Findings showed that non-piped improved sources (boreholes, tube wells, and other improved sources) were significantly riskier than piped water sources, and in some cases, these appeared just as dangerous as unimproved sources. To the extent possible, we recommend that the JMP begin incorporating at least simple free chlorine testing into its suite of monitoring indicators, so that we can begin to get a clearer understanding of true water safety.

We also developed recommendations related to the indicators used to classify JMP **hand hygiene** service levels. This study offered a relatively unique opportunity to study hand hygiene access across multiple points of care within an HCF. The descriptive statistics indicate that when we measure hand hygiene access at *any* one or more points of care (the current monitoring indicator), we see coverage estimates that are far more generous than when we measure hand hygiene access at *all* points of care. While we understand that it is impractical to always require observation of multiple points of care, we would recommend that the JMP consider defining the *critical* points of care where hand hygiene is most important and focus on educating HCFs and partner organizations about the importance of having functional hand hygiene infrastructure at not one but *all* of those critical points of care. We also recommend the JMP consider adding a supplemental indicator to the Hand Hygiene service ladder to measure the percentage of points of care (or percentage of critical points of care) observed to have functional hand hygiene stations at an HCF, in hopes that over time, this indicator may evolve and replace the current indicator that allows one point of care to represent all points of care at the HCF**.** Finally, our analysis of determinants of hand hygiene access led us to the somewhat surprising recommendation that the public health community prioritize capacity-building in formal education and training of medical doctors. Our results revealed that employing at least one Medical Doctor (MD) at an HCF significantly improved the HCF's odds of access to a hand hygiene facility (in Afghanistan), more than any other factor. The positive effects of having MD-level personnel at a facility seem to extend beyond their technical skill, as these individuals may bring a broader array of positive practices and behaviors to the institutions where they eventually work.

With regard to **hygiene in labor and delivery settings** (the Six Cleans), we recommend increasing the specificity of monitoring indicators to the extent possible. The JMP does not currently monitor the availability of specific components of sterile equipment in labor and delivery (L&D) settings. It monitors the availability of "sterile equipment or delivery kit" [emphasis added] as opposed to measuring presence of individual items at the level of detail that the WASHCon assessment permits. "Sterile equipment" implies metal instruments and other items that can be cleaned in an autoclave, and measuring sterile equipment **or** a birth delivery kit may overlook the importance of the soft goods listed in the Six Cleans framework (clean towels or cloths). Our findings showed that these soft goods were an important limiting factor for Six Cleans access in both countries, and previous research has established that they are also are more challenging to clean and require higher levels of water use than the metal instruments that can be sterilized in an autoclave. We recommend that the JMP expand its monitoring of specific materials in L&D wards to assess access to each of the Six Cleans individually.

The Six Cleans models in each country had no shared variables of significance – results differed entirely by country – but reported surgeries per month in Afghanistan and reported inpatients per month in Uganda are both measures of patient volume, and both these and reliable electricity could be loosely construed as indicators of resource *availability* at an HCF. The only factor that was negatively correlated with access to the Six Cleans – reported deliveries per month – can be understood as an indicator of resource *strain* or resource *consumption* at an HCF. These findings lead us to the unfortunate conclusion that many L&D wards have fewer resources than they have patients in need of such resources, suggesting that resource limitations and overcapacity in L&D wards could be hindering Six Cleans access and causing unsafe birth conditions. We recommend the JMP emphasize to HCFs and partners the criticality of WASH in birth settings, and that the JMP find ways to focus its monitoring on labor and delivery wards so that pregnant women can trust that giving birth at an HCF will be safer than giving birth at home. We also recommend that reliable electricity be considered an important metric for future study. The fact that electricity was the strongest predictive factor of Six Cleans access in Afghanistan indicates that it may be a useful predictor of other HCF conditions, and the metric by itself provides important operational insight and perhaps also information about an HCF's overall level of infrastructure and connectedness.

Finally, although behavior is outside the delimited scope of this study, behavioral WASH in HCFs will be a critical component of any intervention proposed in response to these findings. As the JMP continues to improve its monitoring and collection of data specific to HCF WASH infrastructure, we recommend that the JMP also focus on observing and understanding WASH behaviors to ensure that the gains being made to infrastructure and resources will be fully realized in behavior and practice.

4. Recommendations for the WASHCon Study Team

The WASHCon tool is a rich and well-structured data collection tool, but there is always room for improvement to the tools we rely on to collect useful and actionable data. This final section contains some recommendations for the WASHCon team based on lessons learned from compiling, cleaning, and analyzing WASHCon data in Afghanistan and Uganda. Some recommendations here may have already been addressed by the study team since data collection was undertaken. Others may be attributable to a lack of context on the part of the author – i.e., WASHCon team members with a better understanding of the tool's design and use may have been able to avoid some of the pitfalls that drove these recommendations. None of these recommendations should be construed as in any way disparaging to the tool, its designers and data managers, or the teams who carried out this valuable testing. Recommendations have been assigned reference letters based on their subject area and are numbered for ease of reference.

4.1. Water (W)

W-01: Confirm the source of each water sample on the Water Quality form. It is recommended to record for each sample: (A) what type of water source is being sampled; (B) whether it is an improved or unimproved source, especially if the source type does not make that clear; and (C) whether it is the same source mentioned on the Director form as the HCF's Main Water Source. This will allow for clearer assignment of water service levels according to the JMP definition. (Some of this information was recorded in Afghanistan, but only because the Afghanistan Water Quality data set did not follow the standard Form.)

W-02: Confirm whether each water sample was taken from a container of stored water, or from a tap within the premises, or directly from a water source. In the event that a sample was taken from stored water, record the storage type on the Water Quality form. The effects of different water storage types on water quality at HCFs was initially a topic of interest for this study, but we found ourselves unable to study it because we could not parse what type of storage each water sample came from, if any. The Director form asks how the HCF stores water, but the response options are "Select Multiple," so enumerators select all that apply. There is no question that defines a "main" storage type. Similarly, the Ward form asks if water is stored in the ward, but it allows multiple responses and does not specify a "main" storage type – and, this information would only be useful if the Ward and Water Quality forms were able to be directly linked (see **W-03**). The Water Quality form would be the best place to ask this information, but currently it asks only for "WQ location" – which includes an answer option for 'water source' along with answer options for various points of care – but it does not allow the respondent to specify whether the sample was taken from a tap or a storage container at a given location, or if stored, what type of storage was used.

W-03: When a water sample is taken from an observed Ward, consider the best way(s) to link the Ward form with the corresponding sample's Water Quality form. There is a field on the Ward form for ward type (*ward_g_type*), and a field on the Water Quality form for the water sample location (*wq_location*, also referenced in **W-02**), but the response options between the two fields are not standardized, and there is no way to directly link the data from the Ward form with the Water Quality data from water sampled on that ward. If the response options for *ward_g_type* and *wq_location* were standardized, the 'ward type' and 'WQ location' fields could potentially allow analysts to link the data by matching first the HCF name (or caseID) and then matching the ward type with a corresponding 'WQ location' at that HCF. However, even this would still be sub-optimal, especially because some HCFs assessed were very large and had multiple surgical wards or multiple labor & delivery wards observed, preventing exact 1-to-1 linkage of ward data with its relevant water quality data. Enabling a direct link between the Ward form and any corresponding Water Quality form would dramatically expand the range of questions we are able to explore in the data analysis.

W-04: Consider using measurements to corroborate (or replace) interviewee responses to water use and water storage questions requiring a numeric response. Average Water Use per Day and Storage Capacity were of particular interest as predictors in multivariable modeling because they were the only two continuous variables that were specifically focused on water. Values for these variables were obtained through interviews with HCF staff. Many HCF staff members are certainly very familiar with their HCFs' daily water use and storage volumes and able to provide precise estimates during an interview, but several highly improbable estimates were recorded, especially for Average Daily Water

Use, including estimates of up to 1 billion liters of water use per day at low-level, rural facilities. All of the most-questionable values were reported as repeating 9s (i.e., 999999999), suggesting the respondent or enumerator was seeking to convey simply an unknown high number. The existence of suspect values like these (which were removed from the data set prior to analysis) suggested that Average Daily Water Use in particular may be challenging metric to ask an interviewee to provide during an interview, at least in some HCFs. Sole reliance on interview responses for collecting this type of quantitative numerical data seems problematic. It is recommended to explore methods by which these, and similar variables (e.g., water storage capacity), could be verified through measurement. (The water storage capacity variable also displayed some values that seemed surprising, but none of those values were suspicious enough to justify removal from the data set.)

W-05. Consider codifying WASHCon's recommended testing methods and standards for measuring free chlorine, and consider training and regularly re-training country teams on these standards. Different standards were applied for measuring free chlorine across different countries. Enumerators in Afghanistan provided numerical estimates of free chlorine levels that were an order of magnitude more specific than their measurement instrument was capable of conveying. [I.e., results were guessed to two decimal places although the measurement instrument, a visual testing kit designed to test higher levels of free chlorine in recreational water (Palintest, 2019), was only capable of measuring results to one decimal place, and only at certain intervals.] In Uganda, the study team reported that water samples were not tested for free chlorine unless staff believed the HCF had access to chlorinated water, but these untested samples were simply marked 0 mg/L free chlorine. Thus, during data analysis, an untested sample was not differentiable from a true 0.0 mg/L measured result. Omitting the chemical free chlorine test may be the correct course of action in this circumstance, avoiding waste of reagent tablets and conserving resources when a reliable witness states no chlorine will be found, but results should be tagged as such (e.g., a check-box option stating “chemical test omitted due to… [staff report of no access to chlorinated water]”, etc.). This information is important context for analysts working with WASHCon data.

4.2. Hand Hygiene (HH)

HH-01: Consider updating the WASHCon Glossary of Terms and the WASHCon observation forms to align our definition of a hand hygiene facility with the JMP’s 2019 definition of a hand hygiene facility. As of 2019, the JMP definition of a hand hygiene facility includes “water and soap and/or alcohol-based hand rub (ABHR)”. With respect to hand hygiene at points of care, the JMP is explicit that it does not require the presence of soap or water – it emphasizes the importance of “a hand hygiene product (for example, ABHR, **or** soap and water) […] within an arm’s reach of where patient care or treatment is taking place,” [p 39, Box 6: (JMP, 2019); emphasis added]. However, WASHCon’s glossary states that a hand hygiene facility (even at a point of care) must have “water access and water disposal” (WASHCon, 2019) and makes no mention of soap or hand sanitizer – a notably different standard than the standard set forth more recently by the JMP. Because the Ward form enabled enumerators to note the existence of water, soap, hand sanitizer, and any combination of these three with or without the others, it did ultimately capture the data necessary to be able to apply the JMP definition during data analysis. However, it is unclear whether enumerators – presumably having been trained on the WASHCon definition of a hand hygiene facility – may have answered “none” if, at a glance, there was very clearly no sink or water utility present. This possibility would imply potential under-estimation of the prevalence of hand hygiene at points of care. To avoid confusion and align with global standards, we recommend updating the WASHCon definition to align with the latest JMP definition, both in the glossary and in the WASHCon form questions related to hand hygiene.

HH-03: When enumerators are asked to observe a hand hygiene facility, consider including in the form's hint text: (A) the definition of "functionality" for hand hygiene facilities; (B) explicit instruction to verify that the hand hygiene station components are functional; and, (C) a check-box or other space on the form to record whether verification was successfully completed. Currently, when an enumerator evaluates hand hygiene infrastructure at a point of care, the Ward form dictates that the enumerator simply "observe a functional hand hygiene facility" and note the materials present, but the form does not include any specifics about what functionality entails. (The WASHCon Glossary does define functionality, but that is not available to the enumerator during the assessment itself.) More importantly, the Ward observation form does not include instruction to verify functionality; it assumes functionality as part of the question. Without a clear understanding of whether and exactly how the WASHCon enumerators are verifying a hand hygiene station's functionality, we may be over-estimating access to "functional" hand hygiene stations.

HH-03: Consider asking about reported access to hand sanitizer, in addition to water and soap, in the Director survey. Hand sanitizer access is measured on the Ward form when the enumerators observe hand hygiene facilities (see: **HH-01** and **HH-02**). However, the questions through which HCF staff *report* hand hygiene access are located on the Director form, and currently these questions only inquire about access to water and soap.

This prevents meaningful comparison of 'reported' and 'observed' access to hand hygiene, because the 'reported' access questions are missing the hand sanitizer component.

HH-04: Consider adding a behavioral component to the WASHCon forms so that hand hygiene behavior (not just infrastructure) can be observed and investigated. While the WASHCon assessment is a cutting-edge tool, it could be improved by adding observations and qualitative interview questions to the WASHCon tool that will help us understand how to encourage and improve WASH behaviors at HCFs. This behavioral component is especially important for hand hygiene, as hand hygiene behavior is a critical component of all hand hygiene interventions.

4.3. General/Administrative (GA)

GA-01: Ensure all data is entered through the standardized WASHCon forms, and automatically include an HCF-level case ID number on all forms. To link each HCF's data from the five different WASHCon forms relevant to this analysis, we needed to merge the data sets together. Ideally this would have been completed with a unique HCF-level ID number present on all forms, but there was no such ID number provided with the form data sets.[26] In the absence of a linking ID, we used the HCF's name (case_name) as its identifier, which was the only potential linking variable that appeared on every form. While the case_names often matched exactly between data sets, including matching idiosyncrasies like extra spaces or unexpected letters, there were some entire data sets where these case_name idiosyncrasies did *not* match the others. This suggested two things: first, that the forms

[26] There was a 'formID' on many of the form data sets, but this was not a linking variable; it was unique to the entries for each form. After data cleaning had already been completed, we learned of the potential existence of a 'caseID', but the caseID number had not been provided with the forms.

generally seemed to be attached to a higher-level 'case', and could be linked to the case by choosing the original case_name entry from a list; but, second, that not all of the data sets or entries were in fact generated through this standardized form process. The two primary examples were the Water Quality data set in Afghanistan and the 'Facility List' data set in Uganda that formed the basis for all demographic variables that were added to the GPS data set. These data sets did not appear to be the output of a form, and the case_name entries appeared to have been entirely free text. The inclusion of an automated caseID in form outputs would *not* have solved the problems that these two data sets posed for data cleaning and merging, because these data sets did not appear to be the output of a form within the standard system. Thus, this recommendation has two parts: (1) ensure that the standard forms are easily linked by including an HCF ID (case ID) number, and (2) ensure, to the extent possible, that all relevant data is collected and recorded through the standard forms.

GA-02: Consider adding a standardized form or case-level fields to append key demographic information to the HCF's case record. During this study, the author and the study teams in each country worked to amass demographic data on these HCFs (e.g., type, level of care, geographic setting, ownership, etc.), variables which were extremely important for data analysis. But these data points were not collected through WASHCon forms, and thus, adding them to the WASHCon data sets generally required using reference lists and making painstaking corrections to the HCF names on these reference lists such that they exactly matched the WASHCon *case_name* values. Only then could these important demographic variables be merged into the data collected onsite through WASHCon forms directly. (See: description of matching 'Facility List' data in **GA-01**). It is recommended to add a form or section of the database where important case-level variables can be added (before or after the actual data collection at the HCF, or during), so that during the analysis phase those demographic factors are already integrated in with WASHCon data and can be more easily analyzed alongside the outcomes of interest recorded in the WASHCon forms.

GA-03. Country teams and data managers should document their processes and procedures in real time and compile them in a central WASHCon database for ongoing access. Understanding the testing methods, and any deviations from stated methods, is important for interpretation of the data. Finding detailed information on the methods used in each country more than a year after the assessment was challenging, especially due to staff turnover and staff leave. Study teams in both countries were exceptionally accommodating in helping to track down this information, including reaching out to individuals who no longer worked for the study to be able to provide the detail needed, but this kind of 'key person' dependency could be avoided by maintaining a cloud-based repository for the study team where enumerator guidance, testing methods, exceptions, etc. could be documented in real time and could remain available for future users of the data. As new versions are created, automatic or semi-automatic version control protocols can retain the outdated versions in an archive such that data users can find the standards and forms that were in effect during the exact timeframe in which they are interested.

5. Conclusion

The WASHCon study is an innovative and important part of the global effort to monitor and improve conditions at LMIC HFCs, especially in high-risk, low-development situations where data has often been scarce. The results of this analytic study of WASHCon data generally support prior research into the studied phenomena, and contribute important new data to the global public health conversation about HCF WASH. As we work towards meeting the UN's Sustainable Development Goals (SDGs) by the year 2030, the study of HCF WASH – a field at the intersection of many SDG targets – will only continue to grow in relevance and receive more global attention. Small gains in access to and quality of HCF WASH services can make big differences that impact individuals, families, and entire communities. The work of the WASHCon study teams all over the world, and the work of those analyzing the important data collected through WASHCon, will continue to be critical for building successful health systems that provide high-quality health care and ensure access to safe HCF WASH for all.

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Appendix A. WASHCon Tool Executive Summary

This brief highlights the WASHCon tool's purpose and its specific capabilities for use within the broader framework of the WHO's WASH FIT cycle. Reproduced as submitted to the author by the study team on September 19, 2018 (CGSW, 2018a).

EMORY UNIVERSITY | Center for Global Safe Water, Sanitation, and Hygiene — WASH in Healthcare Facilities Initiative

WASHCon & WASH FIT: Working in Concert

WASHCon (WASH Conditions) Assessment Tool is...a data collection tool that provides a broad assessment of WASH conditions, infrastructure and resources in healthcare facilities (HCF) in low and middle-income countries. WASHCon measures five core WASH domains in healthcare facilities: water supply, sanitation facilities, hand hygiene facilities, environmental cleanliness and waste management. The tool encourages users to engage with regional and national stakeholders to undertake the assessment, which include surveys, observations, and water quality data. The data are collected on a mobile device and uploaded to a dashboard for data visualization and analysis. The dashboard allows users to view WASH scores by HCF and/or compare data across multiple HCF.

The purpose of the WASHCon tool is to:

1. Develop a **comprehensive** overview of the status of WASH conditions, infrastructure and resources in HCF, contributing to the evidence base for advocacy and action in the area of WASH in HCF.
2. Allow individual HCF to identify which WASH domains are in need of improvement.
3. Provide data to inform and prioritize local and regional programmatic activities to improve WASH in HCF.

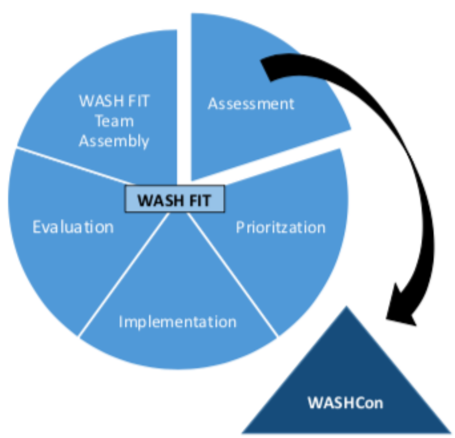
WASH FIT (Water and Sanitation for Health Facility Improvement Tool) is...a practical guide for improving quality of care through water, sanitation, and hygiene in health care facilities. It involves a five-step cycle: creation of a WASH FIT team, assessment, prioritization, implementation, and evaluation. The tool is used at the facility level to help individual hospitals and health centers take ownership of their WASH status, understand the current WASH situation and make phased improvements. WASH FIT covers water, sanitation, hygiene and management.

The purpose of WASH FIT is to:

1. Prioritize and maintain WASH improvements internally within a HCF, focusing on action.
2. Encourage HCF to take improvements upon themselves, through ready-to-use tools and detailed instructions for each step of the WASH FIT cycle.

WASHCon and WASH FIT can be used in concert to complement one another. Specifically, WASHCon can be used within the WASH FIT cycle at the "assessment" step.

By substituting WASHCon for the WASH FIT "assessment" tool, users will achieve several benefits. First, WASH FIT users will be able to quickly identify high priority WASH needs via the WASHCon digital scoring system and dashboard visualization. Second, the WASHCon assessment will provide robust data to optimize the next step of the WASHFIT cycle (i.e. prioritization). Third, WASHCon data can be used for other purposes besides WASH FIT implementation such as reviewing WASH conditions for multiple HCFs or comparing HCFs according to WASH indicators, geographical region, or facility type. Together, the comprehensive WASHCon dataset and the WASH FIT risk based planning focus will provide a systematic approach to designing facility improvements that engages staff and local community members, emphasizing ownership and sustainability.



EMORY UNIVERSITY | Center for Global Safe Water, Sanitation, and Hygiene — WASH in Healthcare Facilities Initiative

Comparison of WASHCon (Emory) and WASH FIT (WHO) Tools

Tool Capabilities	WASHCon	WASH FIT
Facility Type	✓ All	– Primary Care[1]
Facility Conditions Assessment	✓	✓
Management Assessment	✓	✓
Behaviors Assessment	✗	– Minor Focus
BabyWASH Assessment	✓ [2]	✗
Implementation Guide	✓	✓
Facility Scorecard	✓	✓
Risk-Based Planning Approach	✗	✓
Guided Facility Improvement	✗	✓
Individual Facility Reports	✓	✓
Multi-Facility Data Comparison	✓	✗
JMP Indicator Comparison	✓	✗
Mobile Data Collection	✓	✓
Data Visualization	✓	✗

Notes:

1: WASH FIT can be used in larger facilities, however assessment of surgical wards and other wards where invasive procedures occur are not included in the tool. Efforts are underway to adapt the tool to secondary and tertiary HCF.

2: WASHCon offers a version of the tool with BabyWASH questions, as developed by World Vision.

About the Center for Global Safe WASH at Emory University

www.cgswash.org

The Center for Global Safe Water, Sanitation, and Hygiene (CGSW) focuses on increasing access to safe drinking water, adequate sanitation, and appropriate hygiene as part of a global strategy to break the cycle of poverty and disease in developing countries.

For further information on the WASHCon tool, please contact Lindsay Denny - ldenny@emory.edu

For further information on the WASH FIT tool, visit https://www.WASHinHCF.org/resources/tools

Appendix B. WASHCon Enumerator's Guide

This guide provides an overview of the surveys used and recommended data collection techniques for the WASHCon tool. Reproduced as submitted to the author by the study team on September 19, 2018 (CGSW, 2018b).

CHAPTER 5: ENUMERATOR GUIDE

This section guides enumerators through the process of efficient and successful data collection using the WASHCon Assessment Tool. The tool evaluates WASH conditions that fall into five domains: water supply, sanitation facilities, hand hygiene facilities, environmental cleaning practices, and waste management. The questions and domains are based off of the WHO WASH in HCF monitoring indicators. The tool has a GPS reading, six on-site data collection surveys and two water quality assessments to be completed after water quality testing.[27] The tool is broken down into the following forms:

1. GPS reading form
2. Director form
3. Management form
4. Administrative data form (number of patients, services, etc.)
5. Ward observation checklist form
6. Toilet facility observation checklist form
7. Sanitary Inspection form
8. Water quality – aggregate form[28]
9. Water quality – individual form[14]

The length of time required to conduct the survey varies by size of the facility. Health centers take less than two hours per site to complete while larger hospitals will require approximately four hours. In both cases, it is recommended that you conduct the assessment with two enumerators, though it can be done with one.

The assessment is conducted on a mobile device, with separate sections for each survey so that enumerator teams may conduct different sections of the assessment at the same facility simultaneously. It is suggested that both enumerators interview the director, but then they may divide the assessment and complete the remaining sections for efficiency. See Appendix III on mobile data collection (*Note: Appendix III was not provided to the author*).

In order to obtain accurate water quality data, water samples should be collected at the time of visit or as soon as possible following survey data collection, either by an enumerator or a contracted local laboratory technician. A total of three to eight water samples should be collected from key wards and tested for *E. coli.* For sites with chlorine treatment, and chlorine residual should also be measured. Chapter 6 provides further information on water testing (*Note: Chapter 6 was not provided to the author*).

5.1 Pre-Assessment Guidelines

[27] There are a total of nine survey forms.
[28] This assessment may be done by a laboratory technician. This role will be determined and assigned by the project coordinator.

The following are general guidelines that will help in using the tool effectively.

1. Thoroughly read each section of the surveys to understand the meaning of the questions and become familiar with questions and responses.
2. Ensure you have a translated version of the surveys if necessary, including the glossary.
3. Ensure you have the contact information of the HCF and confirm your field visit prior to departure.
4. Ensure all logistics and equipment required for the field visit are in place prior to departure.

5.2 Arrival at a Healthcare Facility

The enumerator should be formally introduced to the director of the HCF and obtain verbal consent before proceeding with data collection. In addition, permission should be sought before the enumerator moves through the wards to conduct observations and collect water samples. It may be helpful for the administrator to assign a staff member to lead the enumerators around the HCF.

The following are guidelines related to each section of the WASHCon tool assessment:

1. Follow the instructions in each section carefully. Use the annotated surveys to guide surveys and observations, as needed.
2. Ask questions as they are written and avoid leading the respondent to select a particular answer
3. Listen attentively to the respondent.
4. Give respondents adequate time to respond to the questions. Respondents may be shy about answering or may need some time to decide what to say. Each time you ask a question, give them at least 10 seconds before prompting them. Once you have asked the question, silently count to 10 before you speak again.
5. Avoid spending too much time per question. Respondents may want to provide additional information that is not relevant to the survey. It is your task to gently steer them back to survey questions.
6. Should the respondent require clarification, the enumerator may rephrase the question slightly to elicit an accurate response.

5.3 GPS Query

To begin the assessment, open the GPS Reading form and record the location of the healthcare facility.

5.4 Director and Management Forms

The first section of the WASHCon Assessment is an interview with the director or his/her designee. The survey is comprised of modules on electricity, water supply, water treatment, hygiene, sanitation, and waste management. The interview will consist of two forms: Director and Management. You should start with the Director form first, and then move onto Management.

Before beginning the assessment:

1. Introduce yourself and explain the purpose of the survey.
2. Describe the various sections of the survey, the areas of the facility you will need to assess during your visit and when/where water sampling will occur.
3. Explain that the assessment is conducted on a mobile device.

4. Ensure the director that his/her responses will be used only to better understand the current condition of WASH in the facility with the intention of improving these conditions through targeted action. There is no intent of reprimanding HCF for falling short. If your team received ethical approval for the assessment, acknowledge this approval.
5. Finally, ask the director if s/he is willing to be interviewed. Once receiving verbal consent, you may proceed with the interview.

The director should answer each of the questions to the best of his or her ability. If the director does not know the answer, s/he should be prompted to give their best guess or identify someone who may be able to answer the question. For some designated questions, the enumerator may select the response option "don't know."

5.5 Administrative Data Form

This section is completed using information gathered from HCF administrative records and through survey questions. After interviewing the director, you should provide him/her with a list of the information from the data records required. The director may assign an administrative staff member to collect the various data records. Questions related to HCF services and populations served are included in this form.

To save time, it may be best to print out the questions in the local language and leave it with the HCF director so s/he can gather the information while you visit the wards and toilets to conduct the observation checklists. You can return after observations to complete the data records section.

5.6 Ward Observation Checklist

This section requires you to visit up to five key wards and the kitchen and record your observations. The ward observation checklist differs from the surveys in that it is filled out multiple times at each HCF. These areas of the HCF include:

1. Outpatient ward
2. Inpatient ward
3. Surgical theatre/post-surgery ward
4. Labor & delivery/maternity ward
5. Pediatric (children's) ward
6. Kitchen

It is most important to visit the outpatient ward and labor and delivery ward. Not all HCF will have these six areas, especially if it is a smaller HCF like a health center or health post. If the HCF does not have the ward, you do not need to complete a checklist for it. If the ward is missing some of these wards but has others of interest to your group, such as emergency or ICU, you may also select "other".

Should the HCF have more than one of any of the wards listed, one should be chosen at random to be observed. Additional wards may be observed by selecting "other" and filling in the name of the ward observed. The ward observation checklist includes information on IPC supplies, handwashing stations, and general hygiene conditions in each ward.

5.7 Toilet Facility Observation Checklist

You will visit all toilets facilities on the HCF premises. Like the ward observation checklist, the toilet facility observation checklist is also filled out multiple times at each HCF. The observation checklist includes questions regarding the type of toilet, the type of user (gender, patient vs. staff), the number and functionality of toilets, and toilet cleanliness and accessibility (including accessibility for persons with disabilities). The checklist also includes observations on the availability of hand washing facilities and menstrual hygiene management. It is important that the enumerator is familiar with the various definitions of terms to ensure consistency of results.

5.8 Sanitary Inspection Form

The sanitary inspection form can be conducted at any point during the visit around the healthcare facility. The purpose of the form is to observe water availability and to collect information about the conditions of the healthcare facility premises.

5.9 Water Quality Forms

The water quality testing should be conducted at the time of the WASHCon tool assessment or as soon as possible following the survey data collection. This requires the collection of water samples from key wards of the HCF to test for *E. coli* and chlorine residual. In addition, if the HCF or its adjoining community has a known history of water contamination not related to the tests recommended above, additional tests may need to be conducted. After the test is completed, both the aggregated and individual water quality forms should be filled out.

Appendix C. WASHCon Survey Forms and Data Dictionary

WASHCon survey forms for **Director**, **Admin**, **Ward**, and **WQ** data sets are reproduced here directly from the WASHCon study team's data dictionary, called the WASHCon Unification Document or "UniDoc" (CGSW, 2018c). Those forms contain the following data for each indicator:

- original variable name;
- question type;
- question and answer text;
- skip logic (if any), as coded into the forms on the mobile survey platform; and,
- hint text provided to the enumerators.

The fifth and final WASHCon form used for this analysis, **GPS**, takes a slightly different format. The GPS form was not a survey. The only analysis variable in the original WASHCon GPS form was information from a GPS device – i.e., the only information on the form was the location information from the GPS and some system-generated variables such as the enumerator's username and the time of form completion. For the purposes of this analytic study, data for certain demographic variables of interest in Afghanistan and Uganda was compiled using outside (non WASHCon) data and was appended to the WASHCon GPS data sets to allow those variables to be included in HCF-level analysis. The GPS section here provides the author's summary of the process of creating those variables from external data. For all other additions, including any variables created as composite variables during data cleaning and analysis, see the Data Cleaning Log in **Appendix E** and the Variables Table in **Appendix F**.

Indicators on the standardized WASHCon forms have been refined and updated over time to conform with updates to international guidance on WASH in HCFs or otherwise improve data collection. Thus, the indicators and responses from Afghanistan (2018) and the indicators and responses from Uganda (2017) did not perfectly match each other, nor do they perfectly match the indicators and responses in this version (2019). For details on indicator changes over time, see **Appendix D** (WASHCon Variable Inclusion Log). For details on this project's data harmonization and any altered values, see **Appendix E** (Data Cleaning Log).

1. GPS Form and Added Demographic Variables

Unlike the other data sets, the GPS data set did not come from a standardized survey. GPS data and general HCF data were sent to the author by the study team in the following formats, which differed by country.

Afghanistan

The Afghanistan GPS form contained the following variables (as received from Lindsay Denny, September 27, 2018):

number	[subregion]	**form.case.case_name**	**formid**	**form.please_record_your_location**

^ Header was blank but contained values for ***subregion*** *(Herat, Ghor, Badghis)*

(cont'd)

completed_time	**started_time**	**username**	**received_on**

Most of these variables were later dropped, as they were unnecessary for analysis. Variables **form.case.case_name** (shortened to **case_name**) and the blank column for subregion (renamed **gps_subregion**) were retained. The study team later relayed the following additional demographic data, which were added to the GPS data set as new variables using Excel's VLOOKUP function (after harmonizing all values of the **case_name** variable).

- **gps_rural_0_urban_1:** Experts from World Vision Afghanistan categorized each HCF as rural or urban (variable initially called "location" - relayed by Lindsay Denny, December 4, 2018). This data was migrated into the GPS form using VLOOKUP and coded in binary format as a 0 (rural) or 1 (urban).
- **gps_type:** The study team provided each HCF's type, also known as level of care (SHC, BHC, etc.) (Lindsay Denny, December 4, 2018). Data was migrated into the GPS form using VLOOKUP.
- **gps_ownership** : All Afghan HCFs sampled were public HCFs (email: Lindsay Denny, April 10, 2019). This data was entered into the GPS data set manually, as the value of this variable was the same for all HCFs in Afghanistan.
- **gps_district**: This was added to Afghanistan's GPS data set from the three Afghanistan Water Quality data sets, as it was determined to fit better with this data set than with the Water Quality data. (See Water Quality section of this Appendix for details.) Ultimately, this variable was not used for analysis.
- **gps_country** Finally, a variable for country was added to the GPS data set (value for all observations =Afghanistan), as we anticipated it would be useful in the next steps when we combined the Afghanistan and Uganda data sets.

Thus, the final version of the Afghanistan GPS form as uploaded into SAS for analysis included the following variables:

case_name	gps_country	gps_subregion	gps_district	gps_rural_0_urban_1	gps_type	gps_ownership

Uganda

The Uganda GPS form initially contained the following variables (as received from Habib Yakubu in two separate sheets labeled "Facility List", one Karamoja and one West Nile, November 9, 2018):

code	name	type	ownership	authority	status	coordinates	region	district	subcounty

*Note: column labeled **code** was blank in both Karamoja and West Nile sheets*

The Facility Lists sheets contained data for sampled HCFs, but also contained data for some other (non-sampled) HCFs in these regions. To create the GPS data set for our sampled HCFs, we first updated the variable "name" to be called **case_name** in keeping with other forms. We then used a VLOOKUP function to pull Facility List data for our 148 sampled HCFs into a separate sheet, after harmonizing the values of the **case_name** variable between the Facility Lists and the existing Director data set. The blank column **code** was dropped and, after determining we could assign rural and urban designations through a different means, the variable **coordinates** was also dropped. The variable **region** was renamed **subregion**, and all variables were renamed to include the prefix '**gps_**'. A variable **gps_country** was added (value for all observations =Uganda), as we anticipated it would be useful in the next steps when we combined the Afghanistan and Uganda data sets. Finally, we created the variable for geographic setting (urban vs. rural) as follows:

- **gps_rural_0_urban_1:** In Uganda, expert advice on designating an HCF as rural vs. urban was not available, so the study team advised adopting a standard definition based on government data. Uganda's definition of "urban areas" comes from its National Population and Housing Census, from the National Bureau of Statistics. The distinction between urban and rural areas is made at the Subcounty level: "The 2002 and 2014 Censuses defined urban areas to include only the gazetted urban centres (City, Municipalities, Town Councils and Town Boards)" (UBoS, 2017). Because we had the data for each HCF's subcounty, we were able to search our sampled HCFs and designate as Urban all HCFs in a Subcounty that contained "City", "Municipality", "Town Council", or "Town Board". All others were designated Rural. This matching was performed using Excel functions IF, SUMPRODUCT, ISNUMBER, and SEARCH, e.g.: =IF(SUMPRODUCT(--ISNUMBER(SEARCH(*[array bracket]* "City","Town Council","Town Board","Municipality"*[array bracket]*, I2)))>0,1,0), where column I is the subcounty column; I2 is the value being searched for those key terms; 1 is the value assigned if any of those terms are found; and 0 is the value assigned if none of those terms are found. The variable for Subcounty was subsequently dropped as it was not necessary for analysis.

Thus, the final version of the Uganda GPS form as uploaded into SAS for analysis included the following variables:

case_name	gps_country	gps_subregion	gps_district	gps_rural_0_urban_1	gps_type	gps_ownership	gps_authority

2. Director Form

DIRECTOR Form Variable Name/ Ans Value	Type	Question/Answer Text	Skip logic	Hint Text
label_section_1	Label	Interview with the Director		
dr_label	Label	– Introduce yourself to the director and explain your purpose. – Explain that the survey will be done on a mobile device. – Ask for permission to interview		

DIRECTOR Form Variable Name/ Ans Value	Type	Question/Answer Text	Skip logic	Hint Text
		and then visit the wards and toilets to observe and take samples.		
dr_g_dep	**Select Multiple**	**Which of the following services or departments are available at this healthcare facility?**		**Read all options. Check all that apply**
aanatal		Antenatal Care		
den		Dentistry		
ed		Emergency Department		
env		Environmental Services		
eye		Eye Clinic		
fam_plan		Family Planning		
hiv		HIV/VCT/ARV Clinic		
housing		Housing for Staff		
immun		Immunization		
inpatient		Inpatient		
icu		Intensive Care Unit		
kitchen		Kitchen		
lab_del		Labor and Delivery		
lab		Laboratory		
sur_maj		Major Surgery		
morgue		Morgue		
sur_min		Minor Surgery		
nut		Nutrition Services		
outpatient		Outpatient		
peds		Pediatric		
pha		Pharmacy		
postnatal		Postnatal		
tb		TB Services		
oth		Other		
dr_g_dep_oth	**Free Text**	**Specify other:**	**dr_g_dep = 'oth'**	
label_electricity	**Label**	**Electricity**		**Now I'm going to ask you some questions about electricity.**
dr_g_esource	**Select Multiple**	**What sources of electricity are used at the healthcare facility?**		**Read all options aloud. Check all that apply**
util		Utility power		

DIRECTOR Form Variable Name/ Ans Value	Type	Question/Answer Text	Skip logic	Hint Text
solar		Solar power		
gen		Generator (petroleum)		
firewood		Firewood		
char		Charcoal		
lpg		LPG		
none		No power source		
other		Other		
dk		Don't know		
dr_g_eprim	**Select One**	**If there is more than one source of electricity, which is the main source used by the healthcare facility?**	**dr_g_esource != none and count-selected(dr_g_esource)>1**	
util		Utility power		
solar		Solar power		
gen		Generator (petroleum)		
firewood		Firewood		
char		Charcoal		
lpg		LPG		
none		No power source		
other		Other		
dk		Don't know		
dr_g_eint	**Select One**	**If electricity (utility, solar, generator) is used to power the facility, how many days last month was the electricity from [the main source] interrupted for more than 2 hours at a time?**	**dr_g_esource != none**	**Read all options aloud**
everyday		Everyday		
most_day		Most days but not every day		
sev_day		Several times		
once		Once		
never		Never		
dk		Don't know		
label_water_supply	**Label**	**Water Supply**		**"Now I am going to ask you some questions about water supply."**
dr_ws_sa_avl	**Select Multiple**	**Please tell me which of the following sources of water are available to the healthcare facility:**		**Read all options aloud. Check all that apply**

DIRECTOR Form Variable Name/ Ans Value	Type	Question/Answer Text	Skip logic	Hint Text
pip		Piped supply from outside the facility		
tub		Tube well		
bor		Borehole		
p_well		Protected dug well		
rain		Rain water		
u_well		Unprotected dug well		
surf_water		Surface water		
tank		Tanker truck		
oth		Other		
dk		Don't know		
none		No water source		
dr_ws_sa_avl_other	**Free Text**	**Specify other:**	**dr_ws_sa_avl = oth**	
dr_ws_sa_main	**Select One**	**What is the main water source for the healthcare facility?**	**dr_ws_sa_avl != none**	
pip		Piped supply from outside the facility		
tub		Tube well		
bor		Borehole		
p_well		Protected dug well		
p_spring		Protected spring		
rain		Rain Water		
u_well		Unprotected dug well		
surf_water		Surface water		
tank		Tanker truck		
oth		Other		
dk		Don't know		
none		No water source		
dr_ws_sa_main_other	**Free Text**	**Specify other:**	**dr_ws_sa_main = oth**	**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**

DIRECTOR Form Variable Name/ Ans Value	Type	Question/Answer Text	Skip logic	Hint Text
				closest to the outpatient area.
dr_ws_sa_msrc	**Select One**	**Where is the main water source for the facility?**	**dr_ws_sa_avl != none**	
on		On premises		
500m		Off premises, within 500m		
off		Off premises, farther than 500m		
no		No water source		
dk		Don't know		
dr_ws_sa_tcol	**Integer**	**What is the round trip travel time to collect water off premises?**	**dr_ws_sa_msrc != on and dr_ws_sa_avl != none**	**in minutes**
dr_ws_sa_wcol	**Select Multiple**	**Who collects the water off premises?**	**dr_ws_sa_msrc != on and dr_ws_sa_avl != none**	
pat		Patients/caregivers only		
staff		Staff only		
both		Both patients/caregivers and staff		
oth		Other		
dk		Don't know		
dr_ws_qn_mnun	**Select One**	**Are there times when the main water source is unavailable?**	**dr_ws_sa_avl != none**	
yes		Yes		
no		No		
dk		Don't know		
dr_ws_qn_mnun_why	**Select Multiple**	**Why are there times when the main water source is unavailable?**	**dr_ws_qn_mnun = yes**	
power_out		Power outage		
water_shortage		Water rationing/shortage		
eq_malfunction		Equipment malfunction (i.e. broken pump)		

DIRECTOR Form Variable Name/ Ans Value	Type	Question/Answer Text	Skip logic	Hint Text
season		Season (dry or wet)		
pipe		Pipe breakage		
problems		Problems at the water provider		
oth		Other:		
dk		Don't know		
dr_ws_qn_mnun_why_other	**Free Text**	**Specify other:**	**dr_ws_qn_mnun_why = oth**	
dr_ws_qn_mnun_freq	**Select One**	**How often is the main water supply unavailable?**	**dr_ws_qn_mnun = yes**	
day_rarely		For part of the day, rarely		
day_freq		For part of the day, frequently		
yr_freq		For part of the year (seasonal problem), frequently		
yr_rarely		For part of the year (seasonal problem), rarely		
dk		Don't know		
dr_ws_sa_mnun_toy	**Select One**	**Is there routinely a time of year when the healthcare facility has severe shortage or lack of water?**	**dr_ws_qn_mnun = yes**	
yes		Yes		
no		No		
dk		Don't know		
dr_ws_qn_rat	**Select One**	**Does the healthcare facility ever ration water?**	**dr_ws_sa_avl != none**	**i.e. is water use intentionally limited or used sparingly**
yes		Yes		
no		No		
dk		Don't know		
dr_ws_qn_rat_why	**Select Multiple**	**Why does the healthcare facility ration water?**	**dr_ws_qn_rat = yes**	**Check all that apply**

DIRECTOR Form Variable Name/ Ans Value	Type	Question/Answer Text	Skip logic	Hint Text
cost		Cost of water		
run_out		Concerned water will run out		
oth		Other		
dk		Don't know		
dr_ws_qn_rat_why_oth	**Free Text**	**Specify other:**	**dr_ws_qn_rat_why = oth**	
dr_ws_sa_store	**Select Multiple**	**How does the healthcare facility store water?**	**dr_ws_sa_avl != none**	**Check all that apply.**
central_tank		In centralized storage tank (s) (plastic/concrete/steel)		
ward_tank		In storage tanks (plastic/concrete/steel) at the various wards		
cont_tank		In containers (such as buckets/jerry cans) inside the wards		
cont_premesis		In containers on facility premises		
oth		Other		
none_available		No water storage available		
dk		Don't know		
dr_ws_qn_store_oth	**Free Text**	**Specify other:**	**dr_ws_sa_store = oth**	
dr_ws_sa_store_fac	**Select Multiple**	**What type of water storage facilities are available?**	**dr_ws_sa_store ! = none_available**	**Check all that apply.**
plastic_tanks		Plastic tanks		
concrete_tanks		Concrete tanks		
elevated_steel_tanks		Elevated steel tanks		
bucketsjerrycans_within_wards		Buckets/jerrycans within wards		
oth		Other		
dk		Don't know		
dr_ws_sa_store_fac_oth	**Free Text**	**Specify other:**	**dr_ws_sa_store_fac = oth**	
dr_ws_sa_store_capacity	**Integer**	**What is the total water storage capacity at the healthcare facility in liters?**	**dr_ws_sa_store ! = none_available**	
dr_ws_sa_store_capacity_24hr	**Select One**	**Can this storage capacity provide at least 24 hours of water supply to meet the needs of this healthcare facility?**	**dr_ws_sa_store ! = none_available**	
yes		Yes		
no		No		
dk		Don't know		
dr_ws_sa_access	**Select Multiple**	**Which users have access to water?**	**dr_ws_sa_avl != none**	**Select all that apply.**
pt_care		Patients/Caregivers		
staff		Staff		

DIRECTOR Form Variable Name/ Ans Value	Type	Question/Answer Text	Skip logic	Hint Text
comm		Community Members		
none		None	\	
dk		Don't know		
dr_ws_sa_atime	**Select One**	**Is water accessible to all users at all times?**	**dr_ws_sa_avl != none**	**i.e. water can be accessed any time of day by anyone (patients, staff and caregivers) at the healthcare facility. Note that this questions has to do with equity of access, and not with water outages.**
yes		Yes		
no_pt_care		No, patients/caregivers do not have access at times		
no_staff		No, staff do not have access at times		
no_both		No, both staff and patients/caregivers do not have access at times		
dk		Don't know		
dr_ws_qa_taste	**Select One**	**Are there tastes, odors or colors that discourage consumption or use of the drinking-water?**	**dr_ws_sa_avl != none**	
yes		Yes		
sometimes		Sometimes		
no		No		
dk		Don't know		
dr_ws_sa_awthn	**Select Multiple**	**How is water accessed within the healthcare facility?**	**dr_ws_sa_avl != none**	**Read all options. Check all that apply.**
piped_taps		Piped taps		
ucov_buckets		Uncovered buckets/barrels		
cov_buckets		Covered buckets/barrels		
cov_buckets_taps		Covered buckets with taps on bottom		
ucov_buckets_taps		Uncovered buckets with taps on bottom		
jerrycans		Jerrycans		
oth		Other		
dk		Don't know		

DIRECTOR Form Variable Name/ Ans Value	Type	Question/Answer Text	Skip logic	Hint Text
dr_ws_sa_awthn_oth	**Free Text**	**Specify other:**	**dr_ws_sa_awthn = oth**	
dr_ws_sa_awthn_rmvd	**Select Multiple**	**How is water removed from buckets/barrels for use in the wards?**	**dr_ws_sa_awthn = (ucov_buckets or cov_buckets or ucov_buckets_taps or cov_buckets_taps)**	**Read all options aloud. Select all that apply.**
cup_ladle		Cup or ladle		
tap		Tap		
pour		Pour		
oth		Other		
dk		Don't know		
dr_ws_sa_awthn_rmvd_oth	**Free Text**	**Specify other:**	**dr_ws_sa_awthn_rmvd = oth**	
dr_ws_sa_pbring	**Select One**	**Does this healthcare facility expect that pregnant women will bring their own water when they come to deliver?**	**dr_ws_sa_avl != none and dr_g_dep = lab_del**	
yes		Yes		
sometimes		Sometimes		
no		No		
dk		Don't know		
label_water_treatment	**Label**	**Water Treatment**		**"Now I am going to ask you some questions about water treatment."**
dr_ws_qa_clsrc	**Select One**	**Is water from the main water source chlorinated (treated with chlorine)?**	**dr_ws_sa_avl != none**	
yes		Yes		
no		No		
dk		Don't know		
dr_ws_qa_hcfcl	**Select One**	**Does chlorination occur on the healthcare facility premises?**	**dr_ws_qa_clsrc = yes**	**As opposed to the water being chlorinated by the water utility.**
yes		Yes		
no		No		
dk		Don't know		
dr_ws_qa_ppat	**Select One**	**Does the healthcare facility purchase or produce drinking-quality water for staff, patients and caregivers?**	**dr_ws_sa_avl != none**	**This includes bottled water.**

DIRECTOR Form Variable Name/ Ans Value	Type	Question/Answer Text	Skip logic	Hint Text
yes		Yes		
no		No		
dk		Don't know		
dr_ws_sa_pdrnk	**Select Multiple**	**How does the healthcare facility provide treated drinking-water?**	**dr_ws_qa_ppat = yes**	**Read all options. Check all that apply.**
cl		Chlorination of drinking-water onsite		
filtration		Filtration of drinking-water onsite		
boil		Boiling of drinking-water onsite		
uv		UV treatment of drinking-water onsite		
bottled		Bottled (or sachet) drinking-water available		
treat_before		Drinking-water is treated before reaching the healthcare facility (i.e. by a utility treatment plant)		
oth		Other:		
dk		Don't know		
dr_ws_sa_pdrnk_oth	**Free Text**	**Specify other:**	**dr_ws_sa_pdrnk = oth**	
dr_ws_sa_pdrink_avail	**Select One**	**In the previous two weeks, was drinking-water available for patients throughout each day?**	**dr_ws_qa_ppat = yes**	
yes		**Yes**		
no		**No**		
dk		**Don't know**		
label_water_var_med	**Label**	**Water treatment for medical purposes**		**"I'm now going to ask you questions about water treatment for various medical purposes."**
dr_wq_qa_proc_surg	**Select Multiple**	**How is water treated for surgical procedures?**	**dr_ws_sa_avl != none and (dr_g_dep = surj_maj or surj_min)**	**Read all purposes aloud. Check all that apply.**
cl		Chlorination		
filtration		Filtration		
boiling		Boiling		
distillation		Distillation		
purchase		Purchase		
uv		UV		
oth		Other		

DIRECTOR Form Variable Name/ Ans Value	Type	Question/Answer Text	Skip logic	Hint Text
no_treat		No treatment		
na		Not applicable		
dk		Don't know		
dr_wq_qa_proc_labor	**Select Multiple**	**How is water treated for labor and delivery?**	**dr_ws_sa_avl != none and dr_g_dep=lab_del**	**Read all purposes aloud. Check all that apply.**
cl		Chlorination		
filtration		Filtration		
boiling		Boiling		
distillation		Distillation		
purchase		Purchase		
uv		UV		
oth		Other		
no_treat		No treatment		
na		Not applicable		
dk		Don't know		
dr_wq_qa_proc_wound	**Select Multiple**	**How is water treated for wound and burn care?**	**dr_ws_sa_avl != none**	**Read all purposes aloud. Check all that apply.**
cl		Chlorination		
filtration		Filtration		
boiling		Boiling		
distillation		Distillation		
purchase		Purchase		
uv		UV		
oth		Other		
no_treat		No treatment		
na		Not applicable		
dk		Don't know		
dr_wq_qa_proc_clneq	**Select Multiple**	**How is water treated for the processing of medical equipment?**	**dr_ws_sa_avl != none**	**Read all purposes aloud. Check all that apply.**
cl		Chlorination		
filtration		Filtration		
boiling		Boiling		
distillation		Distillation		
purchase		Purchase		
uv		UV		
oth		Other		

DIRECTOR Form Variable Name/ Ans Value	Type	Question/Answer Text	Skip logic	Hint Text
no_treat		No treatment		
na		Not applicable		
dk		Don't know		
dr_wq_qa_proc_devices	**Select Multiple**	**How is water treated for use in medical devices?**	**dr_ws_sa_avl != none**	**Read all purposes aloud. Check all that apply.**
cl		Chlorination		
filtration		Filtration		
boiling		Boiling		
distillation		Distillation		
purchase		Purchase		
uv		UV		
oth		Other		
no_treat		No treatment		
na		Not applicable		
dk		Don't know		
dr_wq_qa_proc_dentistry	**Select Multiple**	**How is water treated for dentistry?**	**dr_ws_sa_avl != none and dr_g_dep = den**	**Read all purposes aloud. Check all that apply.**
cl		Chlorination		
filtration		Filtration		
boiling		Boiling		
distillation		Distillation		
purchase		Purchase		
uv		UV		
oth		Other		
no_treat		No treatment		
na		Not applicable		
dk		Don't know		
dr_wq_qa_proc_medication	**Select Multiple**	**How is water treated for mixing medication?**	**dr_ws_sa_avl != none**	**Read all purposes aloud. Check all that apply.**
cl		Chlorination		
filtration		Filtration		
boiling		Boiling		
distillation		Distillation		
purchase		Purchase		
uv		UV		
oth		Other		

DIRECTOR Form Variable Name/ Ans Value	Type	Question/Answer Text	Skip logic	Hint Text
no_treat		No treatment		
na		Not applicable		
dk		Don't know		
dr_wq_qa_proc_lab	**Select Multiple**	**How is water treated for use in the laboratory?**	**dr_ws_sa_avl != none and dr_g_dep=lab**	**Read all purposes aloud. Check all that apply.**
cl		Chlorination		
filtration		Filtration		
boiling		Boiling		
distillation		Distillation		
purchase		Purchase		
uv		UV		
oth		Other		
no_treat		No treatment		
na		Not applicable		
dk		Don't know		
dr_wq_storage	**Select One**	**When is water typically treated?**	**dr_ws_sa_avl != none**	
prior		Prior to storage		
after		After storage		
both		Both prior to and after storage		
never_treated		Never treated		
label_hyg	**Label**	**Hygiene**		**"Now I am going to ask you some questions about hygiene."**
dr_hw_ssoap	**Select One**	**Does the healthcare facility provide the staff with soap for handwashing?**		
yes		Yes		
sometimes		Sometimes		
no		No		
dk		Don't know		
dr_hw_psoap	**Select One**	**Does the healthcare facility provide patients and caregivers with soap for handwashing?**		
yes		Yes		
sometimes		Sometimes		
no		No		
dk		Don't know		

DIRECTOR Form Variable Name/ Ans Value	Type	Question/Answer Text	Skip logic	Hint Text
dr_ws_sa_pbath	**Select One**	**Are bathing facilities available to patients?**		
yes		Yes		
no		No and have inpatient services		
no_inpat		No but do not have inpatient services		
dk		Don't know		
dr_cr_cp_beds	**Select One**	**Are beds, mattresses, pillows and/or mats cleaned between patients?**		**i.e. bed rails and mattresses are cleaned, linens are laundered or changed. Read all options.**
yes_always		Always		
yes_sometimes		Sometimes		
no		Rarely or never		
bed_not_prov		Bedding is not provided by healthcare facility (patients bring their own)		
no_inpat		No inpatient services		
dk		Don't know		
dr_cr_cp_detergent		**Are the healthcare facility floors, surfaces and toilets cleaned whenever soiled, at least once a day, with water and detergent?**		
yes_cleaned		Yes, cleaned every day with water and detergent		
no_cleaned		Cleaned with water and detergent, but less than once a day		
no		No		
dk		Don't know		
dr_cr_cp_laundry		**Are functional laundry facilities available to wash linens and medical scrubs?**		
yes		Yes		
no		No		
dk		Don't know		
dr_cr_cp_stereq	**Select Multiple**	**What functional sterilization equipment is available at the healthcare facility today?**		**Read all options. Check all that apply**
autoclave		Autoclave (pressure & wet heat)		
dry_heat		Dry heat sterilizer		
boiler		Boiler or steamer (no pressure - electric or not)		
oth		Other		

DIRECTOR Form Variable Name/ Ans Value	Type	Question/Answer Text	Skip logic	Hint Text
none		No functional sterilization equipment available		
dk		Don't know		
dr_cr_cp_stereq_oth	**Free Text**	**Specify other:**	**dr_cr_cp_stereq = oth**	
label_sanitation	**Label**	**Sanitation**		**"Now I am going to ask you some questions about sanitation."**
dr_san_sa_toilet	**Select One**	**Are toilet facilities available on the healthcare facility premises?**		
yes		Yes		
no		No		
dk		Don't know		
dr_san_sa_use	**Select One**	**Are there sufficient toilet facilities to meet the healthcare facility's needs?**	**dr_san_sa_toilet != no**	
yes		Yes		
no		No		
dk		Don't know		
dr_san_qa_waste	**Select One**	**How is human waste (feces) from toilets disposed of most of the time?**	**dr_san_sa_toilet ! = no**	**Read all options.**
sewerage		Sewerage system		
septic		Septic Tank		
holding_pit		Pit/chamber		
drain		Discharged into drain or immediate environment		
oth		Other		
dk		Don't know		
dr_san_qa_waste_other	**Free Text**	**Specify other:**	**dr_san_qa_waste = oth**	
dr_san_d_empty	**Select One**	**How is the septic tank or underground holding pit emptied most of the time?**	**dr_san_qa_waste = septic or holding_pit**	
manual		Manually remove waste		
call		Call a waste company for removal		
build		Build a new pit		
oth		Other		
never		Has never been full		
dk		Don't know		
dr_san_qa_empty_other	**Free Text**	**Specify other:**	**dr_san_qa_empty = oth**	

DIRECTOR Form Variable Name/ Ans Value	Type	Question/Answer Text	Skip logic	Hint Text
label_waste_management	Label	Waste Management		"Now I am going to ask you some questions about waste management."
dr_swm_greywater		How is grey water/wastewater (i.e. water from sinks, laundry, cleaning etc.) disposed of?		
offsite_sewage		Off-site sewage treatment		
soak_pit		Soak pit		
drain_field		Drain field		
combined_septic		Combined septic tank		
oth		Other		
dk		Don't know		
dr_swm_greywater_other	Free Text	Specify other:	dr_swm_greywater = oth	
dr_swm_fenced	Select One	Are fenced and protected areas available for the storage of waste awaiting disposal or removal?		
yes		Yes		
sometimes		Sometimes		
no		No		
dk		Don't know		
dr_swm_finc	Select One	Is there a functional incinerator with fuel available?		Read all options aloud.
yes_fuel		Yes, and fuel is available today		
yes_nfuel		Yes, but no fuel is available today		
no		No		
dk		Don't know		
dr_swm_isep	Select One	Is infectious waste separated from other waste in the ward?		i.e. blood soaked clothes, body parts removed during surgery, catheters, vomit, etc.
yes		Yes		
sometimes		Sometimes		
no		No		
not_gen		This kind of waste is not generated		
dk		Don't know		

DIRECTOR Form Variable Name/ Ans Value	Type	Question/Answer Text	Skip logic	Hint Text
dr_swm_isep_treat_how	**Select One**	**How is infectious waste treated most of the time?**	**dr_swm_isep = yes or sometimes**	
auto		Autoclave		
chem		Chemical disinfection with hypochlorite (ex: chlorine, bleach, etc.)		
oth		Other		
not		Not treated		
dk		Don't know		
dr_swm_isep_treat_how_oth	**Free Text**	**Specify other:**	**dr_swm_isep_treat_how = oth**	
dr_swm_isep_how	**Select One**	**How is infectious waste disposed most of the time?**	**dr_swm_isep = yes or sometimes**	**Read each bolded category aloud and then probe for more specific location**
burn_cham		Incinerate (two chamber, 850-100 C)		
burn_brick		Incinerate (brick incinerator)		
bury		Bury in a lined, protected pit		
bury_unprotected		Bury in unprotected pit		
burn_protected		Burn in protected pit		
open_burn		Open burning		
open_dump		Open dumping		
collect		Collect for medical waste disposal offsite		
collect_general		Collect for general waste disposal offsite		
add_general_waste		Add to general waste for onsite disposal		
oth		Other		
dk		Don't know		
dr_swm_isep_how_oth	**Free Text**	**Specify other:**	**dr_swm_isep_how = oth**	
dr_swm_shrps	**Select One**	**Is sharps waste separated from other waste in the ward?**		**give example such as: disposable needles**
yes		Yes		
sometimes		Sometimes		

DIRECTOR Form Variable Name/ Ans Value	Type	Question/Answer Text	Skip logic	Hint Text
no		No		
not_gen		This kind of waste is not generated		
dk		Don't know		
dr_swm_shrps_treat_how	**Select One**	**How is sharps waste treated most of the time?**	**dr_swm_shrps = yes or sometimes**	
auto		Autoclave		
chem		Chemical disinfection with hypochlorite (ex: chlorine, bleach, etc.)		
oth		Other		
not		Not treated		
dk		Don't know		
dr_swm_shrps_treat_how_oth	**Free Text**	**Specify other:**	**dr_swm_shrps_treat_how = oth**	
dr_swm_shrps_how	**Select One**	**How is sharps waste disposed most of the time?**	**dr_swm_shrps = yes or sometimes**	**Read each bolded category aloud and then probe for more specific location**
burn_cham		Incinerate (two chamber, 850-100 C)		
burn_brick		Incinerate (brick incinerator)		
bury		Bury in a lined, protected pit		
bury_unprotected		Bury in unprotected pit		
burn_protected		Burn in protected pit		
open_burn		Open burning		
open_dump		Open dumping		
collect		Collected for medical waste disposal offsite		
collect_general		Collected for general waste disposal offsite		
add_general_waste		Add to general waste for onsite disposal		
oth		Other		
dk		Don't know		
dr_swm_shrps_how_oth	**Free Text**	**Specify other:**	**dr_swm_shrps_how = oth**	
dr_swm_noninf	**Select One**	**How is non-infectious general waste disposed most of the time?**		**Read each bolded**

DIRECTOR Form Variable Name/ Ans Value	Type	Question/Answer Text	Skip logic	Hint Text
				category aloud and then probe for more specific location
burn_cham		Incinerate (two chamber, 850-100 C)		
burn_brick		Incinerate (brick incinerator)		
bury		Bury in a lined, protected pit		
bury_unprotected		Bury in unprotected pit		
burn_protected		Burn in protected pit		
open_burn		Open burning		
open_dump		Open dumping		
collect_general		Collected for general waste disposal offsite		
oth		Other		
dk		Don't know		
dr_swm_noninf_oth	**Free Text**	**Specify other:**	**dr_swm_noninf = oth**	
dr_swm_pla	**Select One**	**Are placentas separated from other waste?**		
yes		Yes		
sometimes		Sometimes		
no		No		
not_gen		This kind of waste is not generated		
dk		Don't know		
dr_swm_pla_how	**Select One**	**How are placentas disposed most of the time?**	**dr_swm_shrps = yes**	**Such as incubators, CPAP. Read each bolded category aloud and the probe for more specific location**
burn_cham		Incinerate (two chamber, 850-100 C)		
burn_brick		Incinerate (brick incinerator)		
blended_septic_tank		Blend and dispose in the septic tank		
bury		Bury in a lined, protected pit		
bury_unprotected		Bury in unprotected pit		
burn_protected		Burn in protected pit		
open_burn		Open burning		
open_dump		Open dumping		
home		Women bring placentas home		

DIRECTOR Form Variable Name/ Ans Value	**Type**	**Question/Answer Text**	**Skip logic**	**Hint Text**
collect		Collected for medical waste disposal offsite		
oth		Other		
dk		Don't know		
dr_swm_pla_how_oth	**Free Text**	**Specify other:**	**dr_swm_pla_how = oth**	
dr_swm_pla_treat	**Select One**	**Are placentas treated before the women bring them home?**	**dr_swm_pla_how = oth**	
yes		Yes		
no		No		

END FORM

3. Administrative Form

ADMIN Form Var Name/Ans Val	Question Type	Question/Ans Text	Skip logic	Hint Text	Validation
note_admin	label	Administrative Data		Fill out this section based on information gathered from administrative records and/or from a reliable source.	
bkg_g_outp	**Select One**	**Does this healthcare facility have outpatient services?**			
yes		Yes			
no		No			
bkg_g_oseen	**Integer**	**On average, how many outpatients are seen per month?**	**bkg_g_outp = yes**		. > 0
bkg_g_omon	**Integer**	**How many days in a month are outpatients seen?**	**bkg_g_outp = yes**		**. > 0 and . <= 31**
bkg_g_inp	**Select One**	**Does this healthcare facility have inpatient services?**			
yes		Yes			
no		No			
bkg_g_iseen	**Integer**	**On average, how many inpatients are seen per month?**	**bkg_g_inp = yes**		. > 0
bkg_g_inum	**Integer**	**On an average day, how many inpatients are at the healthcare facility?**	**bkg_g_inp = yes**		. => 0
bkg_g_ibed	**Integer**	**How many inpatient beds are available?**	**bkg_g_inp = yes**		. => 0
bkg_g_dnum	**Integer**	**On average, how many deliveries take place per month?**			. => 0
bkg_g_cnum	**Integer**	**Of these deliveries, how many were cesarean sections?**	**bkg_g_dnum < 1**		**. => 0 and . <= bkg_g_dnum**
bkg_g_surg	**Select One**	**Are surgical procedures performed at this healthcare facility?**			
yes		Yes			
no		No			
bkg_g_snum	**Integer**	**On average, how many surgical procedures are performed per month?**	**bkg_g_surg = yes**	**If unknown, ask about how many procedures are performed per day, then extrapolate to per month**	. => 0
bkg_g_cstaff	**Integer**	**How many clinical staff are employed at the healthcare facility?**		**i.e. doctors, midwives, nurses, etc.**	. => 0
bkg_g_md	**Integer**	**Of the clinical staff, how many are medical doctors?**			**0 <= . <= bkg_g_cstaff**

ADMIN Form Var Name/Ans Val	Question Type	Question/Ans Text	Skip logic	Hint Text	Validation
bkg_g_ncstaff	Integer	How many non-clinical staff are employed at the healthcare facility?		i.e. administrative staff, janitorial staff, etc.	
bkg_g_clstaff	Integer	Of the non-clinical staff, how many are cleaners?			0 <= . <= bkg_g_ncstaff
bkg_ws_qn_wmon	Integer	On average, how much water is used daily (in liters)?		information may be found on water bill or best estimate from reliable source	. => 0

END FORM

Note: The Administrative/Background form was the only form that had a populated "Validation" column. Other forms that included this column showed all rows blank, and the Director form did not have the column at all.

4. Ward Form

WARD Form Variable Name/Ans Value	Question Type	Question/Answer Text	Skip logic	Hint Text
ward_g_type	**Select One**	**Which ward are you observing?**		
lab_del		Labor and Delivery Ward		
postnatal		Postnatal Ward		
surg		Surgery Ward		
ped		Pediatric Ward		
inpat		Inpatient Ward		
outpat		Outpatient Ward		
ew		Emergency Ward		
kitchen		Kitchen		
oth		Other		
ward_g_type_oth	**Free Text**	**Specify other:**	**tl_san_sa_srv includes oth**	
ward_ws_sa_piped	**Select one**	**Is water piped into this ward?**		
yes		Yes		
yes_but_currently_unavailable		Yes, but currently unavailable		
no		No		
didnt_observe		Didn't observe		
ward_ws_sa_available		**What type of water is currently available in this ward?**		
yes_treated		Treated water		
yes_untreated		Untreated water		
yes_treateduntreated		Treated and untreated water		
no		No water available		
didnt_observe		Didn't observe		
ward_ws_sa_accessed	**Select Multiple**	**How is water accessed in the ward?**	**ward_ws_sa_available ! = no**	
piped_taps		Piped taps		
uncovered_bucketsbarrels		Uncovered buckets/barrels		
covered_bucketsbarrels		Covered buckets/barrels		
uncovered_buckets_with_ taps_on_bottom		Uncovered buckets with tap on bottom		
covered_buckets_with_taps _on_bottom		Covered buckets with tap on bottom		
jerrycans		Jerrycans		
oth		Other		
didnt_observe		Didn't observe		
ward_water_accessed_oth	**Free Text**	**Specify other:**	**ward_ws_sa_accessed = oth**	
ward_ws_sa_access	**Select One**	**Who has access to water in this ward?**	**ward_ws_sa_available ! = no**	
staff		Staff		

WARD Form Variable Name/Ans Value	Question Type	Question/Answer Text	Skip logic	Hint Text
patients		Patients/caregivers		
both		Both staff and patients/caregivers		
neither		Neither staff nor patients/caregivers		
didnt_observe		Didn't observe		
ward_ws_sa_stored_avail	**Select One**	**Is water stored in the ward?**		
yes		Yes		
no_for_ward		No water storage for the ward, but storage is available for whole healthcare facility		
no		No water storage available at all at this healthcare facility		
didnt_observe		Didn't observe		
ward_ws_sa_stored	**Select Multiple**	**How is water stored in the ward?**		
storage_tank		Storage tank		
covered_container		Covered container		
uncovered_container		Uncovered container		
jerrycan		Jerrycan		
oth		Other		
didnt_observe		Didn't observe		
ward_ws_sa_stored_oth	**Free Text**	**Specify other:**	**ward_ws_sa_stored = oth**	
ward_ws_sa_stored_100l	**Select One**	**Is there at least 100L of stored water available?**	ward_g_type = lab_del	
yes		Yes		
no		No		
didnt_observe		Didn't observe		
ward_hw_poc	**Select One**	**Observe a functional hand hygiene facility at the point of care and select the available hand hygiene materials.**	**Clean 6**	
water		Water only		
soap		Soap only		
hand_sanitizer		Hand sanitizer only		
water_soap		Water and soap		
water_sanitizer		Water and sanitizer		
soap_sanitizer		Soap and sanitizer		
water_soap_sanitizer		Water, soap and sanitizer		
none_available		No supplies available		
didnt_observe		Didn't observe		
ward_hw_pat	**Select Multiple**	**Observe a functional hand hygiene facility accessible to patients/caregivers and select**	**Skipped if none_available for ward_hw_poc**	

WARD Form Variable Name/Ans Value	Question Type	Question/Answer Text	Skip logic	Hint Text
		the available hand hygiene materials.		
water		Water only		
soap		Soap only		
hand_sanitizer		Hand sanitizer only		
water_soap		Water and soap		
water_sanitizer		Water and sanitizer		
soap_sanitizer		Soap and sanitizer		
water_soap_sanitizer		Water, soap and sanitizer		
none_available		No supplies available		
didnt_observe		Didn't observe		
ward_cr_cp_spl	**Select Multiple**	**Observe if the following resources/supplies used for infection control are available today in the ward:**	**ward_g_type != kitchen and ward_g_type !=lab_del**	**Check all that apply.**
gloves		Disposable latex gloves		
disenfectant		Environmental disinfectant (chlorine, ethanol, alcohol)		
hand_sanitizer		Hand sanitizer		
soap		Soap/detergent		
mop		Mop and bucket		
broom		Broom		
none_available		No supplies available		
didnt_observe		Didn't observe		
ward_cr_cp_ldspl	**Select Multiple**	**Observe if the following resources/supplies used for infection control are available today in the ward:**	**ward_g_type = lab_del**	**Check all that apply.**
gloves		Disposable latex gloves		
disenfectant		Environmental disinfectant (chlorine, ethanol, alcohol)		
hand_sanitizer		Hand sanitizer		
soap		Soap		
mop		Mop and bucket		
broom		Broom		
clean_blade		Clean blade for cord cutting	6 Cleans	
clean_cord		Clean cord for tying	6 Cleans	
clean_towel_baby		Clean towel to wrap the baby[29]	6 Cleans	
clean_wrap		Clean cloth for the mother	6 Cleans	
clean_delivery_surface		Clean delivery surface	6 Cleans	

[29] These have been separated into two since the WASHCon deployments in Afghanistan and Uganda. During the time period when this study's data was collected, clean_towel_baby and clean_wrap were together as clean_towels.

WARD Form Variable Name/Ans Value	Question Type	Question/Answer Text	Skip logic	Hint Text
none_available		No supplies available		
didnt_observe		Didn't observe		
ward_chlorhex	**Select One**	**Is chlorhexidine available for the treatment of umbilical cords?**	**ward_g_type = lab_del**	
yes		Yes		
no		No		
didnt_observe		Didn't observe		
ward_cr_es_avail	**Select One**	**Is waste safely segregated into at least three labeled bins, including sharps waste, infectious waste and non-infectious general waste?**		**The bins should be clearly labeled, no more than 75% full, and each bin should not contain waste other than that corresponding to its label. If there are multiple bins of the same type, randomly select 1 bin of each type to observe.**
yes		Yes		
bins_present		Bins are present but do not meet all requirements		
no		No		
didnt_observe		Didn't observe		
ward_swm_needle_cutters	**Select One**	**Are there functional needle cutters/hub cutters available next to the sharps bin?**		
yes		Yes		
no		No		
didnt_observe		Didn't observe		
ward_cr_cp_dust	**Select One**	**Is the ward visibly clean and free from dust and soil?**		
yes		Yes		
no		No		
didnt_observe		Didn't observe		
ward_cr_cp_bfld	**Select One**	**Are there uncleaned spills from bodily fluids (blood, urine, feces, vomit, etc.)?**		
yes		Yes		
no		No		
didnt_observe		Didn't observe		
ward_ec_fh_fl	**Select one**	**Are the floors clean?**		
yes		Yes		

WARD Form Variable Name/Ans Value	Question Type	Question/Answer Text	Skip logic	Hint Text
no		No		
didnt_observe		Didn't observe		
ward_hw_promo	**Select One**	**Are there hand hygiene promotion materials clearly visible and understandable at key places within the ward?**		
yes		Yes		
no		No		
didnt_observe		Didn't observe		
ward_san_sa_tl	Select One	Is there a toilet block for patients within 30m of this ward?	ward_g_type != kitchen	
yes		Yes		
nonfunctional		Toilet available, but nonfunctional		
no		No		
dk		Don't know		
ward_san_bath	**Select One**	**Is there a bathing shelter available to patients?**	ward_g_type != kitchen	
yes		Yes		
yes_not_hygenic		Yes, but not hygienic or nonfunctional		
no		No		
dk		Don't know		

END FORM

5. Water Quality Form

WATER QUALITY Form Variable Name/Ans Value	Question Type	Question/Answer Text
wq_location	**Select One**	**Where was this sample taken?**
water_source		Water source
inpatient		Inpatient
outpatient		Outpatient
antenatal_care		Antenatal Care
dentistry		Dentistry
emergency_department		Emergency Department
Environmental_Services		Environmental Services
eye_clinic		Eye Clinic
hivvctarv_clinic		HIV/VCT/ARV Clinic
housing		Housing for Staff
intensive_care_unit		Intensive Care Unit
kitchen		Kitchen
labor_and_delivery		Labor and Delivery
laboratory		Laboratory
major_surgery		Major Surgery
morgue		Morgue
minor_surgery		Minor Surgery
nutrition_services		Nutrition Services
peds		Pediatrics
pharmacy		Pharmacy
postnatal		Postnatal Ward
tb_services		TB Services
oth		Other
dk		Don't know
wq_location_oth	**Free text**	**Please specify other:**
cl_free	**Decimal**	**Enter Free CL (mg/L):**
cl_total	**Decimal**	**Enter Total CL (mg/L):**
coliform_tot	**Decimal**	**Enter Total Coliform (MPN):**
e_coli	**Decimal**	**Enter *E. coli* (MPN):**
turbidity	**Decimal**	**Enter Turbidity (NTU):**

END FORM

Notes:

In Afghanistan, Water Quality data may not have been collected using the standard form. Data was presented by district (three sheets) and included variables not listed in the form.

For nine (9) facilities in Uganda, the study team provided “aggregated” (facility-level) water quality data. Thus, we include that form in this section for reference, although these facility-level variables were only provided for a few facilities.

Aggregated Water Quality Form

WQ-Agg. Form Variable Name/Ans Val	Question Type	Question/Answer Text	Hint Text
wq_ws_qn_cl	**Select One**	**Does the water have appropriate levels of chlorine residual?**	**CDC guidelines recommend between 0.2 and 2.0 mg/L (or ppm)**
3		Water is chlorinated and greater than 50% of samples meet CDC guidelines for chlorine residual	
2		Water is chlorinated but fewer than 50% of samples meet CDC guidelines for chlorine residual	
1		Water is not chlorinated OR chlorine residual levels are all below CDC guidelines for chlorine residual	
na		This question cannot be answered	
wq_ws_qn_mic	**Select One**	**Does the water quality meet WHO microbial water quality guidelines?**	**WHO guidelines recommend less than 1 CFU *E. coli* per 100mL sample**
3		Between 90- 100% of all samples met WHO guidelines for microbial water quality	
2		Between 50-89% of all samples met WHO guidelines for microbial water quality	
1		Fewer than 50% of all samples met WHO guidelines for microbial water quality	
na		This question cannot be answered	

END FORM

Appendix D. WASHCon Variable Inclusion Change Log

Reproduced as submitted to the author by the study team on November 21, 2018. Notes in the Excel document are included here as footnotes.

Indicator	Uganda 2017 April	Uganda 2017 August	Uganda 2017 October	Afghanistan 2018
	9 HCF	98 HCF	41 HCF	104 HCF
dr_ws_sa_avl	Y	Y	Y	Y
dr_ws_sa_main	Y	Y	Y	Y
dr_ws_sa_msrc	Y	Y	Y	Y
dr_ws_sa_tcol	Y	Y	Y	Y
san_ws_sa_water_availab_le[30]	Y	Y	Y	Y
san_ws_sa_alt[31]	*	*	*	Y
dr_ws_sa_wcol	Y	Y	Y	Y
dr_ws_sa_pbring	Y	Y	Y	Y
bkg_ws_qn_wmon	Y	Y	Y	Y
dr_ws_sa_access	Y	Y	Y	Y
dr_ws_sa_atime	Y	Y	Y	Y
dr_ws_sa_awthn	Y	Y	Y	Y
dr_ws_sa_awthn_rmvd	Y	Y	Y	Y
ward_ws_sa_piped	N	Y	Y	Y
ward_ws_sa_accessed	N	Y	Y	Y
ward_ws_sa_access	N	Y[32]	Y	Y
san_ws_drinking_water	N	N	Y	Y
san_ws_drinking_water_mobility	N	N	Y	Y
dr_ws_qn_mnun	Y	Y	Y	Y
dr_ws_qn_mnun_why	Y	Y	Y	Y
dr_ws_qn_mnun_freq	Y	Y	Y	Y
dr_ws_sa_mnun_toy	N	Y	Y	Y
dr_ws_qn_rat	Y	Y	Y	Y
dr_ws_qn_rat_why	Y	Y	Y	Y
dr_ws_sa_store	N	Y	Y	Y
dr_ws_sa_store_fac	N	Y	Y	Y
dr_ws_sa_store_capacity	N	Y	Y	Y
dr_ws_sa_store_capacity_24hr	N	Y	Y	Y
ward_ws_sa_stored_avail	N	Y	Y	Y
ward_ws_sa_stored	N	Y	Y	Y
dr_ws_qa_clsrc	Y	Y	Y	Y

30 This question was split in two after Uganda 2017.
31 Response was part of san_ws_sa_water_availab_le - may be able to use data.
32 Responses were written incorrectly (as ‘yes’/’no’ when the question was asking who has access: staff, patients, both, or neither).

Indicator	Uganda 2017 April	Uganda 2017 August	Uganda 2017 October	Afghanistan 2018
	9 HCF	98 HCF	41 HCF	104 HCF
dr_ws_qa_hcfcl	Y	Y	Y	Y
dr_ws_qa_ppat	Y	Y	Y	Y
dr_ws_sa_pdrnk	Y	Y	Y	Y
dr_ws_sa_pdrink_avail	N	N	N	Y
dr_wq_qa_proc_surg	Y	Y	Y	Y
dr_wq_qa_proc_labor	Y	Y	Y	Y
dr_wq_qa_proc_wound	Y	Y	Y	Y
dr_wq_qa_proc_clneq	Y	Y	Y	Y
dr_wq_qa_proc_devices	Y	Y	Y	Y
dr_wq_qa_proc_dentistry	Y	Y	Y	Y
dr_wq_qa_proc_medication	Y	Y	Y	Y
dr_wq_qa_proc_lab	Y	Y	Y	Y
wq_ws_qn_cl	Y	Y	Y	Y
wq_ws_qn_mic	Y	Y	Y	Y
dr_ws_qa_taste	Y	Y	Y	Y
ward_ws_sa_available	Y	Y	Y	Y

END OF VARIABLE INCLUSION LOG

Appendix E. Data Sets and Data Cleaning Log

Afghanistan Data Sets

Links: Original Uploaded to SAS Final out of SAS

| Stage One Cleaning | | Stage Two Cleaning |

Uganda Data Sets

Links: Original Uploaded to SAS ^ ^ ^

| Stage One Cleaning | | Stage Two Cleaning |

To request access to these data sets for users outside Emory University, or to request access after December 31, 2019, please email the author at w.hannahlouise@gmail.com for direction to the appropriate party. Files may only be made available with approval from Emory University.

The Log explains each step taken by the author and its rationale. **It is not intended to track each individual value changed as a result of these steps.** Although some changed values are tracked here, including **all** changes made to values of the "BY" variable case_name, this log should not be considered an exhaustive list of value changes for other variables. To see every change to an individual value, the author recommends uploading "beginning" and "ending" versions of the data set of interest to the web-based database audit program xltrail, which will show any changes between those two files.

This Data Cleaning Log reflects both first-stage cleaning in Excel, which occurred prior to uploading the 10 data sets into SAS, and second-stage cleaning in SAS, including some cleaning steps undertaken to fix mistakes made in first-stage cleaning. For transparency, the author has logged all steps of data cleaning that occurred, including some that turned out to be unnecessary or imperfect.

1. Stage One Cleaning

1.1. Overview

This first-stage cleaning of raw data sets focused on:

- **The "BY" variable used for merging data sets**
    - Initially this was called 'form.case_case_name' or 'name'. These were aligned to **case_name.** Because there was no case-level ID number provided, this name variable was the "BY" variable used later in SAS to merge the HCF-level data sets (GPS, Director, and Admin) into one Facilities data set, and later, to add ward and water quality data from those data sets into the HCF-level data set.
- **Dependent and Independent Variables considered for inclusion in analysis**
    - Esp.: Free-text "Other" fields, to assign analyzable designations as appropriate.

In theory, each **case_name** had:

- one [1] observation in the GPS data set,
- one [1] observation in the Director data set,
- one [1] observation in the Administrative/Background data set,
- an average of four [4] observations in the Ward data set (mean=4.8, standard deviation=3.1, range of 1 ward per case_name to 19 wards per case_name)

Ideally, each of the five types of data set (GPS, Director, Admin, Ward, and Water Quality) would've had the same set of variables in each country, matching the variables in the standard WASHCon forms. However, in practice, the data sets were not identical, and the variables and responses were sometimes different between the two countries. In stage one cleaning, we explored any deviations from these expected relationships, including where an HCF was missing from a certain data set, or where duplicate observations were logged for the same HCF.

The general steps taken for during Stage One cleaning were as follows:

- **Removed prefix "Form [dot]"** from the beginning of all variables, all data sets.
- Where not already present, **added a form-specific prefix** to all variable names, specifying the form from which the variable originated [data set type]. Most variable names already included these prefixes.
    - Form types (5): gps_, dir_, bkg_, ward_, wq_
- **Translated to English any free-text field values that were written in another language.** Afghanistan forms often had free-text responses written in Persian or Daru script. Uganda forms occasionally had free-text responses written in French. Usually these values were found in 'If Other, Define:' fields. If a comment from the study team noted a translation, I used that translation. Where there were no comments, acting on advice from the study team, I used Google Translate to translate all values to English. All such translated values begin with the text string "(translated)".
- **Examined free-text 'If Other, Describe' fields and assigned analyzable values to their parent variables if appropriately indicated in the free text.** Because the

response options had varied over time, I encountered a number of observations where the main variable was marked 'Other', but the description of 'Other' clearly indicated a response that was now a valid option to code into the main variable. To maximize the data available for analysis and allow for appropriate comparison between countries, I updated values in parent values initially marked "Other" if a clear and valid non-'Other' option was described in the accompanying free text (see: specific Form sections of this Appendix).

  - Primary Variables Affected: HCF Main Water Source Type Ward Type

- **Removed variables deemed strictly administrative** and not relevant to this thesis project (e.g.: timestamp of form receipt; username of submitting team member; etc.)
  - **Note: If I were repeating this process, I would keep these administrative variables,** as some of them could have been useful for tracking purposes. They could also be very useful for certain types of analysis that this project did not attempt to study, such as seasonality or enumerator accuracy. For future projects, I would recommend these operational / administrative variables be retained in case they are needed.

1.2. Standardizing the linking variable (case_name)

To link each HCF's data from the five different forms, we needed to merge the data sets together. Ideally this would have been done with a unique HCF-level ID number, but there was no such ID number that matched across the forms. Thus, we needed to use the HCF name, which was contained in the case_name variable.

Many case_name values had different spellings or different case (upper/lower-case variance) between data sets. **Case_name values needed to be exactly identical, including matching upper- and lower-case, in order to properly match and merge the data sets in SAS.** Understanding that any changes to this critical linking variable would be important to track, we logged the original names here across all forms. Here, we show how the case_name variable was standardized for every HCF in each country.

In the following standardization tables, red text represents a case_name mismatch that required standardization. Other notes are included in footnotes or prior to the tables as needed. If a given cell contains only '---', this means that this form's data was never provided for this case_name. The Uganda study team confirmed that the HCFs missing Water Quality results in Uganda were missing results because there was no water available for testing at those HCFs at the time of the survey.

1.2.1. Afghanistan

Standardized	GPS	Director	Administrative	Ward	WQ
Abkamari	Abkamari	Abkamari	Abkamari	Abkamari	Ab Kamary (Center)
Abubakr Seddiq	Abubakr seddiq	Abubakr seddiq	Abubakr seddiq	Abubakr seddiq	Abubakr seddiq
Alaf	Alaf	Alaf	Alaf	Alaf	Alaf
ARCS	ARCS	ARCS	ARCS	ARCS	ARC
Babae Barq	Babae barq	Babae barq	Babae barq	Babae barq	Babae barq
Barakhana	Barakhana	Barakhana	Barakhana	Barakhana	Bara Khana
Barnabad	Barnabad	Barnabad	Barnabad	Barnabad	Barnabad
Bonyad	Bonyad	Bonyad	Bonyad	Bonyad	Bonyad
Boya	Boya	Boya	Boya	Boya	Boya
Chah Rig	Chah rig	Chah rig	Chah rig	Chah rig	Chah Rig
Chahar Dar	Chahar dar	Chahar dar	Chahar dar	Chahar dar	Chahar Dar
Chakab	Chakab	Chakab	Chakab	Chakab	Chakab
Chalanak	Chalanak	Chalanak	Chalanak	Chalanak	Challanak
Charsada	Charsada	Charsada	Charsada	Charsada	Char Sada
Chartaq	Chartaq	Chartaq	---	Chartaq	Chartaq
Cheshma Dozak	Cheshma dozak	Cheshma dozak	Cheshma dozak	Cheshma dozak	Chashma Dozdak

Standardized	GPS	Director	Administrative	Ward	WQ
Dahan Kocha	دهن کوچه [33]	Dahan Kocha	دهن کوچه [34]	---	Dahan e Kocha
Dara Boom	Dara boom	Dara boom	Dara boom	Dara boom	Dara Boom
Dashte Naizan	Dashte Naizan	Dashte Naizan	Dashte Naizan	Dashte Naizan	Dashte Naizan
Deh Barenj	Deh barenj	Deh barenj	Deh barenj	Deh barenj	Deh Brinj
Dehestan	Dehestan	Dehestan	Dehestan	Dehestan	Dahestan
Dehnow	Dehnow	Dehnow	Dehnow	Dehnow	Dehnow
Dowlatyar	Dowlatyar	Dowlatyar	Dowlatyar	Dowlatyar	Dawlatyar
Dulaina	Dulaina	Dulaina	Dulaina	Dulaina	Dulaina
Enjil	Enjil	Enjil	Enjil	Enjil	Enjil Clinic
Garmab	Garmab	Garmab	Garmab	Garmab	Garmab
Ghorghand	Ghorghand	Ghorghand	Ghorghand	Ghorghand	Ghorghand
Ghoriyan	Ghoriyan	Ghoriyan	Ghoriyan	Ghoriyan	---
Gulkhana	Gulkhana	Gulkhana	Gulkhana	Gulkhana	Gulkhana
Guzarad DH	Guzarad DH	Guzarad DH	Guzarad DH	Guzarad DH	District Hospital
Haft Chah	Haft chah	Haft chah	Haft chah	Haft chah	Haft Chah
Herat Pediatric Hospital	Herat Pediatric Hospital	Herat Pediatric Hospital	Herat Pediatric Hospital	Herat Pediatric Hospital	Herat Pediatric Hospital
Hoze Karbas	Hoze Karbas	Hoze Karbas	Hoze Karbas	Hoze Karbas	Hoze Karbas
Islam Qala	Islam qala	Islam qala	Islam qala	Islam qala	Islam Qala
Jaghartan	Jaghartan	Jaghartan	Jaghartan	Jaghartan	Jaghartan
Jalgi Mazar	Jalgi Mazar	Jalgi Mazar	Jalgi Mazar	Jalgi Mazar	Jalgi Mazar[35]
Jebreil	Jebreil	Jebreil	Jebreil	Jebreil	Jebreil
Jendakhan	Jendakhan	Jendakhan	Jendakhan	Jendakhan	Jendah Khan
Kahdestan	Kahdestan	Kahdestan	Kahdestan	Kahdestan	Kahdestan
Kalagerd	Kalagerd	Kalagerd	Kalagerd	Kalagerd	Kalagerd
Kaminj	Kaminj	Kaminj	Kaminj	Kaminj	Kaminj
Karnail	Karnail	Karnail	Karnail	Karnail	Karnail
Karukh	Karukh	Karukh	Karukh	Karukh	Karukh
Kazergah	Kazergah	Kazergah	Kazergah	Kazergah	Kazergah
Kerman	Kerman	Kerman	Kerman	Kerman	Kerman
Khajagan	Khajagan	Khajagan	Khajagan	Khajagan	Khajagan
Khamshoor	Khamshoor	Khamshoor	Khamshoor	Khamshoor	Khamshoor
Khawaja Charshanbe	Khawaja charshanbe	Khawaja charshanbe	Khawaja charshanbe	Khawaja charshanbe	Khawaja charshanbe
Kocha Zard	Kocha zard	Kocha zard	Kocha zard	Kocha zard	Kocha Zard
Kochael	Kochael	Kochael	Kochael	Kochael	Kokchail
Kohsan	Kohsan	Kohsan	Kohsan	Kohsan	Kohsan
Komori	Komori	Komori	Komori	Komori	Komori
Kondolan	Kondolan	Kondolan	Kondolan	---	Kondalan
Kort	Kort	Kort	Kort	Kort	Kort
Laman	Laman	Laman	Laman	Laman	Laman

33 Comment on cell from Lindsay Denny explained: “This is Dahan Kocha”

34 Comment on cell from Lindsay Denny explained: “This is Dahan Kocha”

35 Comment on cell from H Haqmal: “This Facility was replaced with Ghalmin (in Chenghcharan district) due of security concern”. The facility Jalgi Mazar was included in this analysis, as we had all relevant forms and did not have data for the replacement facility, but this comment seems to indicate that it may not be part of WASHCon going forward.

Standardized	GPS	Director	Administrative	Ward	WQ
Langar Sharif	Provincial Hospital [36]	Langar Sharif	---	Langar Sharif	Langar Sharif
Mahbas (Jail)	Mahbas (Jail)	Mahbas (Jail)	Mahbas (Jail)	Mahbas (Jail)	Mahbas(Jail)
Maladan	Maladan	Maladan	Maladan	Maladan	Maladan
Malan (Ejrim)	Ejrim	Ejrim	Ejrim	Ejrim	Malan
Malmenji	Malmenji	Malmenji	Malmenji	Malmenji	Malmanji
Manare Jam	Manare Jam	Manare Jam	Manare Jam	Manare Jam	Manare Jam
Marabad	Marabad	Marabad	Marabad	Marabad	Marabad
Minarret	Minarret	Minarret	Minarret	Minarret	Minarret
Moqur	Moqur	Moqur	Moqur	Moqur	Moqur (Center)
Nashin	Nashin	Nashin	Nashin	Nashin	Nashin
Nawabad	Nawabad	Nawabad	Nawabad	Nawabad	Naw Abad
Nayestan Guzara	Nayestan Guzara	Nayestan Guzara	Nayestan Guzara	Nayestan Guzara	Nayestan
Nayestan Karukh	Nayestan Karukh	Nayestan Karukh	Nayestan Karukh	Nayestan Karukh	Nayestan
Noor Eye Hospital	Noor Eye hospital	Noor Eye hospital	Noor Eye hospital	Noor Eye hospital	Noor Eye Hospital
Obeh	Obeh	Obeh	Obeh	Obeh	Obeh
Owkhari	Owkhari	Owkhari	Owkhari	Owkhari	Owkhari
Pada	Pada	Pada	Pada	Pada	Pada
Pasaband	Pasaband	Pasaband	Pasaband	Pasaband	Passaband center
Pashtun Zarghun	Pashtun Zarghun	Pashtun Zarghun	Pashtun Zarghun	Pashtun Zarghun	Pashtun Zarghun
Perison Clinic	Perison clinic	Perison clinic	Perison clinic	Perison clinic	Perison clinic
Posht Koh	Posht koh	Posht koh	Posht koh	Posht koh	Posht Koh
Prison Clinic	Prison clinic	Prison Clinic	ARCS [37]	Prison clinic	Prison
Provincial Hospital	Provincial Hospital	Provincial Hospital	Provincial Hospital	Provincial Hospital	Provincial Hospital
Provincial Hospital - Ghor	Provincial Hospital - Ghor	Provincial Hospital - Ghor	Provincial Hospital - Ghor	Provincial Hospital - Ghor	Provincial Hospital
Qadis	Qadis	Qadis	Qadis	Qadis	Qadis Center
Qadis Khordak	Qadis Khordak	Qadis Khordak	Qadis Khordak	Qadis Khordak	Qadis Khordak
Qala Yadega	Qala Yadega	Qala Yadega	Qala Yadega	Qala Yadega	Qala e Yadegar
Qarchaqai	Qarchaqai	Qarchaqai	qarchiqai clinic [38]	qarchiqai clinic	Qarchaqai
Rabat Sangi	Rabat sangi	Rabat sangi	Rabat sangi	Rabat sangi	Rabat sangi
Rawashan	Rawashan	Rawashan	Rawashan	Rawashan	Rawashan
Regional Hospital	Regional hospital	Regional hospital	Regional hospital	Regional hospital	Regional Hospital
Rigi	Rigi	Rigi	Rigi	Rigi	Rigi Jawand
Sabol	Sabol	Sabol	Sabol	Sabol	Sabol
Safid Ab	Safid Ab	Safid Ab	Safid Ab	Safid Ab	Safid Ab

36 Comment on cell from Lindsay Denny explained: “Change to LS”. I confirmed with her that LS meant Langar Sharif.
37 Comment on cell from Lindsay Denny explained: “Change to Prison Clinic”
38 Comment on cell from M Esmatzada stated: “Two facility registration”. No action was taken on this note.

Standardized	GPS	Director	Administrative	Ward	WQ
Saqar	Saqar	Saqar	Saqar	Saqar	Saqar
Sar Hoolang (Poshte-I-Tangi)	Sar hoolang (Poshte-i-tangi)	Sar hoolang (Poshte-i-tangi)	Sar hoolang (Poshte-i-tangi)	Sar hoolang (Poshte-i-tangi)	Sar Hoolang
Shada	Shada	Shada	Shada	Shada	Shada
Shahrak	Shahrak	Shahrak	Shahrak	Shahrak	Shahrak
Shakiban	Shakiban	Shakiban	Shakiban	Shakiban	Shakiban
Shohadaee 24 Hoot	Shohadaee 24 hoot	Shohadaee 24 hoot	Shohadaee 24 hoot	Shohadaee 24 hoot	Shohadaee 24 hoot
Sirwan	Sirwan	Sirwan	Sirwan	Sirwan	Sirwan
Siyawashan	Siyawashan	Siyawashan	Siyawashan	Siyawashan	Siyawashan
Taiwara	Taiwara	Taiwara	Taiwara	Taiwara	Taiwara DH
Tolak	Tolak	Tolak	Tolak	Tolak	Baray/Toolak Center
Toniyan	Toniyan	Toniyan	Toniyan	Toniyan	Toniyan
Torghundi	Torghundi	Torghundi	Torghundi	Torghundi	Torghondi
Yeka Derakht	Yeka derakht	Yeka derakht	Yeka derakht	Yeka derakht	Yeka derakht
Zadali	Zadali	Zadali	Zadali	Zadali	Zad Ali
Zindajan	Zindajan	Zindajan	Zindajan	Zindajan	Zindajan
	n=104	*n=104*	*n=102*	*n=102*	*n=104*
			missing:	**missing:**	
* denotes a comment from study team	Chartaq	Dahan Kocha			
			Langar Sharif	Kondolan	

1.2.2. Uganda

Standardized	GPS	Director	Administrative	Ward	WQ
407 Brigade HC III	407 Brigade HC III	407 Brigade HC III	407 Brigade HC III	407 Brigade HC III	407 Brigade HC III
Abim	Abim HOSPITAL	Abim	Abim	Abim[39]	Abim[40]
Adjumani Hospital	Adjumani HOSPITAL	adjumani hospital	adjumani hospital	adjumani hospital	adjumani hospital
Adjumani Mission	Adjumani Mission HC III	adjumani mission	adjumani mission	adjumani mission	adjumani mission
Adumi	Adumi HC IV	adumi	adumi[41]	adumi	adumi
Ajia	Ajia HC III	Ajia	Ajia	Ajia	Ajia

39 Blue shading of cell backgrounds (n=9, found in the Ward column) represents data that was missing from the initial Ward data set, and was provided separately on February 12, 2019.

40 Green shading in the cell background (n=20, found in the WQ column) represents data that was missing from the initial Water Quality data set. If a green shaded cell contains a value for case_name (n=9), aggregated (facility-level) water quality results were later received for that facility, but not individual sample-level water quality data.

41 Yellow shading of cell backgrounds (n=3, found in the Administrative column) represent facilities that had a duplicate observation that had to be deleted. See subsequent section on cleaning the Admin/Background form for details on the handling of these three duplicates.

Standardized	GPS	Director	Administrative	Ward	WQ
Alere	Alere HC III	alere	alere	alere	alere
Alerek HC III	Alerek HC III	Alerek HC III	Alerek HC III	Alerek HC III	Alerek HC III
Aliba	Aliba HC III	aliba	aliba	aliba	---[42]
Amaler HC III	Amaler HC III	Amaler HC III	Amaler HC III	Amaler HC III	Amaler HC III
Amudat	Amudat HC II [43]	Amudat	Amudat	Amudat	Amudat
Anyiribu	Anyiribu HC III	Anyiribu	Anyiribu	Anyiribu	Anyiribu
Apo	Apo HC III	apo	apo	apo	apo
Arinyapi	Arinyapi HC II	arinyapi	arinyapi	arinyapi	arinyapi
Aripea	Aripea HC III	Aripea	Aripea	Aripea	Aripea
Ariwa	Ariwa HC III	ariwa	ariwa	ariwa	ariwa
Aroi	Aroi HC III	Aroi	Aroi	Aroi	Aroi
Arua Police	Arua Police HC III	Arua Police	Arua Police	Arua Police	Arua Police
Arua Prisons	Arua Prison HC III	Arua Prisons	Arua Prisons	Arua Prisons	---
Arua Regional Ref Hospital	Arua REGIONAL REF HOSPITAL	arua regional ref hospital	arua regional ref hospital	arua regional ref hospital	arua regional ref hospital
Ayilo 1	Ayilo 1 HC III	ayilo 1	ayilo 1	ayilo 1	ayilo 1
Ayipe	Ayipe HC III	ayipe	ayipe	ayipe	ayipe
Ayiri	Ayiri HC III	ayiri	ayiri	ayiri	ayiri
Ayivuni	Ayivuni HC III	Ayivuni	Ayivuni	Ayivuni	Ayivuni
Barakala	Barakala HC III	barakala	barakala	barakala	barakala
Besia	Besia HC III	besia	besia	besia	besia
Bileafe	Bileafe HC III	bileafe	bileafe	bileafe	bileafe
Bondo	Bondo HC III	Bondo	Bondo	Bondo	---
Bondo Military	Bondo Mailitary HC III	Bondo Military	Bondo Military	Bondo Military	---
Ciforo	Ciforo HC III	ciforo	ciforo	ciforo	ciforo
Cilio	Cilio HC III	Cilio	Cilio	Cilio	Cilio
Cou Clinic HC III	CoU Clinic HC III	CoU Clinic HC III	CoU Clinic HC III	CoU Clinic HC III	CoU Clinic HC III
Dramba	Dramba HC III	dramba	dramba	dramba	dramba
Dranya HC III	Dranya HC III	dranya HC III	dranya HC III	dranya HC III	dranya HC III
Dricile	Dricile HC III	dricile	dricile	dricile	dricile
Dufile	Dufile HC III	dufile	dufile	dufile	dufile
Dzaipi	Dzaipi HC III	dzaipi	dzaipi	dzaipi	dzaipi
Ediofe	Ediofe HC III	Ediofe	Ediofe	Ediofe	Ediofe
Eremi	Eremi HC III	eremi	eremi	eremi	eremi
Eria	Eria HC III	eria	eria	eria	eria
Ewanga	Ewanga HC III	Ewanga	Ewanga	Ewanga	Ewanga
Fr. Bilbao/Bilbao	Fr. Bilbao/Bilbao HC III	fr. bilbao/bilbao	fr. bilbao/bilbao	fr. bilbao/bilbao	fr. bilbao/bilbao
Gborokolongo HC III	Gborokolongo HC III	gborokolongo HC III	gborokolongo HC III	gborokolongo HC III	gborokolongo HC III
Gichara	Gichara HC III	gichara	gichara	gichara	gichara

42 If a green shaded cell contains '—' instead of a case_name value (n=11), per the study team, the data was missing because there was no water available for testing at those facilities at the time of the survey. Therefore, no WQ results are available for these case_names – neither at the sample-level nor at the aggregate level.
43 Facility was designated as HC III in the variable for facility type.

Standardized	GPS	Director	Administrative	Ward	WQ
Inde	Inde HC III	Inde	Inde	Inde	Inde
Iriri HC III	Iriri HC III	Iri HC III	Iri HC III	Iri HC III	Iri HC III
Itula	Itula HC III	itula	itula	itula	itula
Kaabong	Kaabong HOSPITAL	Kaabong	Kaabong	Kaabong	Kaabong
Kaabong Mission HC III	Kaabong Mission HC III	Kaabong Mission HC III	Kaabong Mission HC III	Kaabong Mission HC III	---
Kakingol HC III	Kakingol HC III	Kakingol HC III	Kakingol HC III	Kakingol HC III	Kakingol HC III
Kalapata HC III	Kalapata HC III	Kalapata HC III	Kalapata HC III	Kalapata HC III	Kalapata HC III
Kanawat HC III	Kanawat HC III	Kanawat HC III	Kanawat HC III	Kanawat HC III	Kanawat HC III
Kangole HC III	Kangole HC III	Kangole HC III	Kangole HC III	Kangole HC III	Kangole HC III
Kapedo HC III	Kapedo HC III	Kapedo HC III	Kapedo HC III	Kapedo HC III	Kapedo HC III
Karenga	Karenga HC IV	Karenga	Karenga	Karenga	Karenga
Karita	Karita HC III	Karita	Karita	Karita	Karita
Kathile HC III	Kathile HC III	Kathile HC III	Kathile HC III	Kathile HC III	Kathile HC III
Kei	Kei HC III	kei	kei	kei	kei
Koboko Hospital	Koboko Hospital	koboko hospital	koboko hospital	koboko hospital	koboko hospital
Koboko Mission	Koboko Mission HC III	koboko mission	koboko mission	koboko mission	koboko mission
Kochi	Kochi HC III	kochi	kochi	kochi	kochi
Kopoth HC II	Kopoth HC II	Kopoth HC II	Kopoth HC II	Kopoth HC II	---
Kotido	Kotido HC IV	Kotido	Kotido	Kotido	Kotido
Kulikulinga	Kulikulinga HC III	kulikulinga	kulikulinga	kulikulinga	kulikulinga
Kuluva Hospital	Kuluva HOSPITAL	Kuluva Hospital	Kuluva Hospital	Kuluva Hospital	Kuluva Hospital
Laropi	Laropi HC III	laropi	laropi	laropi	laropi
Lefori	Lefori HC III	lefori	lefori	lefori	lefori
Lemusui HC III	Lemusui HC III	Lemusui HC III	Lemusui HC III	Lemusui HC III	---
Lobule	Lobule HC III	lobule	lobule	lobule	lobule
Lodonga	Lodonga HC III	lodonga	lodonga	lodonga	lodonga
Logiri	Logiri HC III	Logiri	Logiri	Logiri	Logiri
Logoba	Logoba HC III	logoba	logoba	logoba	logoba
Lokitelaebu HC III	Lokitelaebu HC III	Lokitelaebu HC III	Lokitelaebu HC III	Lokitelaebu HC III	Lokitelaebu HC III
Lokolia HC III	Lokolia HC III	Lokolia HC III	Lokolia HC III	Lokolia HC III	---
Lokopo HC III	Lokopo HC III	Lokopo HC III	Lokopo HC III	Lokopo HC III	Lokopo HC III
Lolachat HC III	Lolachat HC III	Lolachat HC III	Lolachat HC III	Lolachat HC III	Lolachat HC III
Lopei HC III	Lopei HC III	Lopei HC III	Lopei HC III	Lopei HC III	Lopei HC III
Loputuk HC III	Loputuk HC III	Loputuk HC III	Loputuk HC III	Loputuk HC III	Loputuk HC III
Lorengebwat HC III	Lorengedwat HC III	Lorengebwat HC III	Lorengebwat HC III	Lorengebwat HC III	---
Lorengechora HC III	Lorengechora HC III	Lorengechora HC III	Lorengechora HC III	Lorengechora HC III	Lorengechora HC III
Loroo HC II	Loroo HC II	Loroo HC II	Loroo HC II	Loroo HC II	Loroo HC II
Lotome HC III	Lotome HC III	Lotome HC III	Lotome HC III	Lotome HC III	Lotome HC III
Loyoro HC III	Loyoro HC III	Loyoro HC III	Loyoro HC III	Loyoro HC III	Loyoro HC III
Ludara	Ludara HC III	ludara	ludara	ludara	ludara
Maryland Cocoa	Maryland Kocoa HC III	Maryland cocoa	Maryland cocoa	Maryland cocoa	Maryland cocoa
Matany	Matany HOSPITAL	Matany	Matany	Matany	Matany

Standardized	GPS	Director	Administrative	Ward	WQ
Matuma	Matuma HC III	matuma	matuma	matuma	matuma
Metu	Metu HC III	metu	metu	metu	metu
Midigo	Midigo HC IV	midigo	midigo	midigo	midigo
Moroto Army HC III	Moroto Army HC III	Moroto Army HC III	Moroto Army HC III	Moroto Army HC III	Moroto Army HC III
Moroto Prisons HC III	Moroto Prisons HC III	Moroto Prisons HC III	Moroto Prisons HC III	Moroto Prisons HC III	Moroto Prisons HC III
Moroto RRH	Moroto Regional Refferal HOSPITAL	Moroto RRH	Moroto RRH	Moroto RRH	Moroto RRH
Morulem HC III	Morulem HC III	Morulem HC III	Morulem HC III	Morulem HC III	Morulem HC III
Moyo Hospital	Moyo HOSPITAL	moyo hospital	moyo hospital	moyo hospital	moyo hospital
Moyo Mission	Moyo Mission HC III	moyo mission	moyo mission	moyo mission	moyo mission
Mungula	Mungula HC IV	mungula	mungula	mungula	mungula
Nabilatuk	Nabilatuk HC IV	Nabilatuk	Nabilatuk	Nabilatuk	Nabilatuk
Nadunget HC III	Nadunget HC III	Nadunget HC III	Nadunget HC III	Nadunget HC III	Nadunget HC III
Nakapelimoru HC III	Nakapelimoru HC III	Nakapelimoru HC III	Nakapelimoru HC III	Nakapelimoru HC III	Nakapelimoru HC III
Nakapiripirit HC III	Nakapiripirit HC III	Nakapiripirit HC III	Nakapiripirit HC III	Nakapiripirit HC III	Nakapiripirit HC III
Namalu HC III	Namalu HC III	Namalu HC III	Namalu HC III	Namalu HC III	Namalu HC III
Napumpum HC III	Napumpum HC III	Napumpum HC III	Napumpum HC III	Napumpum HC III	Napumpum HC III
Nyakwae III	Nyakwae HC III	Nyakwae III	Nyakwae III	Nyakwae III	Nyakwae III
Obongi	Obongi HC IV	obongi	obongi	obongi	obongi
Oduoba HC3	Oduobu HC III	oduoba hc3	oduoba hc3	oduoba hc3	oduoba hc3
Odupi	Odupi HC III	Odupi	Odupi	Odupi	Odupi
Offaka	Offaka HC III	Offaka	Offaka	Offaka	Offaka
Ofua	Ofua HC III	ofua	ofua	ofua	ofua
Oje Mission	Oje Mission HC III	Oje Mission	Oje Mission	Oje Mission	Oje Mission
Okollo Refugee	Okollo Refugee HC III	Okollo Refugee	Okollo Refugee	Okollo Refugee	Okollo Refugee
Olujobo	Olujobo HC III	olujobo	olujobo	olujobo	olujobo
Oluko Solidale	Oluko Solidale HC III	Oluko Solidale	Oluko Solidale	Oluko Solidale	Oluko Solidale
Ombidiriondrea	Ombidriondrea HC III	Ombidiriondrea	Ombidiriondrea	Ombidiriondrea	Ombidiriondrea
Omugo	Omugo HC IV	omugo	omugo	omugo	omugo
Openzinzi	Openzinzi HC III	openzinzi	openzinzi	openzinzi	openzinzi
Opia	Opia HC III	opia	opia	opia	opia
Oriajini Hospital	Oriajini HOSPITAL	Oriajini Hospital	Oriajini Hospital	Oriajini Hospital	Oriajini Hospital
Orivu	Orivu HC III	Orivu	Orivu	Orivu	Orivu
Orwamuge	Orwamuge HC III	Orwamuge	Orwamuge	Orwamuge	---
Otumbari St. Lawrence	Otumbari St. Lawrence HC III	Otumbari St. Lawrence	Otumbari St. Lawrence	Otumbari St. Lawrence	Otumbari St. Lawrence
Oyima	Oyima HC III	Oyima	Oyima	Oyima	Oyima

Standardized	GPS	Director	Administrative	Ward	WQ
Pagirinya	Pagirinya HC III	pagirinya	pagirinya	pagirinya	pagirinya
Pajulu	Pajulu HC III	Pajulu	Pajulu	Pajulu	Pajulu
Pakele	Pakele HC III	pakele	pakele	pakele	pakele
Palorinya	Palorinya HC III	palorinya	palorinya	palorinya	palorinya
Panyangara HC III	Panyangara HC III	Panyangara HC III	Panyangara HC III	Panyangara HC III	Panyangara HC III
Pawor	Pawor HC III	Pawor	Pawor	Pawor	Pawor
Pioneer Hospital	Pioneer Hospital	Pioneer Hospital	Pioneer Hospital	Pioneer Hospital	Pioneer Hospital
Rengen HC III	Rengen HC III	Rengen HC III	Rengen HC III	Rengen HC III	Rengen HC III
Rhino Camp	Rhino Camp HC IV	rhino camp	rhino camp	rhino camp	rhino camp
Riki	Riki HC III	Riki	Riki	Riki	Riki
River Oli	River Oli HC IV	river oli	river oli	river oli	river oli
Robidire	Robidire HC III	robidire	robidire	robidire	robidire
Siripi	Siripi HC III	Siripi	Siripi	Siripi	Siripi
St. Pius Kipedo HC III NGO	St.Pius Kidepo HC III NGO	St Pius Kipedo HC III NGO	St Pius Kipedo HC III NGO	St Pius Kipedo HC III NGO	---
St. Assumpta	St. Assumpta HC III	St. Assumpta	St. Assumpta	St. Assumpta	St. Assumpta
St. Francis Ocodri	St. Francis Ocodri HC III	St. Francis Ocodri	St. Francis Ocodri	St. Francis Ocodri	St. Francis Ocodri
St. Luke Katiyi	St. Luke Katiyi HC III	St. luke katiyi	St. luke katiyi	St. luke katiyi	St. luke katiyi
Tapac HC III	Tapac HC III	Tapac HC III	Tapac HC III	Tapac HC III	Tapac HC III
Tokora	Tokora HC IV	Tokora	Tokora	Tokora	Tokora
Ukusijoni	Ukusijoni HC III	ukusijoni	ukusijoni	ukusijoni	ukusijoni
Vurra	Vurra HC III	vurra	vurra	vurra	vurra
Wandi	Wandi HC III	Wandi	Wandi	Wandi	Wandi
Yinga	Yinga HC III	Yinga	Yinga	Yinga	Yinga
Yoyo	Yoyo HC III	yoyo	yoyo	yoyo	yoyo
Yumbe	Yumbe HC IV	yumbe	yumbe	yumbe	yumbe
Yumbe General Hospital	Yumbe Hospital	yumbe general hospital	yumbe general hospital	yumbe general hospital	yumbe general hospital
Zoka	Zoka HC II	zoka	zoka	zoka	zoka
	n=148	*n=148*	*n=148 (initially: 147)*	*n=148 (initially: 139)*	*n=137 (initially: 128)*
			initially missing data *(provided February 12, 2019 in MS Word or Excel format):*	**NO WATER at time of survey:**	
			Nakapelimoru HC III	Abim	Aliba
				Amudat	Arua Prisons
				Kaabong	Bondo
				Karenga	Bondo Military
				Kotido	Kaabong Mission HC III
				Matany	Kopoth HC II

Standardized	GPS	Director	Administrative	Ward	WQ
				Moroto RRH	Lemusui HC III
				Nabilatuk	Lokolia HC III
				Tokora	Lorengebwat HC III
					Orwamuge
					St. Pius Kipedo HC III NGO
				HCF-level aggregated results only *(provided February 12, 2019):*	
					Abim
					Amudat
					Kaabong
					Karenga
					Kotido
					Matany
					Moroto RRH
					Nabilatuk
					Tokora

1.3. GPS data sets

GPS Data sets		
	Afghanistan	Uganda
Variables	7	8
Observations	104	148

As described in the Data Dictionary (**Appendix C – GPS section**), the GPS data sets were not provided in the standard survey format. As a result, aside from the case_name standardization, most of the work done in these GPS data sets prior to uploading into SAS was not the cleaning of existing data but rather the creation of demographic variables. Key changes were as follows:

- Standardized case_name
- Created demographic variables including gps_type (provided by the study team), gps_ownership (provided by the study team), and gps_rural_0_urban_1 (provided by the study team in Afghanistan; derived from national data and definitions in Uganda) (see **Appendix C**)
- Dropped repetitive word "district" from the end of all districts (gps_district – Uganda only)
- Dropped variables not relevant to analysis or not readable in SAS (see **Appendix C**)

1.4. Director Data sets

Director Data sets		
	Afghanistan	Uganda
Variables	97	91
Observations	104	148

Afghanistan Director Data set

i. **Changes to Key Variables**
- **Standardized case_name (see CASE_NAME tables above)**
- dr_ws_sa_main (Main Water Source)**:**
  - **Case_name** Khajagan: **Because dr_ws_sa_avl said 'none', dr_ws_sa_main was listed as missing. Changed '---' (missing) to 'none'**

ii. **Changes to Other Variables**
- **Dropped administrative variables: completed_time, started_time, username, received_on**
- **Case_name** [ALL]: **Translated free-text values written in Persian or Daru to English and marked "(translated)"**
- **Case_name** Alaf**, var form.dr_wq_qa_proc_devices: changed from "oth" to "no_treat" as subsequent "specify other" variable indicated "(translated) "There is no water purification". Case_name** Alaf**, var form.dr_wq_qa_proc_medication: changed from "oth" to "no_treat" as subsequent "specify other" variable indicated "(translated) No cleaning is done"**
- **Case_name** Herat Pediatric Hospital, **var form.dr_g_dep: added "postnatal" to the list of departments after subsequent "specify other" variable indicated "(translated) Baby services".**
- **Case_name** Rawashan**: "form.dr_wv_stockout" changed from "yes" to "no" after subsequent "specify other" variable indicated "(translated) We did not get any shortcomings"**
- **Case_name** Karukh**, var dr_g_esource – changed from "oth" to "solar" after subsequent "specify other" variable indicated "(translated) Solar"**
- **Case_name** Karukh**, var dr_g_eprim – changed from "oth" to "solar" after subsequent "specify other" variable indicated "(translated) Solar"**
- **Case_name** Taiwara**, var dr_g_esource – added "gen" after subsequent "other" variable indicated "(translated) Generator"**
- **Case_name** Taiwara**, var dr_g_eprim – changed from "oth" to "gen" after subsequent "specify other" variable indicated "(translated) Generator"**

Uganda Director Data set

i. Changes to Key Variables

- Standardized case_name (see CASE_NAME tables above)
- **dr_ws_sa_main (Main Water Source)**
    - For the following case_names, review of the "sources available" variable (**dr_ws_sa_avl**) and the "sources available – if other, describe" free text field (**dr_ws_sa_avl_other**) enabled us to populate the Main Water Source variable (**dr_ws_sa_main**) where this variable was previously blank. If a source with an existing answer option was indicated in the free text field, this option was used.

			dr_ws_sa_main	
case_name	dr_ws_sa_avl	dr_ws_sa_avl_other	Old value	New value
lobule	Oth none	rain water harvesting	---	Rain
yoyo	Tank oth none	pipe water under connection	---	Tank
moyo mission	Pip none	---	---	Pip
ariwa	Tank none	---	---	Tank
dricile	Oth none	rain water harvesting faulty	---	Rain

ii. Changes to Other Variables

- Administrative variables were not present in initial data set from study team and thus did not need to be dropped
- var form.dr_g_dep (List of Departments Available at HCF) and form.dr_g_dep_oth:
    - Corrected placement of "immunization" and "family planning" departments from the "other" variable (form.dr_g_ep_oth) to the regular department variable (form.dr_g_dep), to conform with the WASHCon Unification Document (Data Dictionary) and the Director forms for Afghanistan. Exceptions: if the description stated "natural" family planning, I did not add family planning to the list of departments, but retained it as an "other".
    - If "specify other" var indicated "post natal care", added "postnatal"" to the parent variable and removed "post natal care" from "other" field.

1.5. Administrative Data sets

Administrative Data sets		
	Afghanistan	Uganda
Variables	17	18
Observations	102	148

Afghanistan Administrative Data set

iii. Changes to Key Variables
- Standardized case_name (see CASE_NAME tables above)
- Form.bkg_ws_qn_wmon (Average Daily Water Use in Liters)
  - Case_name Dehnow – **ACCIDENTAL CHANGE** (later corrected in SAS, prior to analysis) – accidentally changed value of variable from 999999999 to 10999999999. Corrected after error was discovered.

iv. Changes Other Variables
- Dropped administrative variables: completed_time, started_time, username, received_on

Uganda Administrative Data set

i. Changes to Key Variables

Deleted three (3) duplicate observations where the same case_name was used twice within data set. Where duplicates occurred, we kept the observation with the **later** completed_time. Removed 3 duplicates in total (first-submitted values for Adumi, Logiri, and Panyangara). Where the values for the duplicates were different, the deleted and retained values were as follows:

DUPLICATE 1. CASE_NAME: **adumi**	Deleted duplicate row - kept second-submitted. Values differed for the following variables:	
Variable	**First**	**Second [Kept]**
bkg_g_iseen	58	89
bkg_g_inum	1	4
bkg_g_dnum	16	40
bkg_g_cnum	5	3

DUPLICATE 2. CASE_NAME: **Logiri**	Deleted duplicate row - kept second-submitted. Values differed for the following variables:	
Variable	**First**	**Second [Kept]**
bkg_g_oseen	1345	1786
bkg_g_iseen	34	13
bkg_g_ibed	14	13
bkg_g_dnum	9	23
bkg_g_cstaff	5	6
bkg_g_ncstaff	6	7
bkg_g_clstaff	2	1

bkg_ws_qn_wmon	120	500
bkg_ws_sa_today	no_alt	yes

DUPLICATE 3. CASE_NAME:

Panyangara HC III

Deleted duplicate row - kept second-submitted. Values differed for the following variables:

Variable	**First**	**Second [Kept]**
bkg_g_oseen	1403	1200
bkg_g_iseen	99	26
bkg_g_inum	3	1
bkg_g_ibed	7	18
bkg_g_dnum	37	64
bkg_g_ncstaff	6	3
bkg_g_clstaff	1	2
bkg_ws_qn_wmon	150	120

ii. Changes to Values for Other Variables (Not Analyzed)

- None

1.6. Ward Data sets

Ward Data sets		
	Afghanistan	Uganda
Variables	39	24
Observations	497	422

Afghanistan Wards Data set

i. Changes to Key Variables

- Standardized case_name (see CASE_NAME tables above)

ii. Changes to Other Variables

- Ward_g_type (and ward_g_type_oth)

Note: ward type was to provide descriptive statistics at the ward level, and was used as a potential explanatory model in univariable regressions at the ward level, but was not featured in any multiple regression models or in any HCF-level analysis. Thus, ward type was not considered a key variable. (FormIDs of impacted observations are available upon request.)

- Immunization Wards

If var ward_g_type_oth stated, or was translated to, “Vaccine”, “Vaccination”, “Vaccine section,” “Vaccine Branch”, or “Imported Vaccine”, changed ward_g_type from “Oth” to “Immun” indicating an Immunization Ward per the Unification Document. Changed ward_g_type_oth to blank. This applied to 55 wards.

- Nutrition Wards

If var ward_g_type_oth stated, or was translated to, “Nutrition”, “Nutrition services”, or “Nutrition section”, changed ward_g_type from “Oth” to “Nut” indicating a Nutrition Ward per Unification Document. Changed ward_g_type_oth to blank. This applied to 27 wards.

- Pharmacy Wards

If var ward_g_type_oth stated, or was translated to, “Pharmacy” or “Pharmacy services”, changed ward_g_type from “Oth” to “Pha” indicating a Pharmacy Ward per the Unification Document. Changed ward_g_type_oth to blank. This applied to 15 wards.

- Laboratory Wards

If var ward_g_type_oth stated, or was translated to, “Laboratory”, changed ward_g_type from “oth” to “lab” indicating a Laboratory Ward per the Unification Document. Changed ward_g_type_oth to blank. This applied to 17 wards.

- Antenatal Wards

If var ward_g_type_oth stated, or was translated to, “ANC” or Pre-natal care” or “Before childbirth” or “(translated) Pre-natal care units and family planning” or “(translated) Pre-natal care 0 All births and family planning were all the same” , changed ward_g_type from “Oth” to “aanatal”. Changed ward_g_type_oth to blank. This applied to 5 wards.

- Dentistry Wards

If var ward_g_type_oth stated, or was translated to, “Enters the teeth”, changed ward_g_type from “Oth” to “den” indicating a Dentistry Ward per the Unification Document. Changed ward_g_type_oth to blank. This applied to 1 ward.

- Outpatient Wards

If var ward_g_type_oth stated “opd”, changed ward_g_type from oth” to “outpat”. Changed ward_g_type_oth to blank. This applied to 2 wards.

Afghanistan Wards Data set

- Postnatal Wards

If var ward_g_type_oth stated "mch" or "neonatal" or "(translated) Postpartum care Before you get pregnant, home improvement and nutrition are all about" or "(translated) Pre and postnatal care" or "PNC" or "AND AND PNC", changed ward_g_type from oth" to "postnatal". Changed ward_g_type_oth to blank. This applied to 5 wards.

- Emergency Wards

If var ward_g_type_oth stated "(translated) Malnutrition and emergency department"; changed ward_g_type from oth to ew per Unification Document. Changed ward_g_type_oth to blank. This applied to 1 ward.

- Surgery Wards

If var ward_g_type_oth stated "(translated) Surgery ward"; changed ward_g_type from oth to surg per Unification Document. Changed ward_g_type_oth to blank. This applied to 1 ward.

- Pediatric Wards

If var ward_g_type_oth stated "peds"; changed ward_g_type from oth to ped per the Unification Document. Changed ward_g_type_oth to blank. This applied to 2 wards.

Uganda Wards Data set

i. Changes to Key Variables
- Standardized case_name (see CASE_NAME tables above)

ii. Changes to Other Variables

Note: ward type was to provide descriptive statistics at the ward level, and was used as a potential explanatory model in univariable regressions at the ward level, but was not featured in any multiple regression models or in any HCF-level analysis. Thus, ward type was not considered a key variable. (FormIDs of impacted observations are available upon request.)

- ward_g_type (and ward_g_type_oth)

- Labor & Delivery Wards

If var ward_g_type_oth stated "OPD and Labour suit and postnatal", changed ward_g_type from "Oth" to "lab_del" indicating a Labor & Delivery Ward per the Unification Document. Changed ward_g_type_oth to blank. This applied to 1 ward.

- Pediatric Wards

If var ward_g_type_oth stated "Pediatric, male and female" or "maternity, pediatric, female and male ward", changed ward_g_type from "Oth" to "ped" indicating a Pediatric Ward per the Unification Document. Changed ward_g_type_oth to blank. This applied to 2 wards.

- Inpatient Wards

If var ward_g_type_oth stated "IPD", changed ward_g_type from "Oth" to "inpat" indicating an Inpatient Ward per the Unification Document. Changed ward_g_type_oth to blank. This applied to 1 ward.

- Surgery Wards

If var ward_g_type_oth stated "surgical", changed ward_g_type from "Oth" to "surg" indicating a Surgery Ward per the Unification Document. Changed ward_g_type_oth to blank. This applied to 1 ward.

- General Wards

Uganda Wards Data set
If var ward_g_type_oth stated "General", "Général", "General Ward", or Général Ward", changed ward_g_type from "Oth" to "gen" indicating a General ward. [Note: "General" is not a current option in the Unification Document, but was used in other forms.] Changed ward_g_type_oth to blank. This applied to 53 wards. ○ Female Wards If var ward_g_type_oth stated "Female", "Female ward", or "Female ward (mixed with male)", changed ward_g_type from "Oth" to "female" indicating a Female Ward. [Note: "Female" is not a current option in the Unification Document, but was used in other forms.] Changed ward_g_type_oth to blank. This applied to 4 wards. ○ Male Wards If var ward_g_type_oth stated "male ward" or "male wards", changed ward_g_type from "Oth" to "male" indicating a Male Ward. [Note: "Male" is not a current option in the Unification Document, but was used in other forms.] Changed ward_g_type_oth to blank. This applied to 4 wards. ○ Laboratory Wards If var ward_g_type_oth stated "laboratory", changed ward_g_type from "Oth" to "lab" indicating a Laboratory Ward per the Unification Document. Changed ward_g_type_oth to blank. This applied to 1 ward. • Ward_ws_sa_piped (Does the ward have piped water?) ○ Accidental change discovered during data audit: for case_name Anyiribu, ward_type lab_del, value of variable ward_ws_sa_piped was accidentally changed from 'no' to '5'. Later fixed in SAS.

1.7. Water Quality Data sets

Water Quality Data sets		
	Afghanistan	Uganda
Variables	19	11
Observations	190	285

Afghanistan Water Quality Data set
Note: This data set was the most challenging to clean. The Afghanistan WQ forms came in three (3) separate sheets by province (Badghis, Ghor, Herat), none of which used the standard variable names listed in the Data Dictionary (WASHCon Unification Document). The first step was to combine these into one sheet, and the second step was to assign standard variable names based on the Unifying Document. I removed variables that were not populated for two of the three provinces. Changes to Key Variables Standardized case_name (see CASE_NAME tables above) Note: For these three WQ sheets by province, ALL case_names appeared to have been entered as free text fields. **E_coli** Ghor and Heart provinces' *E. coli* data columns were both labeled "fecal coliforms (e.col/100 mL)". The Afghanistan study coordinator clarified that these data were in fact *E. coli* data measured in CFU/100 mL. Re-labeled column on combined sheet to **wq_e_coli**. *E. coli* data for Badghis province was a mix of numerical and character data, including "Nill" and "TNTC" (too numerous to count). To make this data entirely numerical, I replaced "Nill" with a value of **0** and "**TNTC**" with a value of **500**. (TNTCs were ID#s 16, 23, 30, 31, 32, 33, and 38). Changes to Other Variables Dropped variables that were only present for one province (Badghis) and only populated for a few samples: Nitrite, Nitrate, Sulphate, Chromium, Total Hardness, Calcium Hardness, Magnesium, Boron, Iron HR, Ammonia, Chloride, Manganese, Copper, Arsenic, Fluoride, ORP (v) Dropped administrative variables: Sampling Date

Uganda Water Quality Data set
i. Changes to Key Variables • **wq_location** and **wq_location_oth** 175 of 276 water quality sample locations in Uganda were labeled "other" and were manually assigned to an analyzable value as indicated in the free text field "other" field. Where form.wq_location="oth", reviewed form.wq_location_oth variable to see what "other" area was indicated. If a location_oth value indicated *more than one* ward or area, the guiding principle I used for assigning the I chose the one that the literature indicates has highest risk, according to the following risk flow: lab_del, postnatal, ped, aanatal, inpat, ew, female, male, outpat, nut, immun. ii. Changes to Other Variables • None

2. Stage Two Cleaning

After case_name standardization and preliminary cleaning in Excel, all 10 data sets were imported into SAS software, version 9.4 of the SAS System for Windows (SAS Institute Inc., Cary, NC, USA). An HCF-level data set was created by merging results from both countries' GPS, Director, and Administrative data sets by the HCF name. There existed a one-to-one relationship between these three forms, such that in the final combined data set each HCF was represented by one observation row that included variables from the GPS form, Director form, and Administrative form.[44] This "HCF-level" combined data set was used as the starting point to investigate all HCF-level hypotheses.

Each observation in the Ward-level data set had a "many-to-one" relationship with the observations in the HCF-level data set. The "Wards" data set contained one observation for each ward that was assessed, meaning each HCF was typically (but not always) represented more than once. Similarly, the "Water Quality" data set contained one observation for each water sample collected, so again, each HCF was typically (but not always) represented more than once.

Merging HCF-level information into the ward and water-point data sets would have violated the "independence of observations" requirement for validity of regression modeling. Instead, HCF-level summary variables were created within the ward and water quality data sets and merged into the HCF-level data set for analysis.

[44] There were some exceptions wherein a facility was missing one or more forms. These are noted in Appendices.

Appendix F. Reference Table of Dependent, Independent, and Supplementary Variables

Data Set	Variable	Type	Levels	Dep.	Ind.	Supp.	Data Label	Variable Derivation, if any
Facility	**Basic Water Service (RQ 1.01)**	Binary	no, yes	x	x		**JMP_basic_water**	IF **JMP_service_level** = "Basic Service" THEN JMP_basic_water = "Basic Service"; IF **JMP_service_level** = "Limited Service" OR "No Service" THEN JMP_basic_water = "Limited or No Service"
Facility	**≥ 1 E Coli Violations at Facility (RQ 2.01)**	Binary	No, Yes	x			**hcf_ecoli_viol**	IF **total_ecv**=. then hcf_ecoli_viol= ""; IF **total_ecv**=0 then hcf_ecoli_viol = "No"; IF **total_ecv**>0 then hcf_ecoli_viol = "Yes"
Facility	**Facilities with Staff Hand Hygiene at ≥ 1 Points of Care (RQ 1.02)**	Binary	0,1	x			**poc_handwash_any**	
Facility	**Staff Access to Six Cleans for Delivery at HCF's LND Ward (RQ 1.03)**	Binary	0,1	x			**sixcl_all**	After removing one (1) duplicate where two LND wards were reviewed at the same HCF, merged variable **sixcl_all** from ward data set to facility data set using **case_name**
Facility	JMP Water Service Level	Ordinal (3)	none, limited, basic		x	x	JMP_service_level	IF **water_avail_at_survey** = 1 AND **improved_source** = 1 AND **on_premises** = 1 THEN JMP_service_level = "Basic Service"; IF **improved_source** = 1 AND (**off_but_within_500m** = 1 OR **water_avail_at_survey** = 0) THEN JMP_service_level = "Limited Service"; IF **improved_source** = 0 OR **on_or_within_500m** = 0 THEN JMP_service_level = "No Service"
Facility	Reliable Electricity Available	Binary	No, Yes		x	x	reliable_electricity	IF **dr_g_eint** = 'everyday' OR 'most_day' OR 'sev_day' OR if **dr_g_esource** contains 'none' THEN reliable_electricity = 'no'; IF **dr_g_eint** = 'never' OR 'once' THEN reliable_electricity = 'yes'
Facility	C-Sections per Month (Avg N)	Continuous	--		x		bkg_caesarian_mo_n	Numeric version of **bkg_g_cnum**
Facility	Cleaning Staff (N)	Continuous	--		x		bkg_staff_cleaning_n	Numeric version of **bkg_g_clstaff**
Facility	Clinical Staff (N)	Continuous	--		x		bkg_staff_clinical_n	Numeric version of **bkg_g_cstaff**
Facility	Deliveries per Month (Avg N)	Continuous	--		x		bkg_deliv_mo_n	Numeric version of **bkg_g_dnum**
Facility	Geographic Setting	Binary	Rural, Urban		x		gps_setting	Rural: gps_rural_0_urban_1=0 / Urban: gps_rural_0_urban_1=1
Facility	Inpatient Beds Available (N)	Continuous	--		x		bkg_inpat_beds_n	Numeric version of **bkg_g_ibed**
Facility	Inpatient Services Available	Binary	no, yes		x		bkg_g_inp	Original variable.
Facility	Inpatients Seen per Month (N)	Continuous	--		x		bkg_inpat_seenmo_n	Numeric version of **bkg_g_iseen**

Data Set	Variable	Type	Levels	Dep.	Ind.	Supp.	Data Label	Variable Derivation, if any
Facility	Level of Care H/L	Binary	0, 1		x		hcf_level_high	0 = **gps_type** SHC, BHC, HC I, HC II, HC III; 1 = **gps_type** CHC, DH, PH, RH, SH, HC IV, GH, RRH, NRH
Facility	Main Water Source Type	Categorical (4)	imp_bortub, imp_piped, imp_other, unimp_or_none		x		mainsource_cat	imp_bortub = **dr_ws_sa_main** bor, tub. imp_piped = **dr_ws_sa_main** pip. imp_other = **dr_ws_sa_main** p_well, rain, tank. unimp_or_none = **dr_ws_sa_main** surf_water, oth, none.
Facility	Non-Clinical Staff (N)	Continuous	--		x		bkg_staff_nonclinical_n	Numeric version of **bkg_g_ncstaff**
Facility	Outpatients Seen per Month (N)	Continuous	--		x		bkg_ouitpat_seenmo_n	Numeric version of **bkg_g_oseen**
Facility	Ownership	Binary	Public, Private		x		owner_type	Public = hcf_owner Govt; Private= hcf_owner PNP or PFP
Facility	Storage Capacity (Liters)	Continuous	--		x		dr_storage_capacity_n	Numeric version of **dr_ws_sa_store_capacity**
Facility	Subregion	Categorical (5)	Af.: Badghis, Ghor, Herat / Ug: Karamoja, West Nile		x		gps_subregion	Original variable.
Facility	Surgeries per Month (Avg N)	Continuous	--		x		bkg_surg_mo_n	Numeric version of **bkg_g_snum**
Facility	Surgical Services Available	Binary	no, yes		x		bkg_g_surg	Original variable.
Facility	Total Patients Seen per Month (N)	Continuous	--		x		total_seenmo_n	**bkg_inpat_seenmo_n** + **bkg_outpat_seenmo_n**
Facility	Total Staff (N)	Continuous	--		x		total_staff	bkg_staff_clinical_n + bkg_staff_nonclinical_n
Facility	Water Reported Chlorinated	Binary	no, yes		x		dr_ws_qa_clsrc	Original variable. Cleaned '---' and 'dk' values to make binary.
Facility	Water Reported Chlorinated Onsite	Binary	no, yes		x		dr_ws_qa_hcfcl	Original variable. Added 'no' values from dr_ws_qa_hcfcl and cleaned '---' and 'dk' values to make binary.
Facility	Water Use per Day (Avg N Liters)	Continuous	--		x		bkg_wateruse_day_n	Numeric version of **bkg_ws_qn_wmon**
Ward	Ward Type Category	Categorical (7)	Labor/Delivery and Postnatal Care; Inpatient and General Care; Surgical and Emergency Care; Outpatient Care; Pediatric and Antenatal Care; Medicine and Food: Pharmacy, Immunization, Lab, Nutrition, Kitchen; Other		x		ward_type_category	IF **ward_g_type** = "lab_del" OR "postnatal" THEN ward_type_category = "Labor/Delivery and Postnatal Care"; IF **ward_g_type** = "gen" OR "inpat" THEN ward_type_category = "Inpatient and General Care"; IF **ward_g_type** = "ew" OR "surg" THEN ward_type_category = "Surgical and Emergency Care"; IF **ward_g_type** = "outpat" THEN ward_type_category = "Outpatient Care"; IF **ward_g_type** = "ped" OR 'aanatal' THEN ward_type_category = "Pediatric and Antenatal Care"; IF **ward_g_type** = "lab" OR "kitchen" OR "pha" OR "nut" OR "immun" THEN ward_type_category = "Medicine and Food: Pharmacy, Immunization, Lab, Nutrition, Kitchen";

Data Set	Variable	Type	Levels	Dep.	Ind.	Supp.	Data Label	Variable Derivation, if any
								IF **ward_g_type** = "den" OR "female" OR "male" OR "oth" THEN ward_type_category = "Other"
WQ	Water Point Source Type Category	Categorical (4)	imp_bortub; imp_piped; imp_other; unimp_or_other		x		wq_sourcetype_cat	IF **wq_sourcetype** = "tube well" THEN wq_sourcetype_cat = "imp_bortub"; IF **wq_sourcetype** = "utility" OR "tap" THEN wq_sourcetype_cat = "imp_piped"; IF **wq_sourcetype** = "gravity-scheme spring" OR "rainwater" OR "tanker truck" THEN wq_sourcetype_cat = "imp_other"; IF **wq_sourcetype** = "surface water" OR "hand-dug well" OR "spring" THEN wq_sourcetype_cat = "unimp_or_other"
WQ	Water Quality Location Category	Categorical (7)	Labor/Delivery Care; Inpatient and General Care; Surgical and Emergency Care; Outpatient Care; Pediatric and Antenatal Care; Medicine and Food: Immunization, Lab, Kitchen; Other, Incl. Water Source		x		wq_loc_category	IF **wq_location** = "lab_del" THEN wq_loc_category = "Labor/Delivery Care"; IF **wq_location** = "gen" OR "inpat" THEN wq_loc_category = "Inpatient and General Care"; IF **wq_location** = "ew" OR "surg" THEN wq_loc_category = "Surgical and Emergency Care"; IF **wq_location** = "outpat" THEN wq_loc_category = "Outpatient Care"; IF **wq_location** = "ped" OR "aanatal" THEN wq_loc_category = "Pediatric and Antenatal Care"; IF **wq_location** = "lab" OR "kitchen" OR "immun" THEN wq_loc_category = "Medicine and Food: Immunization, Lab, Kitchen"; IF **wq_location** = "water_source" OR "female" OR "male" OR "oth" THEN wq_loc_category = "Other, incl. Water Source"
Facility	Days per Month Outpatients are Seen (N)	Continuous	--			x	bkg_outpat_daysmo_n	Numeric version of **bkg_g_omon**
Facility	Doctors (N)	Continuous	--			x	bkg_staff_md_n	Numeric version of **bkg_g_md**
Facility	Facilities with Patient Hand Hygiene at All Points of Care	Binary	0,1			x	pat_handwash_all	
Facility	Facilities with Patient Hand Hygiene at Any One or More Points of Care	Binary	0,1			x	pat_handwash_any	
Facility	Facilities with Patient Hand Hygiene at Half or More Points of Care	Binary	0,1			x	pat_handwash_ge_half	
Facility	Facilities with Patient Hand Hygiene at More than Half Points of Care	Binary	0,1			x	pat_handwash_g_half	
Facility	Facilities with Staff Hand Hygiene at All Points of Care	Binary	0,1			x	poc_handwash_all	

Data Set	Variable	Type	Levels	Dep.	Ind.	Supp.	Data Label	Variable Derivation, if any
Facility	Facilities with Staff Hand Hygiene at Half or More Points of Care	Binary	0,1			x	poc_handwash_ge_half	
Facility	Facilities with Staff Hand Hygiene at More than Half of Points of Care	Binary	0,1			x	poc_handwash_g_half	
Facility	Facility *E. Coli* Score	Interval	1,2,3			x	wq_ws_wn_ecoli_hlw	IF **pct_samples_ecoli_pos** <= 0.1 THEN wq_ws_qn_ecoli_hlw= 3; IF 0.1 < **pct_samples_ecoli_pos** <= 0.5 THEN wq_ws_qn_ecoli_hlw= 2; IF **pct_samples_ecoli_pos** > 0.5 THEN wq_ws_qn_ecoli_hlw= 1; IF **pct_samples_ecoli_pos** = . THEN wq_ws_qn_ecoli_hlw = .; IF case_name is one of the 9 for which only facility-level data is available, THEN pull existing facility-level data from WQ data set (see aggregate WQ form)
Facility	Facility Free Chlorine Score	Interval	1,2,3			x	wq_ws_qn_cl_hlw	IF **pct_samples_chlorinated** = 1 AND **pct_samples_fcl_v_hcf** <= 0.5 THEN wq_ws_qn_cl_hlw=3; IF **pct_samples_chlorinated** = 1 AND **pct_samples_fcl_v_hcf** > 0.5 THEN wq_ws_qn_cl_hlw=2; IF **pct_samples_chlorinated** < 1 OR **pct_samples_fcl_v_hcf** = 1 THEN wq_ws_qn_cl_hlw=1; IF **pct_samples_fcl_v_hcf** = . THEN wq_ws_qn_cl_hlw = .; IF case_name is one of the 9 for which only facility-level data is available, THEN pull existing facility-level data from WQ data set (see aggregate WQ form)
Facility	Facility Has One or More E Coli Violations (3 levels)	Ordinal (3)	Not Tested, No, Yes			x	hcf_ecoli_v	IF **total_ecv**=. then hcf_ecoli_v = "Not Tested"; IF **total_ecv**=0 then hcf_ecoli_v = "No"; IF **total_ecv**>0 then hcf_ecoli_v = "Yes"
Facility	Improved Source	Binary	0, 1			x	improved_source	IF **dr_ws_sa_main** = "bor" OR "p_spring" OR "p_well" OR "pip" OR "rain" OR "tank" OR "tub" THEN improved_source = 1; IF **dr_ws_sa_main** = "none" OR "oth" OR "surf_water" THEN improved_source = 0
Facility	Improved Water	Binary	0, 1			x	improved_source	1: **dr_ws_sa_msrc**='on', else 0
Facility	Inpatients at the HCF on an Average Day (N)	Continuous	--			x	bkg_inpat_avgday_n	Numeric version of **bkg_g_inum**
Facility	Level of Care HH/H/L	Ordinal (3)	1. Low-Mid Primary, 2. High-Primary, 3. Hospital+			x	care_level	1. Low-Mid Primary = **gps_type** SHC, BHC, HC I, HC II, HC III; 2. High-Primary = **gps_type** CHC, HC IV; 3. Hospital+ = **gps_type** DH, General Hospital, Other, Provincial Hospital, RR Hospital, Regional Hospital

Data Set	Variable	Type	Levels	Dep.	Ind.	Supp.	Data Label	Variable Derivation, if any
Facility	Level of Care HH/H/L/LL	Ordinal (4)	1. Low-Primary, 2. Mid-Primary, 3. High-Primary, 4. Hospital+			x	care_type	1. Low-Primary = **gps_type** SHC, HC I, HC II; 2. Mid-Primary = **gps_type** BHC , HC III; 3. High-Primary = **gps_type** CHC, HC IV; 4. Hospital+ = **gps_type** DH, General Hospital, Other, Provincial Hospital, RR Hospital, Regional Hospital
Facility	Ownership Gov/PNP/PFP	Categorical (3)	Govt,PNP,PFP			x	hcf_owner	Govt= gps_ownership = Government OR Military OR Prisons; PNFP = gps_ownership NGO OR Private Not For Profit; PFP= gps_ownership Private For Profit
Facility	Patient Access to Hand Hygiene at Facility	Ordinal (3)	no, sometimes, yes			x	dr_hw_psoap	Original variable. Set 'dk' values to missing.
Facility	Patient Access to Soap at Facility Reported	Binary	No or not always, Yes			x	hcf_psoap	IF **dr_hw_psoap**='no' OR 'sometimes' THEN hcf_psoap='No, or not always'; IF **dr_hw_psoap**='yes' THEN hcf_psoap='Yes'
Facility	Patient Access to Water at Facility Reported	Binary	0, 1			x	wateraccess_pt_hcf	IF **dr_ws_sa_access** = "---" OR "none" OR "staff" THEN wateraccess_pt_hcf = 0; IF **dr_ws_sa_access** = "pt_care staff" OR "pt_care staff comm" OR "pt_care" THEN wateraccess_pt_hcf = 1; IF dr_ws_sa_atime='no_pt_care' OR dr_ws_sa_atime = "no_both" THEN wateraccess_pt_hcf = 0
Facility	Percent Samples Chlorinated	Continuous	--			x	pct_samples_chlorinated	**sum_samples_chlorinated / samples_n**; IF samples_n=. THEN pct_samples_chlorinated=.
Facility	Percent Samples *E. Coli* Positive	Continuous	--			x	pct_samples_ecoli_pos	**total_ecv / samples_n**; if samples_n =. THEN pct_samples_ecoli_pos =.
Facility	Percent Samples Meeting Gen FCL Guideline	Continuous	--			x	pct_samples_fcl_v_gen	**sum_fcl_violation_gen / samples_n**; IF samples_n=. THEN pct_samples_fcl_v_gen=.
Facility	Percent Samples Meeting HCF FCL Guideline	Continuous	--			x	pct_samples_fcl_v_hcf	**sum_fcl_violation_hcf / samples_n**; IF samples_n=. THEN pct_samples_fcl_v_hcf=.
Facility	Percent Wards with Patient Hand Hygiene	Continuous	--			x		
Facility	Percent Wards with Patient Hand Hygiene (incl. Water)	Continuous	--			x	pct_pat_handwash	**sum_pat_handwash / wards_n**
Facility	Percent Wards with Staff Hand Hygiene	Continuous	--			x		
Facility	Percent Wards with Staff Hand Hygiene (incl. Water)	Continuous	--			x	pct_poc_handwash	**sum_poc_handwash / wards_n**
Facility	Percent Wards with Toilets	Continuous	--			x	pct_ward_toilets_pts	**sum_ward_toilets_pts / wards_n**
Facility	Percent Wards with Treated Water	Continuous	--			x	pct_water_on_ward_treated	**sum_water_on_ward_treated / wards_n**
Facility	Percent Wards with Water	Continuous	--			x	pct_water_on_ward_01	**sum_water_on_ward_01 / wards_n**

Data Set	Variable	Type	Levels	Dep.	Ind.	Supp.	Data Label	Variable Derivation, if any
Facility	Staff Access to Hand Hygiene at Facility	Ordinal (3)	no, sometimes, yes			x	dr_hw_ssoap	Original variable.
Facility	Staff Access to Soap at Facility Reported	Binary	No or not always, Yes			x	hcf_ssoap	IF d**r_hw_ssoap**='no' OR 'sometimes' THEN hcf_ssoap='No, or not always'; IF **dr_hw_ssoap**='yes' THEN hcf_ssoap='Yes'
Facility	Staff Access to Water at Facility Reported	Binary	0, 1			x	wateraccess_staff_hcf	IF **dr_ws_sa_access** = "---" OR "none" OR "pt_care" THEN wateraccess_staff_hcf = 0; IF **dr_ws_sa_access** ="staff" OR "pt_care staff" OR "pt_care staff comm" THEN wateraccess_staff_hcf = 1; IF dr_ws_sa_atime='no_staff' OR dr_ws_sa_atime = "no_both" THEN wateraccess_staff_hcf = 0;
Facility	Toilet at Facility	Binary	no, yes			x	dr_san_sa_toilet	Original variable.
Facility	Total *E. coli* violations in a Facility	Interval	--			x	total_ecv	In WQ: IF **first.case_name** then total_ecv=0; **total_ecv + ecoli_violation**; IF **LAST.case_name** then output for the total number of E. *coli* violations; merge to Facilities
Facility	Total Number of Wards	Interval	--			x	wards_n	In Wards: IF **FIRST.case_name** then wards_n=0; **ward + wards_n**; OUTPUT LAST.case_name for the total number of wards per facility, merge to Facilities
Facility	Total Samples Chlorinated	Interval	--			x	sum_samples_chlorinated	IF **FIRST.case_name** THEN sum_samples_chlorinated=0; **sum_samples_chlorinated+ sample_chlorinated;** OUTPUT LAST.case_name for the total number of samples chlorinated; merge to Facilities
Facility	Total Samples Meeting Gen FCL Guideline	Interval	--			x	sum_fcl_violation_gen	IF **FIRST.case_name** THEN sum_fcl_violation_gen=0; **sum_fcl_violation_gen + fcl_violation_gen;** OUTPUT LAST.case_name for the total number of samples violating the general guideline for free chlorine; merge to Facilities
Facility	Total Samples Meeting HCF FCL Guideline	Interval	--			x	sum_fcl_violation_hcf	IF **FIRST.case_name** THEN sum_fcl_violation_hcf=0; **sum_fcl_violation_hcf + fcl_violation_hcf;** OUTPUT LAST.case_name for the total number of samples violating the HCF guideline for free chlorine; merge to Facilities
Facility	Total Wards with Patient Handwash	Interval	--			x	sum_pat_handwash	In Wards: IF **FIRST.case_name** then sum_pat_handwash=0; **pat_handwash** + sum_pat_handwash; **OUTPUT LAST.case_name** for the total number of wards with patient handwashing per facility; merge to Facilities

Data Set	Variable	Type	Levels	Dep.	Ind.	Supp.	Data Label	Variable Derivation, if any
Facility	Total Wards with Staff Handwash	Interval	--			x	sum_poc_handwash	In Wards: IF **FIRST.case_name** then sum_poc_handwash=0; **poc_handwash** + sum_poc_handwash; **OUTPUT LAST.case_name** for the total number of wards with staff handwashing per facility; merge to Facilities
Facility	Total Wards with Toilets	Interval	--			x	sum_ward_toilets_pts	In Wards: IF **FIRST.case_name** then sum_ward_toilets_pts=0; **ward_toilets_pts**+ sum_ward_toilets_pts; **OUTPUT LAST.case_name** for the total number of wards with toilets per facility; merge to Facilities
Facility	Total Wards with Treated Water	Interval	--			x	sum_water_on_ward_treated	In Wards: IF **FIRST.case_name** then sum_water_on_ward_treated=0; **water_on_ward_treated** + sum_water_on_ward_treated; **OUTPUT LAST.case_name** for the total number of wards with treated water per facility; merge to Facilities
Facility	Total Wards with Water	Interval	--			x	sum_water_on_ward_01	In Wards: IF **FIRST.case_name** then sum_water_on_ward_01=0; **water_on_ward_01** + sum_water_on_ward_01; **OUTPUT LAST.case_name** for the total number of wards with water per facility; merge to Facilities
Facility	Water Available at Time of Survey [*See Note 1]	Binary	0, 1			x	water_avail_at_survey	IF **case_name** was not found in **Water Quality** data set (i.e., no water samples taken at time of survey), THEN water_avail_at_survey = 0; ELSE water_avail_at_survey = 1
Facility	Water Collection Time (Minutes)	Continuous	--			x	dr_collection_time_rt_n	Numeric version of **dr_ws_sa_tcol**
Facility	Water Off Premises But Within 500 M	Binary	0, 1			x	off_but_within_500m	IF **dr_ws_sa_msrc** = "500m" THEN within_500m = 1; ELSE within_500m = 0
Facility	Water On or Within 500 M	Binary	0, 2			x	on_or_within_500m	IF **dr_ws_sa_msrc** = "on" OR dr_ws_sa_msrc = "500m" THEN on_or_within_500m = 1; ELSE on_or_within_500m = 0
Facility	Water On Premises	Binary	0, 1			x	on_premises	IF **dr_ws_sa_msrc** = "on" THEN on_premises = 1; ELSE on_premises = 0
Facility	Women Asked to Bring Own Water for Delivery	Ordinal (3)	no, sometimes, yes			x	dr_ws_sa_pbring	Original variable. Set '---' values to missing.
Ward	Dummy Variable: Ward	Dummy	1			x	ward	ward = 1 for all observations in Wards data set
Ward	Patient Access to Hand Hygiene at Point of Care	Binary	0, 1			x	pat_handwash_2	
Ward	Patient Access to Hand Sanitizer at Point of Care	Binary	0, 1			x	pat_sani	IF **ward_hw_pat** contains 'sani' then pat_sani=1; ELSE pat_sani = 0; IF ward_hw_pat contains 'none_available'

Data Set	Variable	Type	Levels	Dep.	Ind.	Supp.	Data Label	Variable Derivation, if any
								then pat_sani=0; IF **ward_hw_pat** = "didnt_observe" THEN pat_sani=.
Ward	Patient Access to Sanitation on Ward	Binary	0, 1			x	ward_toilets_pts	IF **ward_san_sa_tl** contains 'yes' then ward_toilets_pts=1; IF **ward_san_sa_tl** contains 'no' then ward_toilets_pts=0; IF **ward_san_sa_tl** = "---" then ward_toilets_pts=.
Ward	Patient Access to Soap at Point of Care	Binary	0, 1			x	pat_soap	IF **ward_hw_pat** contains 'soap' then pat_soap=1; ELSE pat_soap = 0; IF ward_hw_pat contains 'none_available' then pat_soap=0; IF **ward_hw_pat** = "didnt_observe" THEN pat_soap=.
Ward	Patient Access to Water at Point of Care	Binary	0, 1			x	pat_water	IF **ward_hw_pat** contains 'water' then pat_water=1; ELSE pat_water = 0; IF ward_hw_pat contains 'none_available' then pat_water=0; IF **ward_hw_pat** = "didnt_observe" THEN pat_water=.
Ward	Six Cleans - Blade	Binary	0, 1			x	sixcl_blade	IF **ward_cr_cp_ldspl** contains 'blade' THEN sixcl_blade=1 [First: IF **ward_cr_cp_ldspl** missing, THEN set to missing; ELSE set to 0)
Ward	Six Cleans - Cord	Binary	0, 1			x	sixcl_cord	IF **ward_cr_cp_ldspl** contains 'cord' THEN sixcl_cord=1 [First: IF ward_cr_cp_ldspl missing, THEN set to missing; ELSE set to 0)
Ward	Six Cleans - Hands	Binary	0, 1			x	sixcl_hands	IF **poc_handwash**=1 THEN sixcl_hands=1; IF **poc_handwash**=0 THEN sixcl_hands=0; IF **ward_g_type** is not equal to lab_del, THEN sixcl_hands = missing. NOTE: 'Gloves' in ward_cr_cp_ldspl was NOT considered sufficient evidence for clean hands.
Ward	Six Cleans - Surface	Binary	0, 1			x	sixcl_surface	IF **ward_cr_cp_ldspl** contains 'surface' THEN sixcl_surface=1 [First: IF ward_cr_cp_ldspl missing, THEN set to missing; ELSE set to 0)
Ward	Six Cleans - Towels for Baby, Towels for Mother	Binary	0, 1			x	sixcl_towels	IF **ward_cr_cp_ldspl** contains 'towel' THEN sixcl_towel=1 [First: IF ward_cr_cp_ldspl missing, THEN set to missing; ELSE set to 0)
Ward	Staff Access to Hand Hygiene at Point of Care	Binary	0, 1			x	poc_handwash_2	
Ward	Staff Access to Hand Hygiene at Point of Care (incl. Water)	Binary	0, 1			x	poc_handwash	IF **poc_water=**1 AND (**poc_soap** OR **poc_sani**)=1 THEN poc_handwash=1; ELSE poc_handwash=0; IF (**poc_water** AND **poc_soap** AND **poc_sani)** =. then poc_handwash = .
Ward	Staff Access to Hand Hygiene at Point of Care (incl. Water)	Binary	0, 1			x	pat_handwash	IF **pat_water=**1 AND (**pat_soap** OR **pat_sani**)=1 THEN pat_handwash=1; ELSE pat_handwash=0; IF (**pat_water**

Data Set	Variable	Type	Levels	Dep.	Ind.	Supp.	Data Label	Variable Derivation, if any
								AND **pat_soap** AND **pat_sani)** =. then pat_handwash = .
Ward	Staff Access to Hand Sanitizer at Point of Care	Binary	0, 1			x	poc_sani	IF **ward_hw_poc** contains 'sani' then poc_sani=1; ELSE poc_sani = 0; IF ward_hw_poc contains 'none_available' then poc_sani=0; IF **ward_hw_poc** = "didnt_observe" THEN poc_sani=.
Ward	Staff Access to Six Cleans for Delivery on LND Ward	Binary	0, 1			x	sixcl_all	if **sixcl_blade** AND **sixcl_cord** AND **sixcl_towel**s AND **sixcl_surface** AND **sixcl_hands** were all = 1, THEN sixcl_all = 1; else sixcl_all = 0; if ward_g_type was not equal to lab_del then sixcl_all = .
Ward	Staff Access to Soap at Point of Care	Binary	0, 1			x	poc_soap	IF **ward_hw_poc** contains 'soap' then poc_soap=1; ELSE poc_soap = 0; IF ward_hw_poc contains 'none_available' then poc_soap=0; IF **ward_hw_poc** = "didnt_observe" THEN poc_soap=.
Ward	Staff Access to Water on at Point of Care	Binary	0, 1			x	poc_water	IF **ward_hw_poc** contains 'water' then poc_water=1; ELSE poc_water = 0; IF ward_hw_poc contains 'none_available' then poc_water=0; IF **ward_hw_poc** = "didnt_observe" THEN poc_water=.
Ward	Water On Ward	Ordinal (3)	none, untreated, treated			x	water_on_ward	IF **ward_ws_sa_available** = "no" THEN water_on_ward="1: None"; IF **ward_ws_sa_available** = "yes_untreated" THEN water_on_ward="2: Untreated Water"; IF **ward_ws_sa_available** = "yes_treateduntreated" OR "yes_treated" THEN water_on_ward="3: Treated Water"
Ward	Water on Ward - Treated	Binary	0, 1			x	water_on_ward_treated	IF **water_on_ward** = '3: Treated Water' THEN water_on_ward_treated = 1; IF **water_on_ward** = '1: None' OR '2: Untreated Water' THEN water_on_ward_treated = 0
Ward	Water on Ward (0/1)	Binary	0, 1			x	water_on_ward_01	IF **water_on_ward_yn** = 'Yes' THEN water_on_ward_01 = 1; IF **water_on_ward_yn** = 'No' THEN water_on_ward_01 = 0
Ward	Water On Ward (YN)	Binary	no, yes			x	water_on_ward_yn	IF **water_on_ward**='1: None' THEN water_on_ward_yn='No'; IF **water_on_ward**= "2: Untreated Water" OR "3: Treated Water" THEN water_on_ward_yn='Yes'
WQ	Dummy Variable: Water Sample	Dummy	1			x	sample	sample = 1 for all observations in Water Quality data set
WQ	*E. coli* Level in Sample	Continuous	--			x	wq_e_coli	Original variable.
WQ	*E. coli* Level in Sample (No Zeros)	Continuous	--			x	e_coli	e_coli = **wq_e_coli**, but IF **wq_e_coli** = 0 THEN e_coli = 0.005

Data Set	Variable	Type	Levels	Dep.	Ind.	Supp.	Data Label	Variable Derivation, if any
WQ	*E. coli* Level Log-Transformed (base e)	Continuous	--			x	ln_ecoli	Natural log (**e_coli**)
WQ	*E. coli* Level Violates WHO Limit	Binary	0, 1			x	ecoli_violation	IF **wq_e_coli** = 0 THEN ecoli_violation = 0; IF **wq_e_coli** > 0 THEN ecoli_violation = 1; IF **wq_ws_qn_mic** = "3" THEN ecoli_violation = 0 (wq_ws_qn_mic only applies to the 9 facilities for which sample-level data was not available and only facility-level data was available)
WQ	*E. coli* Violations - Sum by Facility	Interval	--			x	sum_ecoli_violations	IF **FIRST.case_name** THEN sum_ecoli_violations=0; sum_ecoli_violations + **ecoli_violation**; IF **LAST.case_name** then sum_ecoli_violations = sum_ecoli_violations; ELSE sum_ecoli_violations = . (delete sums that do not include all wards in a facility)
WQ	Free Chlorine Level	Continuous	--			x	wq_cl_free	Original variable.
WQ	Free Chlorine Level Log-Transformed (base e)	Continuous	--			x	ln_cl_free	Natural log (**wq_cl_free**)
WQ	Free Chlorine Level Rounded Down	Interval	0, 0.1, 0.2, 0.3, 0.4, 0.5, 0.6			x		Created to correct guesses provided for free chlorine mg/L that were beyond the test's sensitivity level. IF wq_cl_free …
WQ	Free Chlorine Violates WHO Limits for Domestic Use (< 0.2 mg/L)	Binary	0, 1			x	fcl_violation_gen	IF **wq_cl_free** < 0.20 THEN fcl_violation_gen = 1; IF **wq_cl_free** >= 0.20 THEN fcl_violation_gen = 0; IF **wq_cl_free** = . THEN fcl_violation_gen = .
WQ	Free Chlorine Violates WHO Limits for HCFs (< 0.5 mg/L)	Binary	0, 1			x	fcl_violation_hcf	IF **wq_cl_free** < 0.50 THEN fcl_violation_hcf = 1; IF **wq_cl_free** >= 0.50 THEN fcl_violation_hcf = 0; IF **wq_cl_free** = . THEN fcl_violation_hcf = .
WQ	Sample Chlorinated	Binary	0, 1			x	sample_chlorinated	IF **wq_cl_free**=0 THEN sample_chlorinated=0; IF **wq_cl_free**>0 THEN sample_chlorinated=1
WQ	Total Number of Water Samples	Interval	--			x	samples_n	IF **FIRST.case_name** then samples_n=0; **samples_n + sample**; OUTPUT LAST.case_name for the total number of samples per facility, merge to Facilities

Appendix G. Pearson Correlation Coefficients for Pairs of Predictor Variables by Country

The following pairs of Pearson correlation coefficients were generated using SAS software, version 9.4 of the SAS System for Windows (SAS Institute Inc., Cary, NC, USA). Pearson correlation coefficients are classically estimated for continuous-continuous pairs but can also be used to evaluate dichotomous-dichotomous variable pairs and dichotomous-continuous variable pairs. For a dichotomous-dichotomous pair, estimating the Pearson coefficient produces the phi coefficient, which is equivalent to the Cramer's V statistic for a 2x2 chi-square test of association. For a dichotomous-continuous pair of predictors, it is equivalent to the point biserial correlation coefficient.

1

Ranked Pearson Correlation Coefficients for All Pairs of Dichotomous HCF-Level Predictors

The CORR Procedure

gps_country=Afghanistan

24 Variables:	gps rural 0 urban 1 owner type private 01 hcf level high reliable electricity 01 bkg g inp 01 bkg g surg 01 md on staff bkg wateruse day n dr storage capacity n bkg outpat seenmo n bkg inpat seenmo n total seenmo n bkg surg mo n all bkg deliv mo n bkg caesarian mo n total staff bkg staff clinical n bkg staff nonclinical n bkg staff md n bkg staff cleaning n bkg inpat beds n all JMP basic water 01 dr ws qa clsrc 01 dr_ws_qa_hcfcl_01

2

Ranked Pearson Correlation Coefficients for All Pairs of Dichotomous HCF-Level Predictors

The CORR Procedure

gps_country=Afghanistan

Pearson Correlation Coefficients
Prob > |r| under H0: Rho=0
Number of Observations

gps rural 0 urban 1 gps_rural_0_urban_1	gps rural 0 urban 1 1.00000 104	hcf level high 0.48028 <.0001 104	bkg g inp 01 0.47998 <.0001 102	dr storage capacity n 0.37123 0.0001 104
owner type private 01	dr ws qa hcfcl 01 . . 100	dr ws qa clsrc 01 . . 100	JMP basic water 01 . . 104	bkg inpat beds n all . . 102
hcf level high	hcf level high 1.00000 104	bkg g inp 01 0.76245 <.0001 102	total seenmo n 0.63027 <.0001 102	bkg outpat seenmo n 0.59449 <.0001 102
reliable electricity 01	reliable electricity 01 1.00000 100	bkg g inp 01 0.20111 0.0471 98	JMP basic water 01 0.19383 0.0533 100	bkg wateruse day n 0.18071 0.0813 94
bkg_g_inp_01	bkg g inp 01 1.00000 102	hcf level high 0.76245 <.0001 102	total seenmo n 0.62451 <.0001 102	bkg outpat seenmo n 0.57625 <.0001 102
bkg g surg 01	bkg g surg 01 1.00000 102	bkg g inp 01 0.50985 <.0001 102	total seenmo n 0.46343 <.0001 102	bkg outpat seenmo n 0.44475 <.0001 102
md on staff	md on staff 1.00000 102	hcf level high 0.45430 <.0001 102	bkg g inp 01 0.38770 <.0001 102	gps rural 0 urban 1 0.29431 0.0027 102
bkg wateruse day n	bkg wateruse day n 1.00000 98	bkg inpat beds n all 0.67156 <.0001 98	bkg staff clinical n 0.66732 <.0001 98	total staff 0.65996 <.0001 98
dr storage capacity n	dr storage capacity n 1.00000 104	bkg wateruse day n 0.53833 <.0001 98	bkg g inp 01 0.46691 <.0001 102	gps rural 0 urban 1 0.37123 0.0001 104
bkg outpat seenmo n	bkg outpat seenmo n 1.00000 102	total seenmo n 0.97884 <.0001 102	hcf level high 0.59449 <.0001 102	bkg g inp 01 0.57625 <.0001 102
bkg inpat seenmo n	bkg inpat seenmo n 1.00000 102	bkg inpat beds n all 0.51193 <.0001 102	bkg staff cleaning n 0.48818 <.0001 102	bkg staff clinical n 0.47739 <.0001 102

Ranked Pearson Correlation Coefficients for All Pairs of Dichotomous HCF-Level Predictors

The CORR Procedure

gps_country=Afghanistan

Pearson Correlation Coefficients Prob > |r| under H0: Rho=0 Number of Observations				
total seenmo n	total seenmo n 1.00000 102	bkg outpat seenmo n 0.97884 <.0001 102	hcf level high 0.63027 <.0001 102	bkg g inp 01 0.62451 <.0001 102
bkg surg mo n all	bkg surg mo n all 1.00000 102	bkg staff md n 0.98997 <.0001 102	bkg deliv mo n 0.98177 <.0001 102	total staff 0.97309 <.0001 102
bkg deliv mo n	bkg deliv mo n 1.00000 102	bkg caesarian mo n 0.98651 <.0001 102	bkg staff md n 0.98351 <.0001 102	bkg surg mo n all 0.98177 <.0001 102
bkg caesarian mo n	bkg caesarian mo n 1.00000 102	bkg deliv mo n 0.98651 <.0001 102	bkg surg mo n all 0.97167 <.0001 102	bkg staff md n 0.97072 <.0001 102
total_staff	total staff 1.00000 102	bkg staff clinical n 0.99811 <.0001 102	bkg staff nonclinical n 0.99639 <.0001 102	bkg inpat beds n all 0.99238 <.0001 102
bkg staff clinical n	bkg staff clinical n 1.00000 102	total staff 0.99811 <.0001 102	bkg inpat beds n all 0.99217 <.0001 102	bkg staff nonclinical n 0.98930 <.0001 102
bkg staff nonclinical n	bkg staff nonclinical n 1.00000 102	total staff 0.99639 <.0001 102	bkg staff clinical n 0.98930 <.0001 102	bkg inpat beds n all 0.98651 <.0001 102
bkg staff md n	bkg staff md n 1.00000 102	bkg surg mo n all 0.98997 <.0001 102	bkg deliv mo n 0.98351 <.0001 102	bkg inpat beds n all 0.98110 <.0001 102
bkg staff cleaning n	bkg staff cleaning n 1.00000 102	total staff 0.98455 <.0001 102	bkg staff nonclinical n 0.98339 <.0001 102	bkg staff clinical n 0.98096 <.0001 102
bkg inpat beds n all	bkg inpat beds n all 1.00000 102	total staff 0.99238 <.0001 102	bkg staff clinical n 0.99217 <.0001 102	bkg staff nonclinical n 0.98651 <.0001 102
JMP basic water 01	JMP basic water 01 1.00000 104	md on staff 0.27794 0.0047 102	bkg g surg 01 0.26459 0.0072 102	bkg g inp 01 0.26375 0.0074 102

Ranked Pearson Correlation Coefficients for All Pairs of Dichotomous HCF-Level Predictors

The CORR Procedure

gps_country=Afghanistan

Pearson Correlation Coefficients Prob > |r| under H0: Rho=0 Number of Observations				
dr ws qa clsrc 01	dr ws qa clsrc 01 1.00000 100	dr ws qa hcfcl 01 0.89514 <.0001 100	bkg g inp 01 0.14600 0.1514 98	bkg deliv mo n 0.13820 0.1748 98
dr ws qa hcfcl 01	dr ws qa hcfcl 01 1.00000 100	dr ws qa clsrc 01 0.89514 <.0001 100	JMP basic water 01 0.20220 0.0436 100	hcf level high 0.12585 0.2122 100

Pearson Correlation Coefficients Prob > |r| under H0: Rho=0 Number of Observations				
gps rural 0 urban 1 gps_rural_0_urban_1	bkg staff cleaning n 0.33449 0.0006 102	bkg staff clinical n 0.31970 0.0011 102	total staff 0.31412 0.0013 102	bkg inpat beds n all 0.30866 0.0016 102
owner type private 01	bkg staff cleaning n . . 102	bkg staff md n . . 102	bkg staff nonclinical n . . 102	bkg staff clinical n . . 102
hcf level high	gps rural 0 urban 1 0.48028 <.0001 104	md on staff 0.45430 <.0001 102	bkg g surg 01 0.41034 <.0001 102	dr storage capacity n 0.33444 0.0005 104
reliable electricity 01	hcf level high 0.17459 0.0823 100	gps rural 0 urban 1 0.16151 0.1084 100	bkg caesarian mo n 0.13838 0.1742 98	dr storage capacity n 0.12863 0.2022 100
bkg g inp 01	bkg g surg 01 0.50985 <.0001 102	gps rural 0 urban 1 0.47998 <.0001 102	dr storage capacity n 0.46691 <.0001 102	md on staff 0.38770 <.0001 102
bkg g surg 01	hcf level high 0.41034 <.0001 102	bkg staff cleaning n 0.31968 0.0011 102	bkg staff clinical n 0.31229 0.0014 102	bkg inpat beds n all 0.31103 0.0015 102
md on staff	total_seenmo_n 0.28739 0.0034 102	dr_storage_capacity_n 0.28023 0.0043 102	JMP_basic_water_01 0.27794 0.0047 102	bkg_outpat_seenmo_n 0.27114 0.0058 102
bkg wateruse day n	bkg staff md n 0.64892 <.0001 98	bkg staff nonclinical n 0.64571 <.0001 98	bkg staff cleaning n 0.64288 <.0001 98	bkg surg mo n all 0.60378 <.0001 98

Ranked Pearson Correlation Coefficients for All Pairs of Dichotomous HCF-Level Predictors

The CORR Procedure

gps_country=Afghanistan

Pearson Correlation Coefficients Prob > |r| under H0: Rho=0 Number of Observations				
dr storage capacity n	total seenmo n 0.36707 0.0001 102	hcf level high 0.33444 0.0005 104	bkg inpat beds n all 0.33043 0.0007 102	bkg inpat seenmo n 0.32914 0.0007 102
bkg outpat seenmo n	bkg g surg 01 0.44475 <.0001 102	dr storage capacity n 0.31526 0.0012 102	md on staff 0.27114 0.0058 102	gps rural 0 urban 1 0.25516 0.0096 102
bkg inpat seenmo n	total staff 0.47580 <.0001 102	bkg staff nonclinical n 0.47064 <.0001 102	bkg staff md n 0.41985 <.0001 102	bkg deliv mo n 0.41333 <.0001 102
total seenmo n	bkg g surg 01 0.46343 <.0001 102	dr storage capacity n 0.36707 0.0001 102	bkg inpat seenmo n 0.34664 0.0004 102	md on staff 0.28739 0.0034 102
bkg_surg_mo_n_all	bkg staff nonclinical n 0.97257 <.0001 102	bkg caesarian mo n 0.97167 <.0001 102	bkg inpat beds n all 0.97043 <.0001 102	bkg staff clinical n 0.96909 <.0001 102
bkg deliv mo n	bkg inpat beds n all 0.97571 <.0001 102	bkg staff clinical n 0.97476 <.0001 102	total staff 0.97409 <.0001 102	bkg staff nonclinical n 0.96711 <.0001 102
bkg caesarian mo n	bkg inpat beds n all 0.96127 <.0001 102	bkg staff clinical n 0.95704 <.0001 102	total staff 0.95367 <.0001 102	bkg staff nonclinical n 0.94308 <.0001 102
total staff	bkg staff cleaning n 0.98455 <.0001 102	bkg staff md n 0.97825 <.0001 102	bkg deliv mo n 0.97409 <.0001 102	bkg surg mo n all 0.97309 <.0001 102
bkg staff clinical n	bkg staff cleaning n 0.98096 <.0001 102	bkg staff md n 0.97777 <.0001 102	bkg deliv mo n 0.97476 <.0001 102	bkg surg mo n all 0.96909 <.0001 102
bkg staff nonclinical n	bkg staff cleaning n 0.98339 <.0001 102	bkg staff md n 0.97283 <.0001 102	bkg surg mo n all 0.97257 <.0001 102	bkg deliv mo n 0.96711 <.0001 102
bkg staff md n	total staff 0.97825 <.0001 102	bkg staff clinical n 0.97777 <.0001 102	bkg staff nonclinical n 0.97283 <.0001 102	bkg caesarian mo n 0.97072 <.0001 102

Ranked Pearson Correlation Coefficients for All Pairs of Dichotomous HCF-Level Predictors

The CORR Procedure

gps_country=Afghanistan

Pearson Correlation Coefficients Prob > |r| under H0: Rho=0 Number of Observations				
bkg staff cleaning n	bkg inpat beds n all 0.97736 <.0001 102	bkg deliv mo n 0.94556 <.0001 102	bkg staff md n 0.94030 <.0001 102	bkg surg mo n all 0.93513 <.0001 102
bkg inpat beds n all	bkg staff md n 0.98110 <.0001 102	bkg staff cleaning n 0.97736 <.0001 102	bkg deliv mo n 0.97571 <.0001 102	bkg surg mo n all 0.97043 <.0001 102
JMP basic water 01	dr ws qa hcfcl 01 0.20220 0.0436 100	dr storage capacity n 0.20187 0.0399 104	reliable electricity 01 0.19383 0.0533 100	bkg wateruse day n 0.13330 0.1907 98
dr ws qa clsrc 01	hcf level high 0.13245 0.1890 100	JMP basic water 01 0.12461 0.2167 100	bkg g surg 01 0.10818 0.2890 98	md on staff 0.09089 0.3734 98
dr_ws_qa_hcfcl_01	md on staff 0.12479 0.2208 98	bkg g inp 01 0.12078 0.2362 98	bkg inpat seenmo n 0.11045 0.2789 98	bkg g surg 01 0.11044 0.2790 98

Pearson Correlation Coefficients Prob > |r| under H0: Rho=0 Number of Observations				
gps rural 0 urban 1 gps_rural_0_urban_1	bkg staff nonclinical n 0.30446 0.0019 102	md on staff 0.29431 0.0027 102	total seenmo n 0.28442 0.0038 102	bkg staff md n 0.25540 0.0096 102
owner type private 01	total staff . . 102	bkg caesarian mo n . . 102	bkg deliv mo n . . 102	bkg surg mo n all . . 102
hcf level high	bkg inpat seenmo n 0.32134 0.0010 102	bkg staff clinical n 0.26080 0.0081 102	bkg inpat beds n all 0.25549 0.0096 102	total staff 0.25489 0.0097 102
reliable electricity 01	bkg_deliv_mo_n 0.12628 0.2153 98	bkg_staff_md_n 0.12157 0.2331 98	bkg_staff_clinical_n 0.11079 0.2775 98	bkg_inpat_beds_n_all 0.10946 0.2833 98
bkg g inp 01	bkg inpat seenmo n 0.37716 <.0001 102	bkg inpat beds n all 0.30192 0.0020 102	bkg staff clinical n 0.30013 0.0022 102	total staff 0.28684 0.0035 102

Ranked Pearson Correlation Coefficients for All Pairs of Dichotomous HCF-Level Predictors

The CORR Procedure

gps_country=Afghanistan

Pearson Correlation Coefficients Prob > |r| under H0: Rho=0 Number of Observations				
bkg g surg 01	bkg deliv mo n 0.31067 0.0015 102	total staff 0.30717 0.0017 102	bkg caesarian mo n 0.30527 0.0018 102	bkg staff nonclinical n 0.29819 0.0023 102
md on staff	bkg g surg 01 0.24846 0.0118 102	bkg wateruse day n 0.16465 0.1052 98	bkg inpat seenmo n 0.14623 0.1425 102	bkg staff clinical n 0.13032 0.1917 102
bkg wateruse day n	bkg deliv mo n 0.59875 <.0001 98	bkg caesarian mo n 0.59796 <.0001 98	dr storage capacity n 0.53833 <.0001 98	bkg inpat seenmo n 0.37223 0.0002 98
dr storage capacity n	bkg staff cleaning n 0.31640 0.0012 102	bkg staff clinical n 0.31593 0.0012 102	bkg outpat seenmo n 0.31526 0.0012 102	total staff 0.30301 0.0020 102
bkg_outpat_seenmo_n	bkg staff cleaning n 0.17751 0.0743 102	bkg inpat seenmo n 0.14736 0.1394 102	bkg staff clinical n 0.13743 0.1684 102	total staff 0.12629 0.2059 102
bkg inpat seenmo n	bkg surg mo n all 0.40629 <.0001 102	bkg caesarian mo n 0.39830 <.0001 102	bkg g inp 01 0.37716 <.0001 102	bkg wateruse day n 0.37223 0.0002 98
total seenmo n	gps rural 0 urban 1 0.28442 0.0038 102	bkg staff cleaning n 0.26934 0.0062 102	bkg staff clinical n 0.22910 0.0205 102	total staff 0.21821 0.0276 102
bkg surg mo n all	bkg staff cleaning n 0.93513 <.0001 102	bkg wateruse day n 0.60378 <.0001 98	bkg inpat seenmo n 0.40629 <.0001 102	bkg g surg 01 0.28556 0.0036 102
bkg deliv mo n	bkg staff cleaning n 0.94556 <.0001 102	bkg wateruse day n 0.59875 <.0001 98	bkg inpat seenmo n 0.41333 <.0001 102	bkg g surg 01 0.31067 0.0015 102
bkg caesarian mo n	bkg staff cleaning n 0.92086 <.0001 102	bkg wateruse day n 0.59796 <.0001 98	bkg inpat seenmo n 0.39830 <.0001 102	bkg g surg 01 0.30527 0.0018 102
total staff	bkg caesarian mo n 0.95367 <.0001 102	bkg wateruse day n 0.65996 <.0001 98	bkg inpat seenmo n 0.47580 <.0001 102	gps rural 0 urban 1 0.31412 0.0013 102

Ranked Pearson Correlation Coefficients for All Pairs of Dichotomous HCF-Level Predictors

The CORR Procedure

gps_country=Afghanistan

Pearson Correlation Coefficients Prob > |r| under H0: Rho=0 Number of Observations				
bkg staff clinical n	bkg caesarian mo n 0.95704 <.0001 102	bkg wateruse day n 0.66732 <.0001 98	bkg inpat seenmo n 0.47739 <.0001 102	gps rural 0 urban 1 0.31970 0.0011 102
bkg staff nonclinical n	bkg caesarian mo n 0.94308 <.0001 102	bkg wateruse day n 0.64571 <.0001 98	bkg inpat seenmo n 0.47064 <.0001 102	gps rural 0 urban 1 0.30446 0.0019 102
bkg staff md n	bkg staff cleaning n 0.94030 <.0001 102	bkg wateruse day n 0.64892 <.0001 98	bkg inpat seenmo n 0.41985 <.0001 102	gps rural 0 urban 1 0.25540 0.0096 102
bkg staff cleaning n	bkg caesarian mo n 0.92086 <.0001 102	bkg wateruse day n 0.64288 <.0001 98	bkg inpat seenmo n 0.48818 <.0001 102	gps rural 0 urban 1 0.33449 0.0006 102
bkg_inpat_beds_n_all	bkg caesarian mo n 0.96127 <.0001 102	bkg wateruse day n 0.67156 <.0001 98	bkg inpat seenmo n 0.51193 <.0001 102	dr storage capacity n 0.33043 0.0007 102
JMP basic water 01	dr ws qa clsrc 01 0.12461 0.2167 100	total seenmo n 0.10608 0.2886 102	bkg inpat seenmo n 0.09434 0.3456 102	bkg caesarian mo n 0.09315 0.3518 102
dr ws qa clsrc 01	bkg inpat seenmo n 0.09068 0.3746 98	bkg staff md n -0.07597 0.4572 98	reliable electricity 01 0.07362 0.4759 96	bkg surg mo n all -0.07196 0.4813 98
dr ws qa hcfcl 01	bkg wateruse day n -0.10735 0.3031 94	bkg deliv mo n 0.09460 0.3542 98	reliable electricity 01 0.06455 0.5321 96	bkg staff md n -0.05785 0.5715 98

Pearson Correlation Coefficients Prob > |r| under H0: Rho=0 Number of Observations				
gps rural 0 urban 1 gps_rural_0_urban_1	bkg_outpat_seenmo_n 0.25516 0.0096 102	bkg_deliv_mo_n 0.25304 0.0103 102	bkg_wateruse_day_n 0.24435 0.0153 98	bkg_surg_mo_n_all 0.24087 0.0147 102
owner type private 01	total seenmo n . . 102	bkg inpat seenmo n . . 102	bkg outpat seenmo n . . 102	dr storage capacity n . . 104

Ranked Pearson Correlation Coefficients for All Pairs of Dichotomous HCF-Level Predictors

The CORR Procedure

gps_country=Afghanistan

Pearson Correlation Coefficients Prob > |r| under H0: Rho=0 Number of Observations				
hcf level high	bkg staff nonclinical n 0.24514 0.0130 102	bkg staff cleaning n 0.24424 0.0134 102	bkg deliv mo n 0.23564 0.0171 102	bkg caesarian mo n 0.20566 0.0381 102
reliable electricity 01	md on staff 0.10469 0.3049 98	bkg surg mo n all 0.10293 0.3132 98	total staff 0.09212 0.3670 98	bkg outpat seenmo n 0.08030 0.4319 98
bkg g inp 01	bkg staff cleaning n 0.28399 0.0038 102	bkg deliv mo n 0.27239 0.0056 102	bkg staff nonclinical n 0.26671 0.0067 102	JMP basic water 01 0.26375 0.0074 102
bkg g surg 01	bkg surg mo n all 0.28556 0.0036 102	JMP basic water 01 0.26459 0.0072 102	md on staff 0.24846 0.0118 102	bkg staff md n 0.23644 0.0167 102
md_on_staff	dr ws qa hcfcl 01 0.12479 0.2208 98	total staff 0.12215 0.2213 102	bkg staff cleaning n 0.11869 0.2348 102	bkg inpat beds n all 0.11706 0.2413 102
bkg wateruse day n	gps rural 0 urban 1 0.24435 0.0153 98	bkg g inp 01 0.21948 0.0299 98	reliable electricity 01 0.18071 0.0813 94	total seenmo n 0.17292 0.0886 98
dr storage capacity n	bkg staff nonclinical n 0.28328 0.0039 102	md on staff 0.28023 0.0043 102	bkg staff md n 0.24713 0.0123 102	JMP basic water 01 0.20187 0.0399 104
bkg outpat seenmo n	bkg staff nonclinical n 0.11012 0.2705 102	bkg wateruse day n 0.10104 0.3222 98	bkg inpat beds n all 0.09946 0.3199 102	JMP basic water 01 0.09127 0.3616 102
bkg inpat seenmo n	total seenmo n 0.34664 0.0004 102	dr storage capacity n 0.32914 0.0007 102	hcf level high 0.32134 0.0010 102	gps rural 0 urban 1 0.20513 0.0386 102
total seenmo n	bkg staff nonclinical n 0.20180 0.0420 102	bkg inpat beds n all 0.20023 0.0436 102	bkg wateruse day n 0.17292 0.0886 98	bkg deliv mo n 0.16251 0.1027 102
bkg surg mo n all	gps rural 0 urban 1 0.24087 0.0147 102	bkg g inp 01 0.21113 0.0332 102	dr storage capacity n 0.18198 0.0672 102	hcf level high 0.17904 0.0718 102

Ranked Pearson Correlation Coefficients for All Pairs of Dichotomous HCF-Level Predictors

The CORR Procedure

gps_country=Afghanistan

Pearson Correlation Coefficients Prob > |r| under H0: Rho=0 Number of Observations				
bkg deliv mo n	bkg g inp 01 0.27239 0.0056 102	gps rural 0 urban 1 0.25304 0.0103 102	hcf level high 0.23564 0.0171 102	dr storage capacity n 0.19621 0.0481 102
bkg caesarian mo n	bkg g inp 01 0.24167 0.0144 102	hcf level high 0.20566 0.0381 102	gps rural 0 urban 1 0.20486 0.0389 102	dr storage capacity n 0.18826 0.0581 102
total staff	bkg g surg 01 0.30717 0.0017 102	dr storage capacity n 0.30301 0.0020 102	bkg g inp 01 0.28684 0.0035 102	hcf level high 0.25489 0.0097 102
bkg staff clinical n	dr storage capacity n 0.31593 0.0012 102	bkg g surg 01 0.31229 0.0014 102	bkg g inp 01 0.30013 0.0022 102	hcf level high 0.26080 0.0081 102
bkg_staff_nonclinical_n	bkg g surg 01 0.29819 0.0023 102	dr storage capacity n 0.28328 0.0039 102	bkg g inp 01 0.26671 0.0067 102	hcf level high 0.24514 0.0130 102
bkg staff md n	dr storage capacity n 0.24713 0.0123 102	bkg g surg 01 0.23644 0.0167 102	bkg g inp 01 0.21174 0.0326 102	hcf level high 0.18219 0.0668 102
bkg staff cleaning n	bkg g surg 01 0.31968 0.0011 102	dr storage capacity n 0.31640 0.0012 102	bkg g inp 01 0.28399 0.0038 102	total seenmo n 0.26934 0.0062 102
bkg inpat beds n all	bkg g surg 01 0.31103 0.0015 102	gps rural 0 urban 1 0.30866 0.0016 102	bkg g inp 01 0.30192 0.0020 102	hcf level high 0.25549 0.0096 102
JMP basic water 01	bkg outpat seenmo n 0.09127 0.3616 102	gps rural 0 urban 1 0.09049 0.3609 104	hcf level high 0.08908 0.3685 104	bkg inpat beds n all 0.08445 0.3987 102
dr ws qa clsrc 01	bkg staff nonclinical n -0.06102 0.5506 98	total staff -0.05535 0.5883 98	total seenmo n 0.05062 0.6206 98	bkg staff clinical n -0.04818 0.6376 98
dr ws qa hcfcl 01	bkg surg mo n all -0.05691 0.5778 98	bkg staff nonclinical n -0.04947 0.6286 98	total seenmo n 0.04438 0.6643 98	total staff -0.04184 0.6825 98

Ranked Pearson Correlation Coefficients for All Pairs of Dichotomous HCF-Level Predictors

The CORR Procedure

gps_country=Afghanistan

Pearson Correlation Coefficients Prob > |r| under H0: Rho=0 Number of Observations				
gps rural 0 urban 1 gps_rural_0_urban_1	bkg inpat seenmo n 0.20513 0.0386 102	bkg caesarian mo n 0.20486 0.0389 102	reliable electricity 01 0.16151 0.1084 100	bkg g surg 01 0.14426 0.1480 102
owner type private 01	bkg wateruse day n . . 98	md on staff . . 102	bkg g surg 01 . . 102	bkg g inp 01 . . 102
hcf level high	bkg staff md n 0.18219 0.0668 102	bkg surg mo n all 0.17904 0.0718 102	reliable electricity 01 0.17459 0.0823 100	bkg wateruse day n 0.17069 0.0929 98
reliable electricity 01	bkg g surg 01 0.07625 0.4555 98	dr ws qa clsrc 01 0.07362 0.4759 96	bkg staff cleaning n 0.07143 0.4846 98	total seenmo n 0.06829 0.5040 98
bkg_g_inp_01	bkg caesarian mo n 0.24167 0.0144 102	bkg wateruse day n 0.21948 0.0299 98	bkg staff md n 0.21174 0.0326 102	bkg surg mo n all 0.21113 0.0332 102
bkg g surg 01	bkg inpat seenmo n 0.20131 0.0425 102	dr storage capacity n 0.18505 0.0626 102	gps rural 0 urban 1 0.14426 0.1480 102	bkg wateruse day n 0.14371 0.1580 98
md on staff	bkg staff nonclinical n 0.11009 0.2707 102	bkg deliv mo n 0.10813 0.2793 102	reliable electricity 01 0.10469 0.3049 98	bkg staff md n 0.09946 0.3199 102
bkg wateruse day n	hcf level high 0.17069 0.0929 98	md on staff 0.16465 0.1052 98	bkg g surg 01 0.14371 0.1580 98	JMP basic water 01 0.13330 0.1907 98
dr storage capacity n	bkg deliv mo n 0.19621 0.0481 102	bkg caesarian mo n 0.18826 0.0581 102	bkg g surg 01 0.18505 0.0626 102	bkg surg mo n all 0.18198 0.0672 102
bkg outpat seenmo n	bkg deliv mo n 0.08119 0.4172 102	reliable electricity 01 0.08030 0.4319 98	bkg caesarian mo n 0.07267 0.4679 102	dr ws qa clsrc 01 0.03499 0.7323 98
bkg inpat seenmo n	bkg g surg 01 0.20131 0.0425 102	bkg outpat seenmo n 0.14736 0.1394 102	md on staff 0.14623 0.1425 102	dr ws qa hcfcl 01 0.11045 0.2789 98

Ranked Pearson Correlation Coefficients for All Pairs of Dichotomous HCF-Level Predictors

The CORR Procedure

gps_country=Afghanistan

Pearson Correlation Coefficients Prob > |r| under H0: Rho=0 Number of Observations				
total seenmo n	bkg caesarian mo n 0.15132 0.1290 102	JMP basic water 01 0.10608 0.2886 102	bkg surg mo n all 0.07449 0.4569 102	bkg staff md n 0.06853 0.4937 102
bkg surg mo n all	reliable electricity 01 0.10293 0.3132 98	md on staff 0.08569 0.3918 102	JMP basic water 01 0.07792 0.4363 102	total seenmo n 0.07449 0.4569 102
bkg deliv mo n	total seenmo n 0.16251 0.1027 102	dr ws qa clsrc 01 0.13820 0.1748 98	reliable electricity 01 0.12628 0.2153 98	md on staff 0.10813 0.2793 102
bkg caesarian mo n	total seenmo n 0.15132 0.1290 102	reliable electricity 01 0.13838 0.1742 98	md on staff 0.09620 0.3361 102	JMP basic water 01 0.09315 0.3518 102
total_staff	total seenmo n 0.21821 0.0276 102	bkg outpat seenmo n 0.12629 0.2059 102	md on staff 0.12215 0.2213 102	reliable electricity 01 0.09212 0.3670 98
bkg staff clinical n	total seenmo n 0.22910 0.0205 102	bkg outpat seenmo n 0.13743 0.1684 102	md on staff 0.13032 0.1917 102	reliable electricity 01 0.11079 0.2775 98
bkg staff nonclinical n	total seenmo n 0.20180 0.0420 102	bkg outpat seenmo n 0.11012 0.2705 102	md on staff 0.11009 0.2707 102	reliable electricity 01 0.06577 0.5199 98
bkg staff md n	reliable electricity 01 0.12157 0.2331 98	md on staff 0.09946 0.3199 102	JMP basic water 01 0.07747 0.4390 102	dr ws qa clsrc 01 -0.07597 0.4572 98
bkg staff cleaning n	hcf level high 0.24424 0.0134 102	bkg outpat seenmo n 0.17751 0.0743 102	md on staff 0.11869 0.2348 102	reliable electricity 01 0.07143 0.4846 98
bkg inpat beds n all	total seenmo n 0.20023 0.0436 102	md on staff 0.11706 0.2413 102	reliable electricity 01 0.10946 0.2833 98	bkg outpat seenmo n 0.09946 0.3199 102
JMP basic water 01	bkg deliv mo n 0.08312 0.4062 102	bkg staff clinical n 0.08287 0.4077 102	bkg surg mo n all 0.07792 0.4363 102	bkg staff md n 0.07747 0.4390 102

Ranked Pearson Correlation Coefficients for All Pairs of Dichotomous HCF-Level Predictors

The CORR Procedure

gps_country=Afghanistan

Pearson Correlation Coefficients Prob > |r| under H0: Rho=0 Number of Observations				
dr ws qa clsrc 01	gps rural 0 urban 1 0.03915 0.6990 100	bkg wateruse day n 0.03913 0.7080 94	dr storage capacity n -0.03712 0.7139 100	bkg outpat seenmo n 0.03499 0.7323 98
dr ws qa hcfcl 01	bkg staff clinical n -0.03393 0.7401 98	gps rural 0 urban 1 0.03196 0.7523 100	bkg staff cleaning n 0.03116 0.7607 98	dr storage capacity n -0.02519 0.8036 100

Pearson Correlation Coefficients Prob > |r| under H0: Rho=0 Number of Observations				
gps rural 0 urban 1 gps_rural_0_urban_1	JMP basic water 01 0.09049 0.3609 104	dr ws qa clsrc 01 0.03915 0.6990 100	dr ws qa hcfcl 01 0.03196 0.7523 100	owner type private 01 . . 104
owner type private 01	reliable electricity 01 . . 100	hcf level high . . 104	owner type private 01 . . 104	gps rural 0 urban 1 . . 104
hcf level high	dr ws qa clsrc 01 0.13245 0.1890 100	dr ws qa hcfcl 01 0.12585 0.2122 100	JMP basic water 01 0.08908 0.3685 104	owner type private 01 . . 104
reliable electricity 01	bkg staff nonclinical n 0.06577 0.5199 98	dr ws qa hcfcl 01 0.06455 0.5321 96	bkg inpat seenmo n -0.03672 0.7196 98	owner type private 01 . . 100
bkg g inp 01	reliable electricity 01 0.20111 0.0471 98	dr ws qa clsrc 01 0.14600 0.1514 98	dr ws qa hcfcl 01 0.12078 0.2362 98	owner type private 01 . . 102
bkg g surg 01	dr ws qa hcfcl 01 0.11044 0.2790 98	dr ws qa clsrc 01 0.10818 0.2890 98	reliable electricity 01 0.07625 0.4555 98	owner type private 01 . . 102
md on staff	bkg_caesarian_mo_n 0.09620 0.3361 102	dr_ws_qa_clsrc_01 0.09089 0.3734 98	bkg_surg_mo_n_all 0.08569 0.3918 102	owner_type_private_01 . . 102
bkg wateruse day n	dr ws qa hcfcl 01 -0.10735 0.3031 94	bkg outpat seenmo n 0.10104 0.3222 98	dr ws qa clsrc 01 0.03913 0.7080 94	owner type private 01 . . 98

Ranked Pearson Correlation Coefficients for All Pairs of Dichotomous HCF-Level Predictors

The CORR Procedure

gps_country=Afghanistan

Pearson Correlation Coefficients Prob > |r| under H0: Rho=0 Number of Observations				
dr storage capacity n	reliable electricity 01 0.12863 0.2022 100	dr ws qa clsrc 01 -0.03712 0.7139 100	dr ws qa hcfcl 01 -0.02519 0.8036 100	owner type private 01 . . 104
bkg outpat seenmo n	dr ws qa hcfcl 01 0.02433 0.8120 98	bkg staff md n -0.01934 0.8470 102	bkg surg mo n all -0.01009 0.9198 102	owner type private 01 . . 102
bkg inpat seenmo n	JMP basic water 01 0.09434 0.3456 102	dr ws qa clsrc 01 0.09068 0.3746 98	reliable electricity 01 -0.03672 0.7196 98	owner type private 01 . . 102
total seenmo n	reliable electricity 01 0.06829 0.5040 98	dr ws qa clsrc 01 0.05062 0.6206 98	dr ws qa hcfcl 01 0.04438 0.6643 98	owner type private 01 . . 102
bkg_surg_mo_n_all	dr ws qa clsrc 01 -0.07196 0.4813 98	dr ws qa hcfcl 01 -0.05691 0.5778 98	bkg outpat seenmo n -0.01009 0.9198 102	owner type private 01 . . 102
bkg deliv mo n	dr ws qa hcfcl 01 0.09460 0.3542 98	JMP basic water 01 0.08312 0.4062 102	bkg outpat seenmo n 0.08119 0.4172 102	owner type private 01 . . 102
bkg caesarian mo n	bkg outpat seenmo n 0.07267 0.4679 102	dr ws qa hcfcl 01 -0.01193 0.9072 98	dr ws qa clsrc 01 -0.00983 0.9234 98	owner type private 01 . . 102
total staff	JMP basic water 01 0.06882 0.4919 102	dr ws qa clsrc 01 -0.05535 0.5883 98	dr ws qa hcfcl 01 -0.04184 0.6825 98	owner type private 01 . . 102
bkg staff clinical n	JMP basic water 01 0.08287 0.4077 102	dr ws qa clsrc 01 -0.04818 0.6376 98	dr ws qa hcfcl 01 -0.03393 0.7401 98	owner type private 01 . . 102
bkg staff nonclinical n	dr ws qa clsrc 01 -0.06102 0.5506 98	dr ws qa hcfcl 01 -0.04947 0.6286 98	JMP basic water 01 0.04898 0.6249 102	owner type private 01 . . 102
bkg staff md n	total seenmo n 0.06853 0.4937 102	dr ws qa hcfcl 01 -0.05785 0.5715 98	bkg outpat seenmo n -0.01934 0.8470 102	owner type private 01 . . 102

Ranked Pearson Correlation Coefficients for All Pairs of Dichotomous HCF-Level Predictors

The CORR Procedure

gps_country=Afghanistan

Pearson Correlation Coefficients Prob > |r| under H0: Rho=0 Number of Observations				
bkg staff cleaning n	JMP basic water 01 0.04521 0.6518 102	dr ws qa hcfcl 01 0.03116 0.7607 98	dr ws qa clsrc 01 0.00152 0.9881 98	owner type private 01 . . 102
bkg inpat beds n all	JMP basic water 01 0.08445 0.3987 102	dr ws qa hcfcl 01 0.01228 0.9045 98	dr ws qa clsrc 01 0.00284 0.9778 98	owner type private 01 . . 102
JMP basic water 01	total staff 0.06882 0.4919 102	bkg staff nonclinical n 0.04898 0.6249 102	bkg staff cleaning n 0.04521 0.6518 102	owner type private 01 . . 104
dr ws qa clsrc 01	bkg caesarian mo n -0.00983 0.9234 98	bkg inpat beds n all 0.00284 0.9778 98	bkg staff cleaning n 0.00152 0.9881 98	owner type private 01 . . 100
dr_ws_qa_hcfcl_01	bkg outpat seenmo n 0.02433 0.8120 98	bkg inpat beds n all 0.01228 0.9045 98	bkg caesarian mo n -0.01193 0.9072 98	owner type private 01 . . 100

Ranked Pearson Correlation Coefficients for All Pairs of Dichotomous HCF-Level Predictors

The CORR Procedure

gps_country=Uganda

24 Variables:	gps rural 0 urban 1	owner type private 01	hcf level high	reliable electricity 01	bkg g inp 01
	bkg g surg 01	md on staff	bkg wateruse day n	dr storage capacity n	
	bkg outpat seenmo n	bkg inpat seenmo n	total seenmo n	bkg surg mo n all	bkg deliv mo n
	bkg caesarian mo n	total staff	bkg staff clinical n	bkg staff nonclinical n	bkg staff md n
	bkg staff cleaning n	bkg inpat beds n all	JMP basic water 01	dr ws qa clsrc 01	
	dr_ws_qa_hcfcl_01				

Ranked Pearson Correlation Coefficients for All Pairs of Dichotomous HCF-Level Predictors

The CORR Procedure

gps_country=Uganda

Pearson Correlation Coefficients Prob > |r| under H0: Rho=0 Number of Observations				
gps rural 0 urban 1 gps_rural_0_urban_1	gps rural 0 urban 1 1.00000 148	hcf level high 0.34724 <.0001 148	dr storage capacity n 0.31852 0.0002 134	total staff 0.29681 0.0002 148
owner type private 01	owner type private 01 1.00000 147	bkg outpat seenmo n -0.22942 0.0052 147	total seenmo n -0.19709 0.0167 147	JMP basic water 01 0.14437 0.0811 147
hcf level high	hcf level high 1.00000 148	md on staff 0.78722 <.0001 148	bkg inpat beds n all 0.65385 <.0001 148	bkg staff md n 0.63192 <.0001 148
reliable electricity 01	reliable electricity 01 1.00000 148	owner type private 01 0.11062 0.1823 147	bkg staff cleaning n 0.10560 0.2015 148	gps rural 0 urban 1 -0.10555 0.2017 148
bkg_g_inp_01	bkg g inp 01 1.00000 148	bkg g surg 01 0.19288 0.0188 148	bkg staff nonclinical n 0.18165 0.0271 148	bkg inpat beds n all 0.14566 0.0773 148
bkg g surg 01	bkg g surg 01 1.00000 148	bkg staff nonclinical n 0.30510 0.0002 148	md on staff 0.26453 0.0012 148	hcf level high 0.22370 0.0063 148
md on staff	md on staff 1.00000 148	hcf level high 0.78722 <.0001 148	bkg staff md n 0.69039 <.0001 148	bkg inpat beds n all 0.57880 <.0001 148
bkg wateruse day n	bkg wateruse day n 1.00000 148	bkg inpat beds n all 0.44610 <.0001 148	md on staff 0.36668 <.0001 148	bkg staff md n 0.33658 <.0001 148
dr storage capacity n	dr storage capacity n 1.00000 134	total staff 0.40085 <.0001 134	bkg staff clinical n 0.39326 <.0001 134	bkg staff md n 0.37249 <.0001 134
bkg outpat seenmo n	bkg outpat seenmo n 1.00000 148	total seenmo n 0.98396 <.0001 148	bkg staff clinical n 0.66039 <.0001 148	bkg caesarian mo n 0.66010 <.0001 148
bkg inpat seenmo n	bkg inpat seenmo n 1.00000 148	bkg inpat beds n all 0.72008 <.0001 148	bkg caesarian mo n 0.68073 <.0001 148	total seenmo n 0.64493 <.0001 148

Ranked Pearson Correlation Coefficients for All Pairs of Dichotomous HCF-Level Predictors

The CORR Procedure

gps_country=Uganda

Pearson Correlation Coefficients Prob > |r| under H0: Rho=0 Number of Observations				
total seenmo n	total seenmo n 1.00000 148	bkg outpat seenmo n 0.98396 <.0001 148	bkg caesarian mo n 0.72190 <.0001 148	bkg staff clinical n 0.69257 <.0001 148
bkg surg mo n all	bkg surg mo n all 1.00000 148	bkg staff clinical n 0.49646 <.0001 148	total staff 0.48931 <.0001 148	bkg staff md n 0.47472 <.0001 148
bkg deliv mo n	bkg deliv mo n 1.00000 148	bkg caesarian mo n 0.65000 <.0001 148	total seenmo n 0.61757 <.0001 148	bkg staff clinical n 0.60727 <.0001 148
bkg caesarian mo n	bkg caesarian mo n 1.00000 148	bkg staff md n 0.84962 <.0001 148	bkg staff clinical n 0.80250 <.0001 148	bkg inpat beds n all 0.79335 <.0001 148
total_staff	total staff 1.00000 148	bkg staff clinical n 0.98809 <.0001 148	bkg staff md n 0.86464 <.0001 148	bkg caesarian mo n 0.76993 <.0001 148
bkg staff clinical n	bkg staff clinical n 1.00000 148	total staff 0.98809 <.0001 148	bkg staff md n 0.86916 <.0001 148	bkg caesarian mo n 0.80250 <.0001 148
bkg staff nonclinical n	bkg staff nonclinical n 1.00000 148	bkg staff cleaning n 0.65587 <.0001 148	md on staff 0.56654 <.0001 148	hcf level high 0.55767 <.0001 148
bkg staff md n	bkg staff md n 1.00000 148	bkg staff clinical n 0.86916 <.0001 148	total staff 0.86464 <.0001 148	bkg caesarian mo n 0.84962 <.0001 148
bkg staff cleaning n	bkg staff cleaning n 1.00000 148	bkg staff nonclinical n 0.65587 <.0001 148	md on staff 0.39466 <.0001 148	bkg inpat seenmo n 0.38114 <.0001 148
bkg inpat beds n all	bkg inpat beds n all 1.00000 148	bkg staff md n 0.81864 <.0001 148	bkg caesarian mo n 0.79335 <.0001 148	total staff 0.75669 <.0001 148
JMP basic water 01	JMP basic water 01 1.00000 148	bkg staff nonclinical n 0.18671 0.0231 148	owner type private 01 0.14437 0.0811 147	bkg staff cleaning n 0.12309 0.1361 148

Ranked Pearson Correlation Coefficients for All Pairs of Dichotomous HCF-Level Predictors

The CORR Procedure

gps_country=Uganda

Pearson Correlation Coefficients
Prob > |r| under H0: Rho=0
Number of Observations

dr ws qa clsrc 01	dr ws qa clsrc 01 1.00000 140	dr ws qa hcfcl 01 0.39831 <.0001 140	md on staff 0.28307 0.0007 140	total seenmo n 0.23437 0.0053 140
dr ws qa hcfcl 01	dr ws qa hcfcl 01 1.00000 140	dr ws qa clsrc 01 0.39831 <.0001 140	bkg wateruse day n 0.25490 0.0024 140	md on staff 0.15102 0.0749 140

Pearson Correlation Coefficients
Prob > |r| under H0: Rho=0
Number of Observations

gps rural 0 urban 1 gps_rural_0_urban_1	bkg staff clinical n 0.28167 0.0005 148	md on staff 0.23078 0.0048 148	bkg inpat beds n all 0.22386 0.0062 148	bkg staff nonclinical n 0.20910 0.0108 148
owner type private 01	gps rural 0 urban 1 0.11632 0.1606 147	reliable electricity 01 0.11062 0.1823 147	bkg staff clinical n -0.11021 0.1839 147	bkg deliv mo n -0.10404 0.2098 147
hcf level high	total staff 0.59744 <.0001 148	bkg staff nonclinical n 0.55767 <.0001 148	bkg staff clinical n 0.54295 <.0001 148	bkg caesarian mo n 0.46513 <.0001 148
reliable electricity 01	bkg g inp 01 0.10365 0.2100 148	bkg wateruse day n 0.10081 0.2228 148	bkg outpat seenmo n -0.09875 0.2324 148	bkg inpat beds n all 0.09755 0.2382 148
bkg g inp 01	bkg staff cleaning n 0.12141 0.1416 148	JMP basic water 01 0.11252 0.1733 148	total staff 0.10627 0.1986 148	reliable electricity 01 0.10365 0.2100 148
bkg g surg 01	total staff 0.19656 0.0166 148	bkg g inp 01 0.19288 0.0188 148	total seenmo n 0.18782 0.0223 148	bkg inpat beds n all 0.18750 0.0225 148
md on staff	total_staff 0.56791 <.0001 148	bkg_staff_nonclinical_n 0.56654 <.0001 148	bkg_staff_clinical_n 0.50971 <.0001 148	bkg_deliv_mo_n 0.40786 <.0001 148
bkg wateruse day n	total seenmo n 0.29350 0.0003 148	bkg staff nonclinical n 0.29302 0.0003 148	bkg outpat seenmo n 0.27771 0.0006 148	hcf level high 0.27504 0.0007 148

Ranked Pearson Correlation Coefficients for All Pairs of Dichotomous HCF-Level Predictors

The CORR Procedure

gps_country=Uganda

Pearson Correlation Coefficients
Prob > |r| under H0: Rho=0
Number of Observations

dr storage capacity n	gps rural 0 urban 1 0.31852 0.0002 134	bkg surg mo n all 0.31734 0.0002 134	hcf level high 0.27268 0.0014 134	total seenmo n 0.25750 0.0027 134
bkg outpat seenmo n	total staff 0.64542 <.0001 148	bkg staff md n 0.60280 <.0001 148	bkg deliv mo n 0.58914 <.0001 148	bkg inpat seenmo n 0.49826 <.0001 148
bkg inpat seenmo n	bkg staff md n 0.57204 <.0001 148	total staff 0.56258 <.0001 148	bkg staff clinical n 0.53690 <.0001 148	bkg outpat seenmo n 0.49826 <.0001 148
total seenmo n	total staff 0.68465 <.0001 148	bkg staff md n 0.64903 <.0001 148	bkg inpat seenmo n 0.64493 <.0001 148	bkg deliv mo n 0.61757 <.0001 148
bkg_surg_mo_n_all	bkg caesarian mo n 0.44453 <.0001 148	hcf level high 0.42184 <.0001 148	bkg inpat beds n all 0.40448 <.0001 148	total seenmo n 0.40001 <.0001 148
bkg deliv mo n	total staff 0.59955 <.0001 148	bkg outpat seenmo n 0.58914 <.0001 148	bkg staff md n 0.57615 <.0001 148	bkg inpat beds n all 0.51437 <.0001 148
bkg caesarian mo n	total staff 0.76993 <.0001 148	total seenmo n 0.72190 <.0001 148	bkg inpat seenmo n 0.68073 <.0001 148	bkg outpat seenmo n 0.66010 <.0001 148
total staff	bkg inpat beds n all 0.75669 <.0001 148	total seenmo n 0.68465 <.0001 148	bkg outpat seenmo n 0.64542 <.0001 148	bkg deliv mo n 0.59955 <.0001 148
bkg staff clinical n	bkg inpat beds n all 0.72725 <.0001 148	total seenmo n 0.69257 <.0001 148	bkg outpat seenmo n 0.66039 <.0001 148	bkg deliv mo n 0.60727 <.0001 148
bkg staff nonclinical n	total staff 0.48200 <.0001 148	bkg inpat beds n all 0.48099 <.0001 148	bkg inpat seenmo n 0.37926 <.0001 148	bkg staff clinical n 0.34142 <.0001 148
bkg staff md n	bkg inpat beds n all 0.81864 <.0001 148	md on staff 0.69039 <.0001 148	total seenmo n 0.64903 <.0001 148	hcf level high 0.63192 <.0001 148

Ranked Pearson Correlation Coefficients for All Pairs of Dichotomous HCF-Level Predictors

The CORR Procedure

gps_country=Uganda

Pearson Correlation Coefficients Prob > |r| under H0: Rho=0 Number of Observations				
bkg staff cleaning n	hcf level high 0.34825 <.0001 148	bkg inpat beds n all 0.28132 0.0005 148	bkg wateruse day n 0.25104 0.0021 148	total staff 0.20314 0.0133 148
bkg inpat beds n all	bkg staff clinical n 0.72725 <.0001 148	bkg inpat seenmo n 0.72008 <.0001 148	hcf level high 0.65385 <.0001 148	md on staff 0.57880 <.0001 148
JMP basic water 01	bkg wateruse day n -0.12291 0.1367 148	bkg g surg 01 0.12167 0.1407 148	bkg outpat seenmo n -0.11845 0.1516 148	bkg g inp 01 0.11252 0.1733 148
dr ws qa clsrc 01	bkg staff md n 0.22987 0.0063 140	bkg outpat seenmo n 0.22089 0.0087 140	bkg deliv mo n 0.22063 0.0088 140	bkg surg mo n all 0.20782 0.0137 140
dr_ws_qa_hcfcl_01	bkg staff nonclinical n 0.15054 0.0758 140	bkg inpat beds n all 0.10213 0.2299 140	bkg staff md n 0.09045 0.2879 140	total staff 0.08897 0.2959 140

Pearson Correlation Coefficients Prob > |r| under H0: Rho=0 Number of Observations				
gps rural 0 urban 1 gps_rural_0_urban_1	bkg staff md n 0.20539 0.0123 148	bkg inpat seenmo n 0.13945 0.0910 148	bkg caesarian mo n 0.13109 0.1123 148	bkg deliv mo n 0.12974 0.1160 148
owner type private 01	md on staff -0.10373 0.2112 147	bkg inpat beds n all 0.09466 0.2541 147	total staff -0.09361 0.2595 147	bkg wateruse day n 0.09067 0.2747 147
hcf level high	bkg deliv mo n 0.45894 <.0001 148	bkg surg mo n all 0.42184 <.0001 148	bkg inpat seenmo n 0.41606 <.0001 148	bkg staff cleaning n 0.34825 <.0001 148
reliable electricity 01	bkg_deliv_mo_n -0.09112 0.2707 148	dr_ws_qa_hcfcl_01 0.08883 0.2966 140	bkg_staff_clinical_n -0.07976 0.3352 148	total_seenmo_n -0.07457 0.3677 148
bkg g inp 01	bkg deliv mo n 0.09505 0.2505 148	hcf level high 0.09267 0.2626 148	bkg inpat seenmo n 0.09006 0.2763 148	total seenmo n 0.08474 0.3059 148

Ranked Pearson Correlation Coefficients for All Pairs of Dichotomous HCF-Level Predictors

The CORR Procedure

gps_country=Uganda

Pearson Correlation Coefficients Prob > |r| under H0: Rho=0 Number of Observations				
bkg g surg 01	bkg outpat seenmo n 0.17658 0.0318 148	bkg staff md n 0.16417 0.0462 148	bkg staff clinical n 0.15727 0.0563 148	bkg inpat seenmo n 0.15638 0.0577 148
md on staff	bkg caesarian mo n 0.40738 <.0001 148	bkg staff cleaning n 0.39466 <.0001 148	total seenmo n 0.39298 <.0001 148	bkg surg mo n all 0.37992 <.0001 148
bkg wateruse day n	dr ws qa hcfcl 01 0.25490 0.0024 140	bkg staff cleaning n 0.25104 0.0021 148	bkg inpat seenmo n 0.23675 0.0038 148	bkg caesarian mo n 0.22762 0.0054 148
dr storage capacity n	bkg outpat seenmo n 0.23770 0.0057 134	md on staff 0.23363 0.0066 134	bkg inpat seenmo n 0.23306 0.0067 134	bkg inpat beds n all 0.21807 0.0114 134
bkg_outpat_seenmo_n	bkg inpat beds n all 0.47592 <.0001 148	bkg surg mo n all 0.37481 <.0001 148	md on staff 0.35858 <.0001 148	bkg wateruse day n 0.27771 0.0006 148
bkg inpat seenmo n	bkg deliv mo n 0.47764 <.0001 148	hcf level high 0.41606 <.0001 148	bkg staff cleaning n 0.38114 <.0001 148	bkg staff nonclinical n 0.37926 <.0001 148
total seenmo n	bkg inpat beds n all 0.56765 <.0001 148	bkg surg mo n all 0.40001 <.0001 148	md on staff 0.39298 <.0001 148	hcf level high 0.30617 0.0002 148
bkg surg mo n all	bkg deliv mo n 0.38138 <.0001 148	md on staff 0.37992 <.0001 148	bkg outpat seenmo n 0.37481 <.0001 148	bkg inpat seenmo n 0.33847 <.0001 148
bkg deliv mo n	bkg inpat seenmo n 0.47764 <.0001 148	hcf level high 0.45894 <.0001 148	md on staff 0.40786 <.0001 148	bkg surg mo n all 0.38138 <.0001 148
bkg caesarian mo n	bkg deliv mo n 0.65000 <.0001 148	hcf level high 0.46513 <.0001 148	bkg surg mo n all 0.44453 <.0001 148	md on staff 0.40738 <.0001 148
total staff	hcf level high 0.59744 <.0001 148	md on staff 0.56791 <.0001 148	bkg inpat seenmo n 0.56258 <.0001 148	bkg surg mo n all 0.48931 <.0001 148

Ranked Pearson Correlation Coefficients for All Pairs of Dichotomous HCF-Level Predictors

The CORR Procedure

gps_country=Uganda

Pearson Correlation Coefficients Prob > |r| under H0: Rho=0 Number of Observations				
bkg staff clinical n	hcf level high 0.54295 <.0001 148	bkg inpat seenmo n 0.53690 <.0001 148	md on staff 0.50971 <.0001 148	bkg surg mo n all 0.49646 <.0001 148
bkg staff nonclinical n	bkg staff md n 0.33233 <.0001 148	bkg g surg 01 0.30510 0.0002 148	bkg wateruse day n 0.29302 0.0003 148	total seenmo n 0.23849 0.0035 148
bkg staff md n	bkg outpat seenmo n 0.60280 <.0001 148	bkg deliv mo n 0.57615 <.0001 148	bkg inpat seenmo n 0.57204 <.0001 148	bkg surg mo n all 0.47472 <.0001 148
bkg staff cleaning n	total seenmo n 0.18314 0.0259 148	bkg staff md n 0.13321 0.1065 148	JMP basic water 01 0.12309 0.1361 148	bkg g inp 01 0.12141 0.1416 148
bkg_inpat_beds_n_all	total seenmo n 0.56765 <.0001 148	bkg deliv mo n 0.51437 <.0001 148	bkg staff nonclinical n 0.48099 <.0001 148	bkg outpat seenmo n 0.47592 <.0001 148
JMP basic water 01	dr ws qa clsrc 01 0.11233 0.1864 140	hcf level high 0.10925 0.1862 148	total seenmo n -0.09453 0.2531 148	md on staff 0.07997 0.3340 148
dr ws qa clsrc 01	bkg inpat seenmo n 0.19605 0.0203 140	bkg inpat beds n all 0.18354 0.0300 140	bkg wateruse day n 0.17466 0.0390 140	total staff 0.16245 0.0552 140
dr ws qa hcfcl 01	reliable electricity 01 0.08883 0.2966 140	bkg staff cleaning n 0.08627 0.3108 140	gps rural 0 urban 1 0.07787 0.3605 140	bkg staff clinical n 0.06916 0.4168 140

Pearson Correlation Coefficients Prob > |r| under H0: Rho=0 Number of Observations				
gps rural 0 urban 1 gps_rural_0_urban_1	owner_type_private_01 0.11632 0.1606 147	reliable_electricity_01 -0.10555 0.2017 148	bkg_surg_mo_n_all 0.09299 0.2610 148	dr_ws_qa_hcfcl_01 0.07787 0.3605 140
owner type private 01	bkg g surg 01 0.06927 0.4045 147	bkg staff cleaning n 0.05872 0.4799 147	bkg staff nonclinical n 0.05640 0.4975 147	bkg surg mo n all -0.04994 0.5480 147

Ranked Pearson Correlation Coefficients for All Pairs of Dichotomous HCF-Level Predictors

The CORR Procedure

gps_country=Uganda

Pearson Correlation Coefficients Prob > |r| under H0: Rho=0 Number of Observations				
hcf level high	gps rural 0 urban 1 0.34724 <.0001 148	total seenmo n 0.30617 0.0002 148	bkg wateruse day n 0.27504 0.0007 148	dr storage capacity n 0.27268 0.0014 134
reliable electricity 01	total staff -0.07309 0.3774 148	bkg inpat seenmo n 0.06063 0.4642 148	bkg surg mo n all -0.06018 0.4675 148	md on staff -0.05302 0.5221 148
bkg g inp 01	bkg staff clinical n 0.08209 0.3212 148	bkg outpat seenmo n 0.07511 0.3642 148	gps rural 0 urban 1 0.06644 0.4224 148	dr ws qa hcfcl 01 -0.06119 0.4726 140
bkg g surg 01	bkg wateruse day n 0.13379 0.1050 148	bkg surg mo n all 0.13350 0.1058 148	bkg deliv mo n 0.13009 0.1151 148	bkg caesarian mo n 0.12325 0.1356 148
md_on_staff	bkg inpat seenmo n 0.37384 <.0001 148	bkg wateruse day n 0.36668 <.0001 148	bkg outpat seenmo n 0.35858 <.0001 148	dr ws qa clsrc 01 0.28307 0.0007 140
bkg wateruse day n	total staff 0.21777 0.0078 148	dr storage capacity n 0.18360 0.0337 134	bkg staff clinical n 0.18215 0.0267 148	bkg surg mo n all 0.18101 0.0277 148
dr storage capacity n	bkg caesarian mo n 0.20923 0.0153 134	bkg wateruse day n 0.18360 0.0337 134	bkg staff nonclinical n 0.14371 0.0976 134	bkg deliv mo n 0.13763 0.1128 134
bkg outpat seenmo n	hcf level high 0.25023 0.0022 148	dr storage capacity n 0.23770 0.0057 134	owner type private 01 -0.22942 0.0052 147	dr ws qa clsrc 01 0.22089 0.0087 140
bkg inpat seenmo n	md on staff 0.37384 <.0001 148	bkg surg mo n all 0.33847 <.0001 148	bkg wateruse day n 0.23675 0.0038 148	dr storage capacity n 0.23306 0.0067 134
total seenmo n	bkg wateruse day n 0.29350 0.0003 148	dr storage capacity n 0.25750 0.0027 134	bkg staff nonclinical n 0.23849 0.0035 148	dr ws qa clsrc 01 0.23437 0.0053 140
bkg surg mo n all	dr storage capacity n 0.31734 0.0002 134	dr ws qa clsrc 01 0.20782 0.0137 140	bkg wateruse day n 0.18101 0.0277 148	bkg staff nonclinical n 0.16201 0.0492 148

Ranked Pearson Correlation Coefficients for All Pairs of Dichotomous HCF-Level Predictors

The CORR Procedure

gps_country=Uganda

Pearson Correlation Coefficients Prob > |r| under H0: Rho=0 Number of Observations				
bkg deliv mo n	dr ws qa clsrc 01 0.22063 0.0088 140	bkg staff nonclinical n 0.20439 0.0127 148	dr storage capacity n 0.13763 0.1128 134	bkg g surg 01 0.13009 0.1151 148
bkg caesarian mo n	bkg wateruse day n 0.22762 0.0054 148	dr storage capacity n 0.20923 0.0153 134	dr ws qa clsrc 01 0.14263 0.0927 140	bkg staff nonclinical n 0.13345 0.1059 148
total staff	bkg staff nonclinical n 0.48200 <.0001 148	dr storage capacity n 0.40085 <.0001 134	gps rural 0 urban 1 0.29681 0.0002 148	bkg wateruse day n 0.21777 0.0078 148
bkg staff clinical n	dr storage capacity n 0.39326 <.0001 134	bkg staff nonclinical n 0.34142 <.0001 148	gps rural 0 urban 1 0.28167 0.0005 148	bkg wateruse day n 0.18215 0.0267 148
bkg_staff_nonclinical_n	gps rural 0 urban 1 0.20910 0.0108 148	bkg deliv mo n 0.20439 0.0127 148	JMP basic water 01 0.18671 0.0231 148	bkg outpat seenmo n 0.18204 0.0268 148
bkg staff md n	dr storage capacity n 0.37249 <.0001 134	bkg wateruse day n 0.33658 <.0001 148	bkg staff nonclinical n 0.33233 <.0001 148	dr ws qa clsrc 01 0.22987 0.0063 140
bkg staff cleaning n	bkg outpat seenmo n 0.11881 0.1504 148	bkg g surg 01 0.11799 0.1532 148	reliable electricity 01 0.10560 0.2015 148	bkg staff clinical n 0.10272 0.2141 148
bkg inpat beds n all	bkg wateruse day n 0.44610 <.0001 148	bkg surg mo n all 0.40448 <.0001 148	bkg staff cleaning n 0.28132 0.0005 148	gps rural 0 urban 1 0.22386 0.0062 148
JMP basic water 01	dr storage capacity n 0.07870 0.3660 134	gps rural 0 urban 1 -0.06691 0.4191 148	bkg caesarian mo n -0.04976 0.5481 148	bkg inpat seenmo n 0.04801 0.5623 148
dr ws qa clsrc 01	bkg staff clinical n 0.15147 0.0740 140	hcf level high 0.14336 0.0911 140	bkg caesarian mo n 0.14263 0.0927 140	bkg staff nonclinical n 0.12963 0.1269 140
dr ws qa hcfcl 01	bkg g surg 01 0.06778 0.4262 140	bkg g inp 01 -0.06119 0.4726 140	hcf level high 0.05710 0.5028 140	bkg deliv mo n -0.05076 0.5514 140

Ranked Pearson Correlation Coefficients for All Pairs of Dichotomous HCF-Level Predictors

The CORR Procedure

gps_country=Uganda

Pearson Correlation Coefficients Prob > |r| under H0: Rho=0 Number of Observations				
gps rural 0 urban 1 gps_rural_0_urban_1	JMP basic water 01 -0.06691 0.4191 148	bkg g inp 01 0.06644 0.4224 148	total seenmo n 0.06108 0.4608 148	dr ws qa clsrc 01 0.05967 0.4838 140
owner type private 01	bkg staff md n -0.04027 0.6282 147	dr ws qa hcfcl 01 -0.03673 0.6677 139	bkg inpat seenmo n 0.02491 0.7646 147	dr storage capacity n -0.02149 0.8061 133
hcf level high	bkg outpat seenmo n 0.25023 0.0022 148	bkg g surg 01 0.22370 0.0063 148	dr ws qa clsrc 01 0.14336 0.0911 140	JMP basic water 01 0.10925 0.1862 148
reliable electricity 01	dr storage capacity n -0.05123 0.5566 134	bkg caesarian mo n 0.05009 0.5455 148	dr ws qa clsrc 01 -0.04117 0.6291 140	bkg staff md n -0.01405 0.8655 148
bkg_g_inp_01	bkg staff md n 0.05325 0.5204 148	bkg wateruse day n 0.04353 0.5994 148	bkg caesarian mo n 0.04310 0.6029 148	bkg surg mo n all 0.03297 0.6908 148
bkg g surg 01	JMP basic water 01 0.12167 0.1407 148	bkg staff cleaning n 0.11799 0.1532 148	dr storage capacity n 0.08412 0.3339 134	owner type private 01 0.06927 0.4045 147
md on staff	bkg g surg 01 0.26453 0.0012 148	dr storage capacity n 0.23363 0.0066 134	gps rural 0 urban 1 0.23078 0.0048 148	dr ws qa hcfcl 01 0.15102 0.0749 140
bkg wateruse day n	dr ws qa clsrc 01 0.17466 0.0390 140	bkg g surg 01 0.13379 0.1050 148	JMP basic water 01 -0.12291 0.1367 148	bkg deliv mo n 0.10264 0.2145 148
dr storage capacity n	dr ws qa clsrc 01 0.10777 0.2297 126	bkg staff cleaning n -0.08452 0.3316 134	bkg g surg 01 0.08412 0.3339 134	JMP basic water 01 0.07870 0.3660 134
bkg outpat seenmo n	bkg staff nonclinical n 0.18204 0.0268 148	bkg g surg 01 0.17658 0.0318 148	bkg staff cleaning n 0.11881 0.1504 148	JMP basic water 01 -0.11845 0.1516 148
bkg inpat seenmo n	dr ws qa clsrc 01 0.19605 0.0203 140	bkg g surg 01 0.15638 0.0577 148	gps rural 0 urban 1 0.13945 0.0910 148	bkg g inp 01 0.09006 0.2763 148

Ranked Pearson Correlation Coefficients for All Pairs of Dichotomous HCF-Level Predictors

The CORR Procedure

gps_country=Uganda

Pearson Correlation Coefficients Prob > |r| under H0: Rho=0 Number of Observations				
total seenmo n	owner type private 01 -0.19709 0.0167 147	bkg g surg 01 0.18782 0.0223 148	bkg staff cleaning n 0.18314 0.0259 148	JMP basic water 01 -0.09453 0.2531 148
bkg surg mo n all	bkg g surg 01 0.13350 0.1058 148	gps rural 0 urban 1 0.09299 0.2610 148	reliable electricity 01 -0.06018 0.4675 148	owner type private 01 -0.04994 0.5480 147
bkg deliv mo n	gps rural 0 urban 1 0.12974 0.1160 148	owner type private 01 -0.10404 0.2098 147	bkg wateruse day n 0.10264 0.2145 148	bkg g inp 01 0.09505 0.2505 148
bkg caesarian mo n	gps rural 0 urban 1 0.13109 0.1123 148	bkg g surg 01 0.12325 0.1356 148	reliable electricity 01 0.05009 0.5455 148	JMP basic water 01 -0.04976 0.5481 148
total_staff	bkg staff cleaning n 0.20314 0.0133 148	bkg g surg 01 0.19656 0.0166 148	dr ws qa clsrc 01 0.16245 0.0552 140	bkg g inp 01 0.10627 0.1986 148
bkg staff clinical n	bkg g surg 01 0.15727 0.0563 148	dr ws qa clsrc 01 0.15147 0.0740 140	owner type private 01 -0.11021 0.1839 147	bkg staff cleaning n 0.10272 0.2141 148
bkg staff nonclinical n	bkg g inp 01 0.18165 0.0271 148	bkg surg mo n all 0.16201 0.0492 148	dr ws qa hcfcl 01 0.15054 0.0758 140	dr storage capacity n 0.14371 0.0976 134
bkg staff md n	gps rural 0 urban 1 0.20539 0.0123 148	bkg g surg 01 0.16417 0.0462 148	bkg staff cleaning n 0.13321 0.1065 148	dr ws qa hcfcl 01 0.09045 0.2879 140
bkg staff cleaning n	dr ws qa hcfcl 01 0.08627 0.3108 140	dr storage capacity n -0.08452 0.3316 134	owner type private 01 0.05872 0.4799 147	bkg caesarian mo n 0.04590 0.5796 148
bkg inpat beds n all	dr storage capacity n 0.21807 0.0114 134	bkg g surg 01 0.18750 0.0225 148	dr ws qa clsrc 01 0.18354 0.0300 140	bkg g inp 01 0.14566 0.0773 148
JMP basic water 01	bkg surg mo n all 0.04761 0.5655 148	bkg inpat beds n all 0.03374 0.6839 148	dr ws qa hcfcl 01 0.02856 0.7377 140	bkg deliv mo n 0.02580 0.7556 148

Ranked Pearson Correlation Coefficients for All Pairs of Dichotomous HCF-Level Predictors

The CORR Procedure

gps_country=Uganda

Pearson Correlation Coefficients Prob > |r| under H0: Rho=0 Number of Observations				
dr ws qa clsrc 01	JMP basic water 01 0.11233 0.1864 140	dr storage capacity n 0.10777 0.2297 126	gps rural 0 urban 1 0.05967 0.4838 140	bkg g surg 01 0.05843 0.4929 140
dr ws qa hcfcl 01	bkg outpat seenmo n 0.05036 0.5546 140	total seenmo n 0.04964 0.5602 140	owner type private 01 -0.03673 0.6677 139	dr storage capacity n -0.02896 0.7475 126

Pearson Correlation Coefficients Prob > |r| under H0: Rho=0 Number of Observations				
gps rural 0 urban 1 gps_rural_0_urban_1	bkg outpat seenmo n 0.03675 0.6574 148	bkg g surg 01 0.03143 0.7046 148	bkg wateruse day n 0.02670 0.7473 148	bkg staff cleaning n 0.00749 0.9280 148
owner type private 01	bkg caesarian mo n -0.01261 0.8795 147	hcf level high -0.01208 0.8846 147	dr ws qa clsrc 01 -0.00806 0.9250 139	bkg g inp 01 0.00501 0.9520 147
hcf level high	bkg g inp 01 0.09267 0.2626 148	dr ws qa hcfcl 01 0.05710 0.5028 140	owner type private 01 -0.01208 0.8846 147	reliable electricity 01 -0.00303 0.9708 148
reliable electricity 01	bkg g surg 01 -0.01144 0.8903 148	bkg staff nonclinical n 0.00772 0.9258 148	hcf level high -0.00303 0.9708 148	JMP basic water 01 -0.00139 0.9866 148
bkg g inp 01	md on staff 0.02162 0.7943 148	dr storage capacity n 0.01806 0.8359 134	dr ws qa clsrc 01 0.01668 0.8449 140	owner type private 01 0.00501 0.9520 147
bkg g surg 01	dr ws qa hcfcl 01 0.06778 0.4262 140	dr ws qa clsrc 01 0.05843 0.4929 140	gps rural 0 urban 1 0.03143 0.7046 148	reliable electricity 01 -0.01144 0.8903 148
md on staff	owner_type_private_01 -0.10373 0.2112 147	JMP_basic_water_01 0.07997 0.3340 148	reliable_electricity_01 -0.05302 0.5221 148	bkg_g_inp_01 0.02162 0.7943 148
bkg wateruse day n	reliable electricity 01 0.10081 0.2228 148	owner type private 01 0.09067 0.2747 147	bkg g inp 01 0.04353 0.5994 148	gps rural 0 urban 1 0.02670 0.7473 148

Ranked Pearson Correlation Coefficients for All Pairs of Dichotomous HCF-Level Predictors

The CORR Procedure

gps_country=Uganda

Pearson Correlation Coefficients Prob > |r| under H0: Rho=0 Number of Observations				
dr storage capacity n	reliable electricity 01 -0.05123 0.5566 134	dr ws qa hcfcl 01 -0.02896 0.7475 126	owner type private 01 -0.02149 0.8061 133	bkg g inp 01 0.01806 0.8359 134
bkg outpat seenmo n	reliable electricity 01 -0.09875 0.2324 148	bkg g inp 01 0.07511 0.3642 148	dr ws qa hcfcl 01 0.05036 0.5546 140	gps rural 0 urban 1 0.03675 0.6574 148
bkg inpat seenmo n	reliable electricity 01 0.06063 0.4642 148	JMP basic water 01 0.04801 0.5623 148	dr ws qa hcfcl 01 0.02780 0.7444 140	owner type private 01 0.02491 0.7646 147
total seenmo n	bkg g inp 01 0.08474 0.3059 148	reliable electricity 01 -0.07457 0.3677 148	gps rural 0 urban 1 0.06108 0.4608 148	dr ws qa hcfcl 01 0.04964 0.5602 140
bkg_surg_mo_n_all	JMP basic water 01 0.04761 0.5655 148	bkg g inp 01 0.03297 0.6908 148	bkg staff cleaning n -0.01748 0.8330 148	dr ws qa hcfcl 01 0.00893 0.9166 140
bkg deliv mo n	reliable electricity 01 -0.09112 0.2707 148	dr ws qa hcfcl 01 -0.05076 0.5514 140	JMP basic water 01 0.02580 0.7556 148	bkg staff cleaning n 0.02435 0.7690 148
bkg caesarian mo n	bkg staff cleaning n 0.04590 0.5796 148	bkg g inp 01 0.04310 0.6029 148	dr ws qa hcfcl 01 0.01396 0.8700 140	owner type private 01 -0.01261 0.8795 147
total staff	owner type private 01 -0.09361 0.2595 147	dr ws qa hcfcl 01 0.08897 0.2959 140	reliable electricity 01 -0.07309 0.3774 148	JMP basic water 01 0.01925 0.8164 148
bkg staff clinical n	bkg g inp 01 0.08209 0.3212 148	reliable electricity 01 -0.07976 0.3352 148	dr ws qa hcfcl 01 0.06916 0.4168 140	JMP basic water 01 -0.01215 0.8835 148
bkg staff nonclinical n	bkg caesarian mo n 0.13345 0.1059 148	dr ws qa clsrc 01 0.12963 0.1269 140	owner type private 01 0.05640 0.4975 147	reliable electricity 01 0.00772 0.9258 148
bkg staff md n	bkg g inp 01 0.05325 0.5204 148	owner type private 01 -0.04027 0.6282 147	JMP basic water 01 -0.02172 0.7933 148	reliable electricity 01 -0.01405 0.8655 148

Ranked Pearson Correlation Coefficients for All Pairs of Dichotomous HCF-Level Predictors

The CORR Procedure

gps_country=Uganda

Pearson Correlation Coefficients Prob > |r| under H0: Rho=0 Number of Observations				
bkg staff cleaning n	dr ws qa clsrc 01 0.03136 0.7130 140	bkg deliv mo n 0.02435 0.7690 148	bkg surg mo n all -0.01748 0.8330 148	gps rural 0 urban 1 0.00749 0.9280 148
bkg inpat beds n all	dr ws qa hcfcl 01 0.10213 0.2299 140	reliable electricity 01 0.09755 0.2382 148	owner type private 01 0.09466 0.2541 147	JMP basic water 01 0.03374 0.6839 148
JMP basic water 01	bkg staff md n -0.02172 0.7933 148	total staff 0.01925 0.8164 148	bkg staff clinical n -0.01215 0.8835 148	reliable electricity 01 -0.00139 0.9866 148
dr ws qa clsrc 01	reliable electricity 01 -0.04117 0.6291 140	bkg staff cleaning n 0.03136 0.7130 140	bkg g inp 01 0.01668 0.8449 140	owner type private 01 -0.00806 0.9250 139
dr_ws_qa_hcfcl_01	JMP basic water 01 0.02856 0.7377 140	bkg inpat seenmo n 0.02780 0.7444 140	bkg caesarian mo n 0.01396 0.8700 140	bkg surg mo n all 0.00893 0.9166 140