An assessment of the use and performance of Ceramic Water Filters (CWFs) in the emergency context of Rakhine State, Myanmar

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Executive Summary

Background

Household Water Treatment and Safe Storage (HWTS) has been identified as priority programmatic area within the Water, Sanitation and Hygiene (WASH) cluster in Rakhine State, Myanmar – with the aim to improve drinking water quality while reducing and preventing incidences of diarrheal disease among populations affected by the protracted emergency – ongoing since 2012. Since they were first introduced to Rakhine in late-2012, approximately 25,000 Ceramic Water Filters (CWFs) have been distributed and promoted throughout the affected area by over half a dozen agencies. The CWF method has been proven in various settings around the world to significantly improve drinking water quality when produced, operated, and maintained correctly. However, as with all HWTS methods, CWFs have their drawbacks which most notably include limited filtration flow-rates (typically 1-4 liters per hour) and fragility of the ceramic pot that can result in increased risk of breakage and disuse over time. The Rakhine WASH cluster is a platform for agencies focusing on WASH interventions, and has endorsed CWFs that are produced in Myanmar to address the disadvantages associated with water point and household-level chlorination. Chlorination was previously promoted in the Rakhine context, but had very limited sustained use due in particular to strong dissatisfaction with the taste and smell of chlorinated water. Many of the agencies now promoting CWFs have been conducting Post-Distribution Monitoring (PDM), however, given the scale of the intervention and ongoing uncertainties relating to performance and use – the WASH Cluster decided to initiate a formal CWF assessment as one component of a broader review of CWF-related activities and guidance to the cluster. The aim of the CWF assessment was to characterize their use and performance, as well as household practices and perceptions – to generate lessons learned, define overall relevancy, and guide future decision-making.

Methods

A cross-sectional survey was conducted in November and December 2015 among 338 households that previously received a CWF (13 months ago on average). Households were randomly selected from camps and villages in Sittwe and Pauktaw townships that were directly or indirectly affected by the emergency crisis. For households that were currently using the CWF, water samples were collected at 2 stages: pre CWF-treated water stored in the household; and post CWF-treated drinking water stored in the plastic receptacle and accessed from the spigot. Water samples were analyzed in duplicate for Fecal Coliforms (FC) at a centralized laboratory using Delagua © test kits. Incidences of diarrheal disease were reported by the respondent for all household members. The study area encapsulated a region where nearly 85% of

all reported CWFs distributions have occurred in Rakhine State. However, remote sites (that were more likely to rely on surface water and dug wells – rather than boreholes) were excluded due to logistical and time constraints. Informed consent and confidentiality of respondents were ensured.

Results

The results of the study are presented below – grouped by the key study questions to facilitate interpretation.

1. After an average of 13 months since distribution, are the households that received a CWF still using it?

Approximately 62% of households were found to be using their CWF regularly for drinking and most (~90%) use borehole water to fill it up. These households typically use the CWF actively and consistently – every day and through the wet and dry seasons. Nearly all CWF-using households reported rarely or never consuming raw untreated water.

2. Why were 38% of households not using the CWF?

Some households reportedly never used the CWF after they received it (14%) and some used the CWF for sometime but then stopped (24%). The most common reason for disuse among both groups was due to breakage of the ceramic pot (56% and 75% respectively). Among the *never* users, it is not clear whether broken pots were received during distribution or whether respondents provided such an answer because they were embarrassed to admit to interviewers that they never used the filter. Slow filtration flow rates were the second most common reason for disuse (~10%) among *former users* - significantly lower than pot breakage. It is important to note that nearly all households reported using non-turbid water to fill the CWF. CWF use in settings with turbid water may produce significantly different performance and satisfaction results. A focus group discussion among a group of *former users* revealed a strong desire for a CWF pot replacement scheme but a low/no willingness to pay.

3. What factors are associated with households that are currently <u>not</u> using CWF?

The sample size of the study was small and therefore limited the ability to analyze factors associated with non-use. However, it was discovered that households residing in villages (rather than camps) and those residing in Pauktaw township (rather than Sittwe) were *less* likely to be *current users*. However, the exact reasons why these geographical factors cause increased non-use is not evident from the data. Negative associations were observed between *never users* and various indicators of training quality and duration. Negative associations were also observed between *former users* and various indicators of education and socio-economic status.

4. How long are the CWFs being used?

Once a household starts using the CWF, most remain in use for the first 300 days (~85%). After 300 days, the drop-out rate increases more rapidly – down to approximately 65% use after 400 days. The average monthly drop-out rate is 2% and the main cause is overwhelmingly due to breakage of the CWF pot.

5. Are CWFs actually improving the drinking water quality and health for those that use them?

During dry season conditions, over 50% of the households currently using the CWF had low levels of Fecal Coliforms (FC) (<10 cfu/100mL) in their raw untreated water stored in the household. Such conditions somewhat limit the impact potential of the CWF intervention at-large. The generally high quality of pre-treated waters is likely due to the fact that most households in the survey area (>80%) relied on boreholes that are more protected from contamination than surface water and dug wells.

Approximately 79% of CWF users had post-filtration water quality in either the *no* or *low* microbial risk categories (<10 cfu/100mL) indicating that the majority of users had access to high quality drinking water for consumption. SPHERE and Myanmar national drinking water quality standards for FC (0 cfu/100mL) were achieved at 56% of households. Approximately 50% of households that used the CWF experienced a *notable* improvement to their water quality (improvement between raw and treated samples of at least one risk category). Some households (28%) experienced a notable decrease in water quality. There is some evidence to suggest that households with degrading water quality after filtration have lower education and socio-economic status.

Approximately 10% of households had CWF post-treated water in the high risk category indicating that having and using a CWF does not guarantee high quality drinking water. An association was observed between the visual hygienic condition of the plastic storage receptacle and FC concentrations – indicating that post-filtration contamination may be due in-part to poor cleaning practices of the bucket.

Diarrhea incidence over the 1-week period before the survey was assessed for all household members and was found to be very low (~1% of the survey population). No difference in diarrhea disease incidence rates was observed between households that use and do not use the CWF, neither those that treat and never treat their drinking water.

6. What is the situation like for households that are not using the CWF?

Approximately 50% of *never users* reportedly still treat their water – with most practicing cloth filtration (54%). The performance of pathogen removal associated with cloth filtration is not understood. Approximately 50% of *never users* report that they always drink raw untreated water – the quality of which was not studied.

7. Are the households that use a CWF satisfied?

Satisfaction rates were reportedly extremely high among households that were currently using the CWF. Nearly all households were reportedly confident about how to operate and maintain the CWF and demonstrated correct understanding of its functionality and cleaning. Nearly all households trusted that the CWF can provide safe water – however a focus group discussion in one camp revealed the former presence of a rumor that CWFs were the cause of sterilization to control Muslim populations. Whether this rumor was believed beyond the single camp where the discussion was held is unclear. It was reported during the discussion that the rumour is no longer widely believed. Among *current users* and *former users*, nearly all reported that the CWF produced enough water for drinking, that it functioned as it should, and were satisfied with its production quality.

8. What is the role of CWF education, training, and follow-ups to support uptake and use?

CWF education and training was reportedly received by 97% of households with most receiving training in a group session (95%) and/or at their household (85%). The average total training contact time for a household was estimated at 100 minutes. *Never users* appear to be more likely to have received less CWF education and training. No association was observed between CWF training and *former users* – perhaps due to the fact that CWF pot breakage may be more related to chance than to practices.

It is logical and likely that the high trust, satisfaction, and knowledge of and good practices associated with operation and maintenance that were observed are the result of the thorough CWF training, education, and follow-up reported. However, this relationship could not be evaluated because the sample size of households with low CWF satisfaction and understanding was too small to make comparisons.

<u>*Conclusions and recommendations*</u>

A significant quantity of human and financial resources have been spent on the hardware (CWF package) and software (distribution, training, and monitoring) components of CWF promotion in Rakhine State – in response to the emergency and humanitarian situation that began in 2012. The majority of CWF distributions have occurred in late-2014 and early-2015. The study revealed that 62% of households were currently using the CWF at the time of survey and 31% of all households appear to be experiencing notable improvements to their drinking water quality (factoring non-use over time and comparing raw and treated water quality). Nearly 80% of all *current users* experienced drinking water quality in the *low* to *no* microbial risk category. Self-reported diarrheal disease rates were found to be very low among the study population and no differences in incidence rates were observed between households that treat and did not treat their water, nor those that use and do not use the CWF. It should be well noted that the findings are indicative of dry seasons and exposure pathways to disease causing pathogens and incidences of diarrhea may be higher in the wet season.

Generally, CWF practices and the performance of the filter itself are very high and enhanced due to extensive and thorough household training and follow-ups. Thorough training and follow-ups appear to be a key factor towards getting households to start using the CWF. The CWF (as an HWTS method) is most limited by moderate breakage rates over time. Flow rate and sufficiency of filtered drinking water does not appear to be major limitations in the study area. The hygienic conditions of the storage bucket could also be improved through focused hygiene training.

It is not possible to estimate the number of diarrheal diseases prevented by the intervention as a control group was not studied (a group of households that never *received* the CWF). However, such CWF programme impacts may be limited by overall high quality untreated water (typically from boreholes) and apparent low underlying incidences of diarrheal disease (including among *non-users*). Impacts and performance of such an intervention could increase further under different contextual conditions than that observed during this study – such as locations where boreholes are not readily available, during the early stages of a humanitarian response, or if a highly dynamic disease outbreak (i.e. cholera) were to occur. The impact of high turbidity source waters on filter performance and user satisfaction remains poorly understood as such conditions existed only at sites outside of the study area.

Considering the significant investments in hardware and software made to-date and the high level of knowledge and satisfaction towards CWF use, the Rakhine WASH cluster should strongly consider implementing an ongoing CWF pot replacement scheme – in particular at sites where distribution has occurred more than 300 days ago. Replacement should be conducted on a household-by-household and as-needed basis to ensure cost-efficiency. Planning can be conducted based on the assumption of a 2% drop-out rate per month. Complete CWF pot replacement should occur after the design life of 2-years is reached. Breakage of plastic buckets and spigots may begin to increase in frequency after 1-year of use.

In settings where agencies and/or government are for the first time considering HWTS interventions and promotion and distribution of CWFs, pre-intervention diarrheal disease incidence and raw water quality should first be understood to ensure relevancy and to develop realistic performance and impact targets. The limitations of the CWF method (and other treatment alternatives) must also be well understood during the design and decision-making phase.

Future research is needed to assess the performance and use CWFs in non-boreholes and high turbidity settings. Pre-treatment techniques such as cloth filtration or *stand-and-settle* may sufficiently remove large turbidity particles prior to loading of the CWF. Such practices should be explored in relevant contexts to ensure sufficient flow rates, high user satisfaction, and continued use.

Efficacy and performance of the CWFs produced in Myanmar should be formally evaluated as part of a controlled laboratory study and covering a range of measurable pathogen indicators. If the CWFs are likely to be scaled-up in Myanmar in the future, and potentially marketed as consumer good (as in other countries such as Cambodia), the government and development partners should eventually consider a formal mechanism for regulation and monitoring of production quality. International CWF networks and working groups, and a national NGO are available to assist with such endeavors.

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List of Acronyms

CFU	Colony forming units
CI	Confidence interval
CWF	Ceramic water filter
DHS	Demographic Health Survey
FC	Fecal coliforms
HWTS	Household water treatment and safe storage
IDP	Internally displaced people
NGO	Non-governmental organization
OCHA	Office for the Coordination of Humanitarian Affairs
OR	Odds ratio
PDM	Post-distribution monitoring
RPD	Relative percent difference
WASH	Water, sanitation, and hygiene

1. Introduction

This chapter details the background, rationale, aims, and objectives of the Ceramic Water Filter (CWF) field assessment conducted in November and December 2015 in Rakhine State, Myanmar. The field assessment is part of a greater CWF review conducted from October 2015 to January 2016 by an independent consultant for the Myanmar WASH cluster.

1.1 Background

Diarrheal disease and related illnesses are reportedly the second most common cause of mortality among children under the age of 5 worldwide – contributing to 11% of all deaths within the age group [(1),(2)]. In emergency and humanitarian contexts, diarrheal diseases are among the main causes of all-age morbidity and mortality. In the early phases of humanitarian emergencies, diarrheal diseases have shown to be responsible for up to 40% of all deaths – the majority of which are among young children (3). Exposure pathways to disease-causing pathogens can result from:

- Poor drinking water quality
- Insufficient water quantity
- Inadequate sanitation facilities and practices
- Poor hygiene practices

In the aftermath of a humanitarian crisis, overcrowding and the lack of adequate supplies and facilities can increase the frequency of exposures and subsequent incidents of disease.

Household Water Treatment and Safe Storage (HWTS) can achieve improvements to the quality of drinking waters at the point-of-consumption and reduce incidences of diarrheal disease [(4),(5)]. HWTS has also been employed in emergency and post-emergency settings in combination with other Water, Sanitation, and Hygiene (WASH) interventions to break exposure pathways [(6),(7)].

Ceramic Water Filters (CWFs) represent one of several HWTS methods that have been developed and promoted in various developing countries around the world [(8),(9),(10)]. CWFs have been proven to improve the quality of drinking waters when produced and used properly. Like all HWTS options, CWFs have advantages and disadvantages that must be well understood to ensure effective use and performance. Training and promotion of the CWFs among new users is vital towards ensuring that they are valued by the household and that they will be used and maintained correctly to ensure performance.

CWFs have been produced and promoted in Myanmar for almost one decade. Three factories near Yangon are operational at the time of writing - operating privately by selling CWFs to agencies and NGOs working on development or humanitarian projects.

Rakhine State has a population of approximately 3 million people and is among the poorest regions in Myanmar. Rakhine has by far the lowest access to sanitation (32%) and improved drinking water supply (38%) of all the regions in the country (11). Nearly 60% of rural residents in the State rely on surface water as their main drinking water supply. This situation may be due at least in part to saline coastal aquifers in some areas that render groundwater non-potable. Centralized treatment and distribution options are generally not feasible. Prevalence of diarrheal disease in this region is not well characterized and documented, however this may be resolved in the future with the ongoing national 2015 Demographic and Health Survey (DHS).

In 2012, inter-communal conflict between ethnic Rakhine and ethnic Muslim groups erupted resulting in the movement of Internally Displaced People (IDPs) into camps, within their own communities, and into hosting communities. Many surrounding villages have also been affected by the crisis. Agencies engaged in the humanitarian response have identified WASH as a priority programme area to support the health and livelihoods of affected populations. Many agencies are involved in WASH programmes throughout the affected area – with a coordination and knowledge sharing platform arranged through a WASH cluster. To address access to safe drinking water, the WASH cluster agencies have engaged in water source-level and household-level interventions including drilling boreholes, protecting ponds, conducting hygiene education, and distributing Household Water Treatment (HWT) products. Initial HWT interventions consisted of chlorination of water at the water point and that stored at the household. Eventually this was found to be generally inefficient and unsustainable due to the abundance of water points and dissatisfaction with the taste and smell of chlorinated waters. CWFs were subsequently trialed and promoted with the hope of addressing the disadvantages associated with chlorine treatment. Distribution of CWFs and activities to support their promotion and monitoring have been ongoing in recent years by at least eight agencies with approximately 25,000 filters deployed throughout affected camps and villages in the State (12). Populations affected by strong winds and floodwaters due to Cyclone Komen in July 2015 have been similarly supported.

1.2 Rationale

WASH cluster agencies (including SCi, Oxfam, SI, ACF, RI, and Malteser) have been assessed the performance of their CWF distribution activities by collecting Post-Distribution Monitoring (PDM) data. The PDM data collected to-date has been limited in scope and depth and cannot not describe the overall performance of CWF interventions representative of the coverage area as a whole. Additionally, potential data collection bias and quality control issues have been raised by the agencies involved with regard to surveying techniques and water testing. As a result, the Rakhine WASH cluster decided in 2015 to initiate a thorough review of CWF distribution and monitoring activities. One component of this review is a household assessment among those that received a CWF. This report details the background, rationale, objectives, methodology, results, and recommendations of the CWF assessment conducted in November and December 2015 in Rakhine State, Myanmar.

1.3 Aims and objectives

The aim of the study is to characterize the use and performance of CWFs distributed and promoted in the context of the protracted emergency situation in Rakhine State, Myanmar. The objectives are to determine the proportion of CWFs that remain in use over time since distribution – while characterizing factors associated with disuse and CWF performance in terms of the quality of pre-treated and post-treated waters. The secondary objectives of this study are to examine knowledge, attitudes, and practices towards the CWF and examine potential factors and variables that may be associated with use.

The study and its findings are intended to inform future strategies to address access to safe drinking water in the protracted emergency context of Rakhine as well as CWF distributions or promotion initiatives associated with current and future humanitarian response in other parts of the country.

2. Methodology

This chapter details the methodology on how the CWF assessment was designed and conducted. It is compiled into the following sub-sections: study type, location and target population; site selection and sampling; household selection; measurement of variables and outcomes; data collection and management; and ethical considerations.

2.1 Study type, location, and target population

The assessment was conducted using a cross-sectional design to characterize at a single point in time a representative sample of households that previously received a CWF. The target area for the study included IDP camps and villages within Rakhine State that were affected or in the vicinity of those affected by the humanitarian crisis and where CWF delivery and promotion have already occurred. Therefore the results represent a snapshot of the post-distribution situation as of late-2015.

2.2 Site selection and sampling

The WASH cluster maintains a dataset of all camps and affected/surrounding villages where agencies are actively engaged in humanitarian response activities in Rakhine State. This dataset presents various WASH-related activities that have been conducted at each site and respective coverage rates (12). The dataset is comprised of 284 camp and village sites with a total population of approximately 400,000 people and spread across 11 of Rakhine State's 17 townships.

Of the 284 sites, CWF distributions have occurred at 67 (24%). Of these 67 sites, 54 of them (81%) experienced blanket CWF distributions – meaning that 100% of households have reportedly received a filter.

Approximately 85% of the population *directly* affected by the humanitarian crisis reside in two of the eleven intervention townships – namely Sittwe and Pauktaw townships. Additionally, 76% and 8% of all CWF distributions in Rakhine State have occurred at sites in Sittwe and Pauktaw townships, respectively – followed by Rathedaung (7%), Minbya (3%), and several other townships with very low coverage. Sittwe and Pauktaw townships are geographically situated close to Sittwe town – the capital of Rakhine State (Figure 1).

Figure 1 – Map of Rakhine State and its townships

The survey sampling approach and design were largely guided by the availability of human resources to serve as interviewers and data collectors, along with the maximum water-testing throughput of the local laboratory facility utilized for the study. Field interviewers were recruited from existing WASH cluster agency staff to ensure permissions to enter the selected sites and ensure sensitivities were maintained. After thorough discussions with participating and supporting WASH cluster agencies – it was determined that the maximum commitment of human resources could include six teams interviewers available for seven days of data collection. Additionally, the laboratory could process a maximum of 120 plates (60 water samples tested in duplicate) per day. The duration of questionnaire administration, travel to/from the prospective sites, and maximizing statistical power and sample size, were also carefully considered when designing the sampling strategy.

Considering the aforementioned factors and constraints, three site selection criteria were established to narrow down the list of 67 sites that participated in CWF distributions, as follows:

1. 100% of the households at the site received CWFs;
2. Sites located in Sittwe or Pauktaw townships;
3. Total population size of the site is greater than 500 people.

After applying these site selection criteria, 28 prospective sites were identified. This list was further refined as several sites had begun recent relocation back to pre-conflict homes and villages, would have presented extreme logistical/access challenges to interviewers, or would not have been welcoming to external data collectors from agencies that they did not have a relationship with. After these additional exclusions, 24 candidate sites remained, as characterized in Table 1.

Table 1 - Characterization of the eligible study sites

	%/No.
Site location (by population)	
Sittwe	90.2%
Pauktaw	9.8%
Site location (by # of sites)	
Sittwe	21 sites
Pauktaw	3 sites
Site location type (by population)	
Camp	70.1%
Village	29.9%
Site location type (by # of sites)	
Camp	12 sites
Village	12 sites
Site ethnicity (by population)	
Rakhine	8.3%
Muslim	91.7%
Site ethnicity (by # of sites)	
Rakhine	6 sites
Muslim	18 sites

The estimated number of households residing within the eligible study sites (target population) is approximately 17,500. It was estimated that each data collection team could feasibly survey 8 households per day over the 7 workdays. Therefore the maximum achievable sample size for six teams of interviewers was calculated to be 336 households. This sample size represents approximately 2% of all the households within the study area.

Considering a confidence interval of 95% and a sample size of 336 households among a target population of 17,500 households, this translates into a survey margin of error of 5.3%. This means that if the survey were repeated 100 times, in 95 of those surveys the observed results would be within ±5.3% of the true result. For example, if the percentage of households that stopping using a CWF were found to be 50%, then we would be 95% confident that the actual percentage of users that stopping using would be between 44.7% and 55.3%.

To determine which among the 24 sites would be selected for data collection, and the exact number of households to be surveyed in each selected site, the sample size of 336 was divided into 42 clusters of 8 households (each cluster representing one full day of work for one survey team). These 42 clusters were randomly assigned to the 24 target sites in such a way that the probability of a cluster being assigned to a site was proportional to size of the population of each site. This essentially means that sites with a larger population were more likely to be assigned a cluster. After conducting the cluster randomization, 16 of the 24 sites were randomly assigned at least one cluster, with total sample sizes and site details presented in (Table 2).

2.3 Household selection

Within the randomly selected sites, household selection was performed differently for camps and villages. For each selected *camp*, a list of all shelter and room numbers was obtained in advance from the Office for the Coordination of Humanitarian Affairs (OCHA). Sufficient numbers of shelters/households were randomly selected for each camp site up to the allocated sample size (Table 2).

For each selected *village*, the total number of households was obtained in advance. This total was divided by the allocated sample size for the village to calculate a sampling interval. Data collection teams travelled to the center of the village, spun a pen to determine a random starting point, and then systemically proceeded to count house-by-house through the sampling interval to randomly identify the next household to administer the survey. This process was repeated until the total sample size for the village was achieved.

Table 2 – Characterization of randomly selected sites

Nº	Township	Sites (in alphabetical order)	Population	Type	Months since CWF distribution	Wash focal point agency	# of clusters randomly assigned	# of samples assigned
1	Sittwe	Ah Lar Than Village	1,286	Muslim	14	ACF	1	8
2	Sittwe	Basara Camp	1,980	Muslim	12	SCI	1	8
3	Sittwe	Baw Du Pha Camp	10,827	Muslim	10	SI	6	48
4	Sittwe	Dar Pai Camp	10,663	Muslim	12	SI	3	24
5	Sittwe	Hmansi (from Kaung Doke Khar) Camp	1,982	Muslim	12	SI	2	16
6	Pauktaw	Kyein Ni Pyin Camp	4,861	Muslim	16	DRC	4	32
7	Sittwe	Nga/ Pun Ywar Gyi Village	1,418	Muslim	14	ACF	1	8
8	Sittwe	Ohn Taw Gyi North Camp	14,216	Muslim	12	SCI	9	72
9	Sittwe	Phwe Yar Gone Camp	2,115	Muslim	16	DRC	1	8
10	Sittwe	Say Tha Mar Gyi Camp	12,064	Muslim	14	Oxfam	6	48
11	Pauktaw	Sin Tet Maw (Host) Village	3,634	Muslim	12	SCI	1	8
12	Sittwe	Thea Chaung Camp	5,446	Muslim	12	SI	1	8
13	Sittwe	Thea Chaung Village	716	Rakhine	12	SI	1	8
14	Sittwe	Thet Kel Pyin Camp	5,974	Muslim	13	SCI	2	16
15	Sittwe	Thet Kel Pyin Village	13,367	Muslim	12	SCI	2	16
16	Sittwe	Thin Pone Tan Village	1,231	Rakhine	14	ACF	1	8
		Total:	**91,780**	**-**		**-**	**42**	**336**

It was anticipated that not all randomly selected households would participate in the survey and such cases are referred to as '*non-response*'. Justifications for non-response could include:

1. Nobody at home
2. Household never actually received a CWF
3. Respondent refuses to participate
4. Available household members do not meet the eligibility requirements

When a case of non-response was encountered, interviewers were instructed to replace the non-responding household with the next nearest household. Re-visitations of non-responding households were not prescribed due to strict time limitations associated with the study.

A candidate respondent at a randomly selected household was considered to be eligible to serve as a respondent if they met the following conditions:

1. Age was greater or equal to 18 years;

2. Lived at the household for the majority (approximately more than 80%) of the time over the past year;
3. Was generally familiar with the day-to-day water collection and treatment practices at the household.

2.4 Measurement of variables and outcomes

Each selected and eligible household was interviewed using a digitally based quantitative household questionnaire covering the following topics:

- Respondent and household attributes;
- Household roster including completed levels of education and recent incidences of diarrhea for each member;
- Drinking water supplies and drinking water treatment practices;
- CWF distribution and related education/training;
- Knowledge of best practices;
- Frequency and duration of CWF use;
- Perceptions, satisfaction, and practices;
- Visual observation of the CWF and water sample collection.

The final household questionnaire in Myanmar and English language is presented in Annex A.

A rapid socio-economic assessment was conducted for each household by the interviewer based on a visual observation of the shelter and its contents. Interviewers were instructed to observe the household shelter (roof, walls, floor), inquire about transportation options, and to rank overall household wealth on a four point scale (high, medium, low, lowest).

Incidences of self-reported diarrhea were characterized over a time period of seven days preceding the day of the survey and using a Bristol Stool Chart to ensure consistency of definition. The respondent answered on behalf of all household members.

The respondent was asked how long ago the CWF distribution occurred, but this was only used as a crosscheck against reported distribution dates from the agencies themselves (which were considered to be more accurate). Analysis of CWF lifespan (duration of use) was determined using the month of distribution reported by the agency for each site. For *previous users*, usage duration was determined based on the self-reported number of months since CWF use ended.

For the purposes of the survey *use of the CWF* was defined as filling the CWF pot with water and drinking the water that had passed through the filter. *Current users* were defined as households that *used* the CWF at least one time during the seven days preceding the survey. *Previous users* were those that used the CWF for a time, and then stopped. *Never users* were those that never began using the CWF.

Fecal coliforms (FC) – also known as thermotolerant coliforms - live in the digestive tract of warm-blooded animals such as humans, and are the most common microbiological contaminant of water. Most FCs do not actually cause disease in humans, but their presence in a drinking water system indicates that contamination has occurred and exposure to disease causing organisms may be possible (13). FCs are comparatively easy and affordable to test and detect than other microbiological parameters, and their analysis and quantification is commonly used to measure the microbial quality of water. Some WASH cluster agencies operate equipment and have trained technicians for FC testing, including a centralized laboratory currently operational at the SCi Sittwe office. As such, FC was selected as the parameter to measure microbiological quality of water for the purpose of this study.

Water samples were analyzed for FCs using Delagua © membrane filtration test kits at the SCi Sittwe laboratory. Protocols and procedures for water analysis followed the same day-to-day methods employed at the laboratory – which included the those prescribed by Delagua (Annex C). An initial check of the laboratory and testing procedures was undertaken to confirm its validity. Water samples were collected (Day 1), stored overnight in a refrigerator at 4°C, filtered and incubated (Day 2), after which colonies were counted (Day 3).

Just prior to filtration, sample bottles were shaken for a several seconds to mix the contents thoroughly. Sample volumes of 100mL were filtered in duplicate less than 24 hours from the time of sample collection and plated onto culture media. Filtration equipment was sterilized between samples in accordance with Delagua methods (Annex C). Plates were incubated at 44 degrees Celsius for 16 hours after which FC colonies visually counted. Counts were recorded on standardized log sheets. Plates with more than 100 colonies were marked as '*too numerous to count*' and assigned a value of 100 cfu/100mL for the purpose of analysis*.* The final concentration of FC for each sample was reported as the average of the two duplicate results. Laboratory blank tests were performed using (in the absence of lab-grade sterilized water) locally available bottled water at every 20 water samples processed to ensure that cross-contamination between samples was being avoided and sterilization practices were thorough.

2.5 Data collection and management

Design of the household questionnaire was supported by the *"Toolkit for Monitoring and Evaluating Household Water Treatment and Safe Storage Programmes"* (14). The questionnaire was translated into Myanmar and back translated to English to resolve any translation errors and ambiguities in the terms and definitions.

A team of two people consisting of either one male and one female or two females, were responsible for administering the household questionnaire to respondents. This gender arrangement was designed to ensure security and safety and so that each team had at least one female interviewer present. For Muslim households, males that are not household members are typically not able to enter the household. Therefore to collect water samples and inspect the CWF, each team was required to have at least one female interviewer.

Administration of the survey was performed in the Myanmar language unless the respondent could not communicate sufficiently in Myanmar. In such cases, the interviewer posed the questions in the local Muslim language. Interviewer groups were composed so as to balance Muslim language speakers across the groups. Two groups did not have any fluent Muslim speakers and were connected with the local WASH agency focal point at respective sites, who were able to provide translation assistance, as needed.

The household surveys were administered using portable electronic tablets. The questionnaire was digitized and skip-patterns and responses setup using a software application called KoboToolbox (http://www.kobotoolbox.org) – a free suite of data collection tools developed for challenging environments and humanitarian situations. The electronic export file of the questionnaire in Annex D can be used to import the questionnaire back into the Kobo interface for future use and/or revision. At the end of each field day, data from each of the tablets was uploaded into the Kobo platform and compiled for review and checking.

Water samples were collected for households meeting the following requirements:

- Household currently uses the CWF;
- Respondent allows the interviewers to collect a sample;
- Household demonstrated correct and complete setup of the CWF;
- Filtered water is available in the plastic bucket at the time of visit.

In such cases, the interviewer would be directed by the electronic questionnaire to collect a pre-treatment and post-treatment water sample for subsequent analysis of FCs. Before interviewers collected a sample, they first sterilized their hands using hand sanitizer. Sample bottles consisted of locally available drinking water bottles that remained closed and sealed until the time of sample collection. Sample bottles were pre-labeled using a unique 3-digit code. When the interviewer was ready to collect a sample, the sample bottle was opened and the contents were discarded. Then the bottle was rinsed one time with sample water before sample collection. Sample water was filled to approximately ¾ of the bottle volume to ensure air space for shaking and mixing at the laboratory and sufficient sample volume for duplicate analysis (minimum 200mL).

Treated water samples were collected only from the CWF tap and it was verified with the respondent that the waters were in fact post-filtered. Interviewers ensured that the sample bottle did not make contact with the tap during collection.

Untreated water samples were collected from the source of water used to fill the CWF pot. If the household did not have untreated water available at the household, no untreated water sample was collected. The sample ID on the sample bottles was subsequently recorded in the digital questionnaire. Sample bottles were also labeled as being collected in the morning or the afternoon – to assist with processing and prioritization in the laboratory.

Once a sample was collected, the sample ID code was also recorded on a sample tracking log-sheet. This log-sheet served to inform interviewers when they needed to collect special quality control samples – including field duplicates and field blanks. Field blank samples were collected by transferring locally produced and bottled drinking water into a sample bottle while at the household (simulating the sampling process and any environmental exposures). Field blank samples and field duplicate samples were collected for every 20 households surveyed. All samples were stored in a cooler with ice and returned to the laboratory at the end of the day where they were stored in a refrigerator overnight until processing the next day.

Data was automatically digitized at the time of entry into the tablet using the KoboToolkit interface. Upon the completion of data collection, the data were checked and cleaned for erroneous values and entries – any of which were subsequently coded as missing data or corrected appropriately. Data was analyzed using STATA 12©. Tables and graphs were produced using STATA and Microsoft Excel ©.

Data collection was conducted according to the fieldwork plan presented in Annex B.

In addition, two focus group discussions were conducted in one camp location – one with a group of CWF users and the other with a group of former users. The purpose of the discussion was to gather qualitative insights on perceptions, attitudes, beliefs, and feelings related to CWF use and reasons for current disuse.

2.6 Ethical Considerations

Informed consent was secured from all agreeing respondents prior to administration of the survey. Confidentiality was maintained as survey data were de-identified after data collection and the dataset was stored on a secure computer. Ethical approval of the study was received through UNICEF's internal ethics mechanisms.

2.7 Recruitment and training of human resources

Eleven staff were assigned by various participating and supporting WASH cluster agencies to serve as interviewers for the assignment. All interviewers participated in a 3-day training covering the following components:

- Background and rationale for the assessment;
- Data collection using a tablet;
- Assessment protocol including ethical procedures;
- Assessment household questionnaire;
- Ethical survey practices.
- Classroom practice;
- Field practice.

Four laboratory technicians were assigned by various participating and supporting WASH cluster agencies. Their responsibilities were to log-in water samples received from the field teams upon arrival to the laboratory, analyze water samples for FCs, and conduct data entry of water testing results. The technicians were oriented on the CWF assessment, any special procedures for the assessment, and the roles and responsibilities of all stakeholders involved.

3. Results

Data collection was conducted from November 27 to 28 and November 30 to December 4, 2015. A total of 338 households were surveyed, two more than the prescribed sample size of 336 households as there may have been cases where interviewers lost count of the number of households completed. This section details the results of the assessment, grouped by: summary of CWF use; characteristics of the surveyed households; water supply and drinking water treatment; CWF distribution, education/training, and knowledge and perceptions; characterization of non-CWF users; factors associated with CWF disuse; and characterization of current CWF users.

3.1 Summary of CWF use

Current users were defined as those households that *used* the CWF at least one time in the past 7 days – of which there were 210 households [62% of all surveyed households – 95% Confidence Interval (CI): 57-67%]. The remaining households (38%) comprised of *never users* (14%: 95% CI 11-18%) or *former users* (24%: 95% CI 19-29%) as visualized in Figure 2.

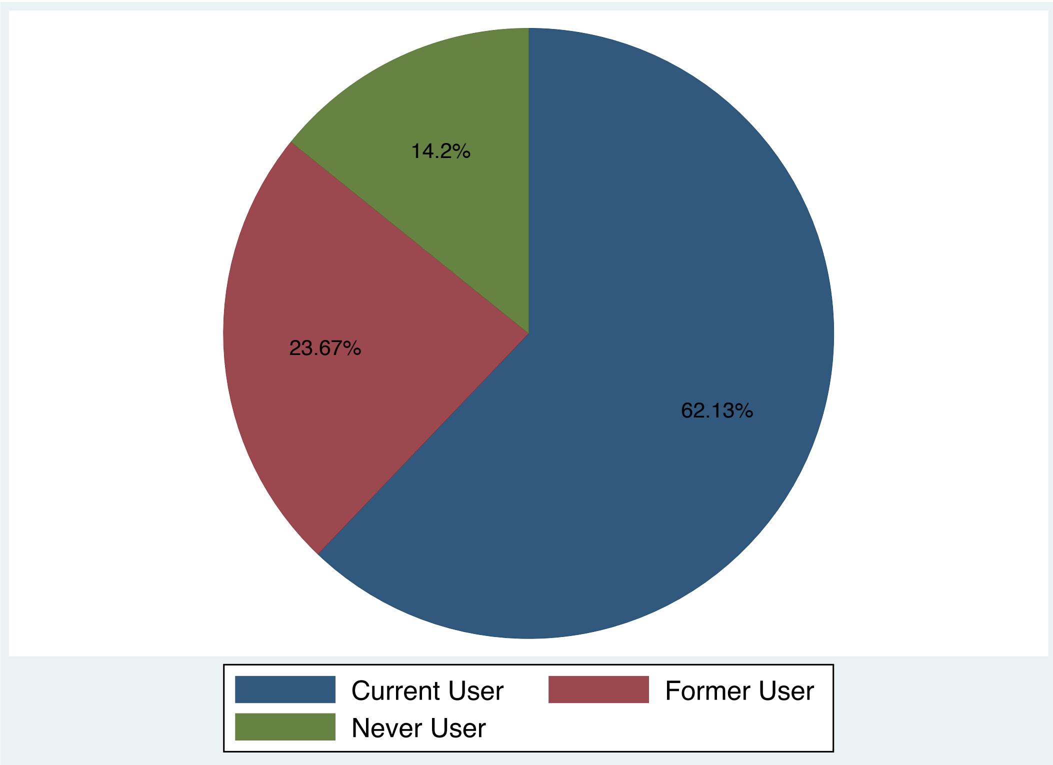

Figure 2 – Characterization of households by CWF use (n=338)

3.2 Characterization of surveyed households

Table 3 describes household and respondent characteristics grouped by current, former, and never users.

Table 3 - Characteristics of surveyed households and respondents

	All households (n=338)		Current CWF users (n=210)		Former CWF users (n=80)		Never CWF users (n=48)	
	n	**%**	**n**	**%**	**n**	**%**	**n**	**%**
Gender of respondent								
Female	286	85	174	83	70	88	42	88
Male	52	15	36	17	10	13	6	13
Site type								
Camp	282	83	181	86	71	89	30	63
Village	56	17	29	14	9	11	18	38
Location								
Sittwe	298	88	194	92	66	83	38	79
Pauktaw	40	12	16	8	14	18	10	21
Literacy of primary HH caretaker								
Literate	100	30	75	36	13	16	12	25
Illiterate	238	70	135	64	67	84	36	75
Socio-economic status								
High	13	4	9	4	1	1	3	6
Medium	108	32	76	36	18	23	14	29
Low	193	57	114	54	49	61	30	63
Very low	24	7	11	5	12	15	1	2
Household size								
Big (8-10 people)	54	16	36	17	14	18	4	8
Medium (5-7 people)	197	58	125	60	48	60	24	50
Small (1-4 people)	87	26	49	23	18	23	20	42
Diarrhea among any household members (all ages)								
Yes	18	5	14	7	3	4	1	2
No	320	95	196	93	77	96	47	98
Diarrhea among household members <5 years old								
Yes	10	3	7	3	2	3	1	2
No	328	97	203	97	78	98	47	98
Highest completed education								
High (More than high school)	11	3	7	3	1	1	3	6
Medium (Grade 8-12)	72	21	50	24	9	11	13	27
Low (Grade 4-7)	104	31	73	35	23	29	8	17
Very low (None-Grade 3)	151	45	80	38	47	59	24	50
Primary drinking water supply								
Borehole	279	83	182	87	64	80	33	69
Non-borehole	59	18	28	13	16	20	15	31
Treatment of drinking water in the past year								
Yes	280	83	188	90	69	86	24	50
No	58	17	22	11	11	14	24	50
Water treatment methods in past year								
CWF	201	72	169	90	30	44	2	8
Cloth	49	18	3	2	33	48	13	54
Boil	23	8	15	8	3	4	5	21

	All households (n=338)		Current CWF users (n=210)		Former CWF users (n=80)		Never CWF users (n=48)	
	n	%	n	%	n	%	n	%
Other	7	3	0	0	3	4	4	17
Frequency of drinking untreated water in past year								
Always	57	17	22	11	11	14	24	50
Usually	4	1	3	2	0	0	1	2
Sometimes	10	3	6	3	0	0	4	8
Rarely	143	43	84	41	49	61	10	21
Never	117	35	88	43	20	25	9	19
Time since CWF received								
Shorter (10-12 months)	210	62	149	71	42	53	19	40
Longer (13-16 months)	128	38	61	29	38	48	29	60
Any CWF education/training received	325	97	203	98	79	99	43	90
Any CWF education/training received at the household	274	85	178	88	67	86	29	67
Number of household CWF trainings								
High (3-30 sessions)	69	54	46	52	15	63	8	50
Low (1-2 sessions)	59	46	42	48	9	38	8	50
Duration of household CWF trainings								
Long (30-70 min)	106	62	80	67	19	51	7	50
Short (10-29 min)	64	38	39	33	18	49	7	50
Total household-based CWF training time								
Long (61-480 min)	64	57	46	55	13	68	5	46
Short (10-60 min)	49	43	37	45	6	32	6	55
Any education/training received in a group	292	95	184	94	71	95	37	97
Number of group education/trainings								
High (2-10 sessions)	106	44	71	46	31	63	4	11
Low (1 session)	133	56	84	54	18	37	31	89
Duration of group education/trainings								
Long (60-240 min)	178	62	114	62	39	58	25	69
Short (15-59 min)	108	38	69	38	28	42	11	31
Total group CWF education/training time								
Long (120-600 min)	145	61	100	65	35	73	10	29
Short (15-59 min)	91	39	54	35	13	27	24	71
Group size of CWF education/training								
Big (50-250 participants)	80	28	49	27	11	16	20	56
Medium (25-49 participants)	107	37	78	42	22	33	7	19
Small (5-24 participants)	100	35	57	31	34	51	9	25
Total CWF education/training time								
High (150-840 min)	90	58	64	62	18	67	8	32
Low (15-149 min)	66	42	40	39	9	33	17	68

Most of the survey respondents were female (85%) with an average respondent age of 37 years and a range from 18 to 81 years old. The majority of households resided in camps (83%) and in Sittwe township (88%). Comparing the results from the surveyed households to the characterization of the target population in Table 1, the random selection of clusters appears to have marginally under-represented households that reside in villages.

The majority of households had low socio-economic status (57%) based on visual inspection of the household and its assets as conducted by the interviewers. The average household size was 5.7 members with a range from 1 to 10 members.

In the majority of households, the primary caregiver (defined as the person most responsible for day-to-day activities in the household) was not literate (70%). The highest level of completed education among all household members was typically low (31%) or very low (45%) with 17% of households without a member possessing any completed formal education.

The presence of any household member exhibiting recent (over the past 7 days) diarrhea was reportedly very rare at 5%. The overall incidence rate of diarrhea among all household members over the past 7 days was 0.9% (18 cases among 1,935 total household members within the 338 households). Diarrhea was defined as Type 7 on the Bristol Stool Chart as shown and explained to each respondent during the survey. The majority of the cases of diarrhea were among children under 5 years old (56% - 10 out of 18 cases).

3.2.1 Water supply and drinking water treatment

Figure 3 characterizes primary household drinking water supplies used over the past year for the wet and dry seasons. Boreholes are overwhelmingly the most common water supply used for drinking in both the dry and wet seasons (over 80% of all households). Surface water and dug wells are less common and overall there is very little difference between dry and wet season water supply practices. These figures differ significantly from the water supplies used by the general township populations, whereby only 19% and 0.4% of Sittwe and Pauktaw township residents rely on boreholes as their main source for drinking water, respectively (11). Boreholes are therefore likely to be an intervention related to humanitarian activities supported by donors and agencies and may not be attainable for the general population at large. These contrasting water supply figures could also in part be due to the fact that camp populations were not included in the National Census which served as the data source for the general population.

Few households reportedly rely on secondary water supplies in the dry (1%) and wet seasons (5%). Fourteen households used rainwater as a secondary supply in the wet season.

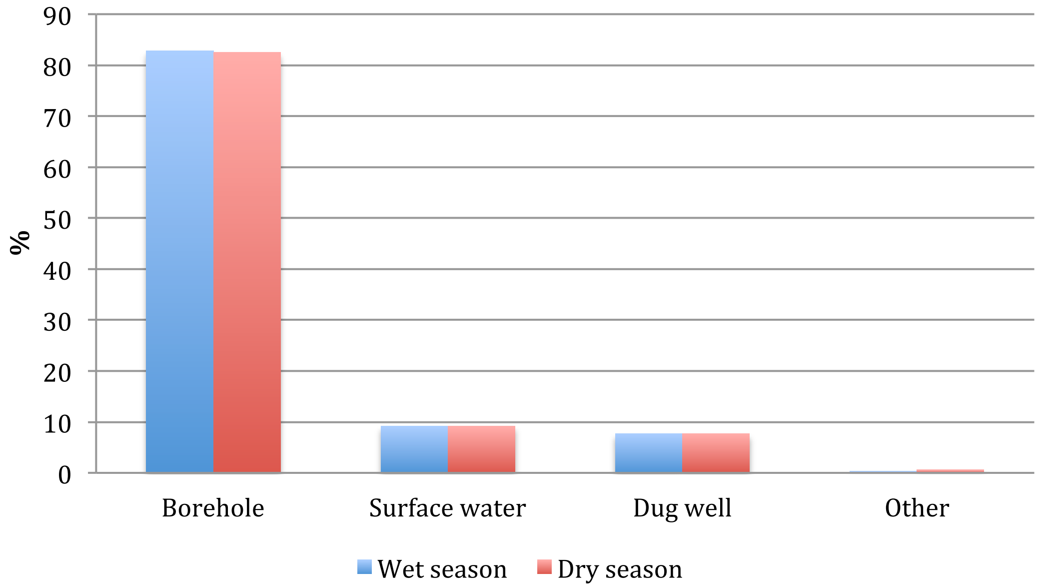

Figure 3 – Dry and wet season primary drinking water supply

Over the last wet and dry season, 83% of households reportedly practiced some method of HWT. Figure 4 presents the distribution of reported HWT methods over the past year.

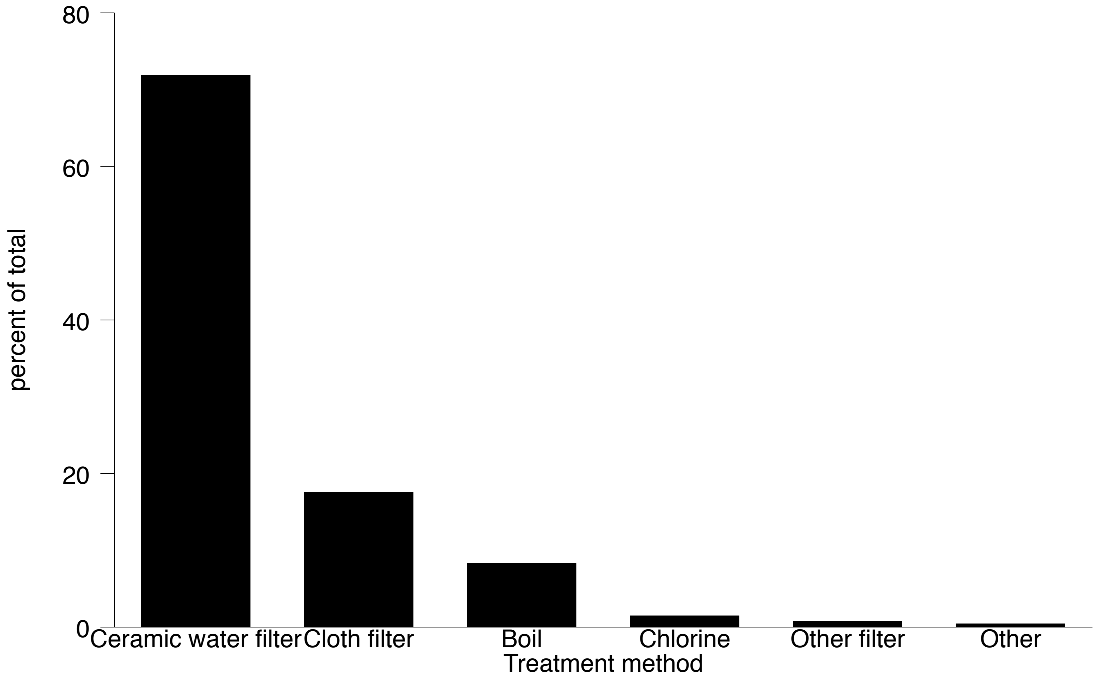

Figure 4 – Primary drinking water treatment method in the past year

As the survey is only inclusive of households that received a CWF, as expected the overall use of a CWF for water treatment over the past year was reportedly high (72%), followed by cloth filtration (18%) and boiling (8%).

Similarly, households did not report substantial differences in the frequency of consuming untreated drinking water between wet and dry seasons – the results of which are shown in Figure 5.

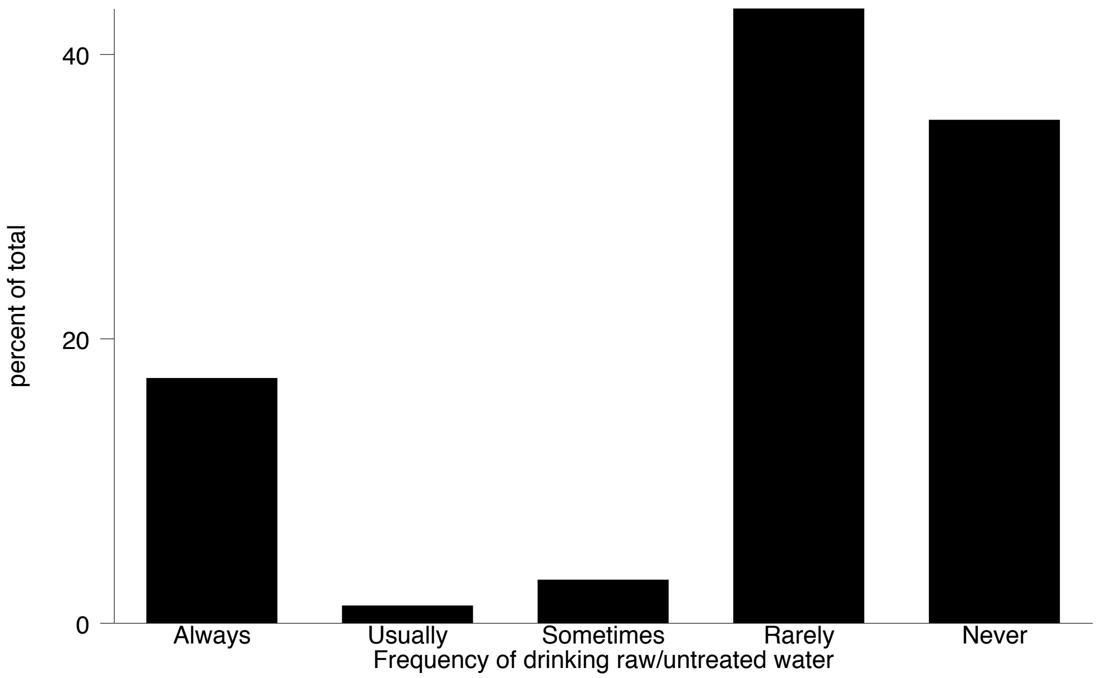

Figure 5 – Year-round frequency of drinking untreated water

Most households report rarely or never drinking raw/untreated water – with the exception of course being the households that reportedly do not practice any method of drinking water treatment – who always drink raw water (17%).

As reported in Table 3, 11% of current CWF users reported always drinking raw water during the past year, indicating that there may have been some confusion with this question among the interviewers and/or respondents.

3.2.2 CWF distribution and education/training

Agencies responsible for WASH activities at each surveyed site reported the time since the CWFs were distributed to households, as shown in Figure 6 - ranging from 10 to 16 months with an average of 12.7 months. Nearly all households reportedly received all of the correct components of the CWF kit, including plastic bucket with lid (100%), hand brush (99%), and instructions (97%).

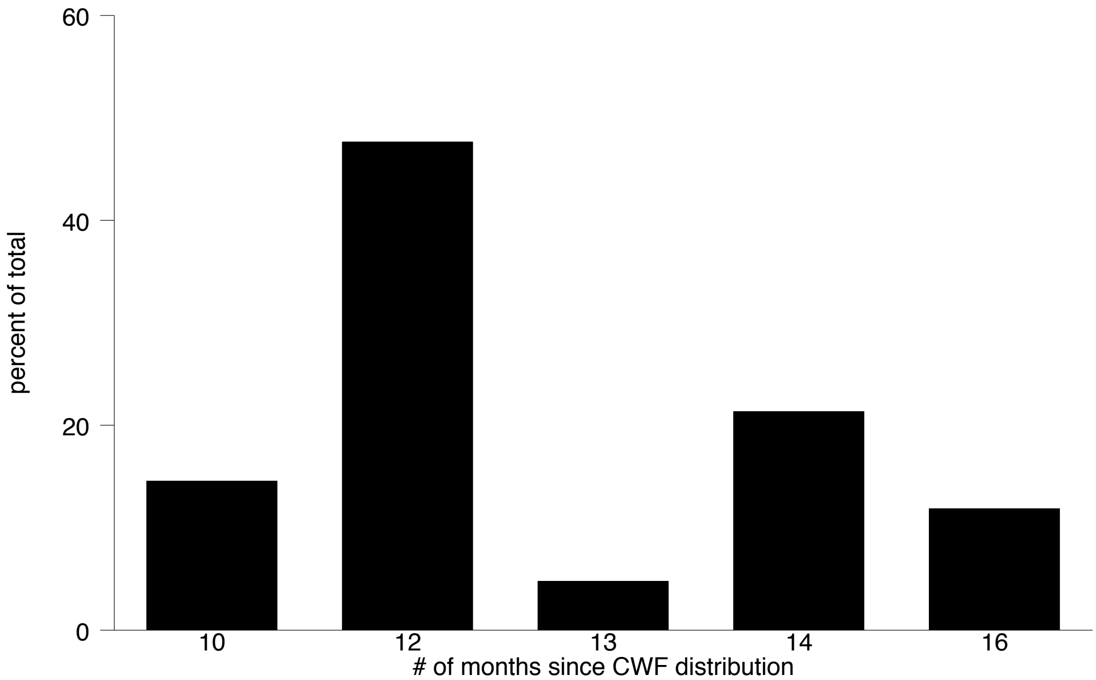

Figure 6 – Time since CWF distribution at each of the 16 survey sites

Respondents were asked to recall and characterize CWF training/education sessions or meetings that any members of the household participated in during or after CWF distribution (Table 3). Most households (97%) reported that they received some format of externally provided training on the CWF – with 85% of households reporting at least one activity occurring at their household and 95% attending at least one group session.

Most respondents that received household-level training *could not* approximate how many sessions they participated in. However, among those that could remember, the average number of household sessions was 3.4. The average duration of the training at the household was 32 minutes. The average duration of all household-level trainings combined was 100 minutes per household (n=113).

Most households that received group-based training *could* remember approximately how many sessions they participated in. The average number of group sessions was 2.6 and the median was 1. The average duration of a group session was 58 minutes with an average number of participants of 39 people. The average total duration of all group-level trainings participated by a household was 140 minutes (n=236).

Considering both the household and group level education/training sessions combined, the average total training time was 192 minutes per household (n=156). Households that could not recall the respective duration or frequency of both the household or group trainings were excluded from analysis. Also assessed were the respondent's confidence of how to use and operate the CWF as well as knowledge of best practices (Table 4).

Table 4 – Post-training perceptions and knowledge of CWF

	Response n (%)	
	Yes n (%)	No n (%)
Confidence about how to use CWF	333 (98.8)	4 (1.2)
Confidence about how to clean CWF	332 (98.8)	4 (1.2)
Trusting that the CWF provides safe water	334 (99.4)	2 (0.6)
Correct understanding about the location of the CWF pot	337 (99.7)	1 (0.3)
Correct understanding about the location to put the raw water	320 (94.7)	18 (5.3)
Correct understanding about the purpose of the CWF pot	304 (89.9)	34 (10.1)
Correct understanding about the location of stored water	329 (97.3)	9 (2.7)
Correct understanding about the purpose of the plastic bucket	326 (96.5)	12 (3.6)
Correct understanding about the purpose of the plastic lid	332 (98.2)	6 (1.8)
Correct understanding about the purpose of the tap	337 (99.7)	1 (0.3)
Correct understanding to use brush to clean CWF pot	337 (99.7)	1 (0.3)
Correct understanding to not use soap to clean CWF pot	305 (90.2)	33 (9.8)

Confidence on the knowledge of how to operate and maintain the CWF was extremely high, as was trust that it provides safe water. Knowledge of CWF functionality and operation was also very high for all categories, the lowest among which were knowledge of the purpose of the CWF pot (90%) and knowledge that soap should *not* be used to clean it (90%).

3.3 Characterization of former and never users

After receiving the CWF, 48 households (14%) reportedly never used it. Self-reported reasons for households never using the CWF are detailed in Figure 7. The most common reason why the CWF was never used was because the pot was broken (56%), followed by slow flow rates (13%), and a bad smell from the pot or from the water (8%). Other reasons included not being interested to use it, unpleasant water color, the CWF was given away or sold, or the number of household members was too high for one filter. It is unclear whether the CWF pot as actually broken once received by the household or whether this was a false answer provided to the interviewer because the respondent did not want to admit that they were responsible somehow for not using the CWF.

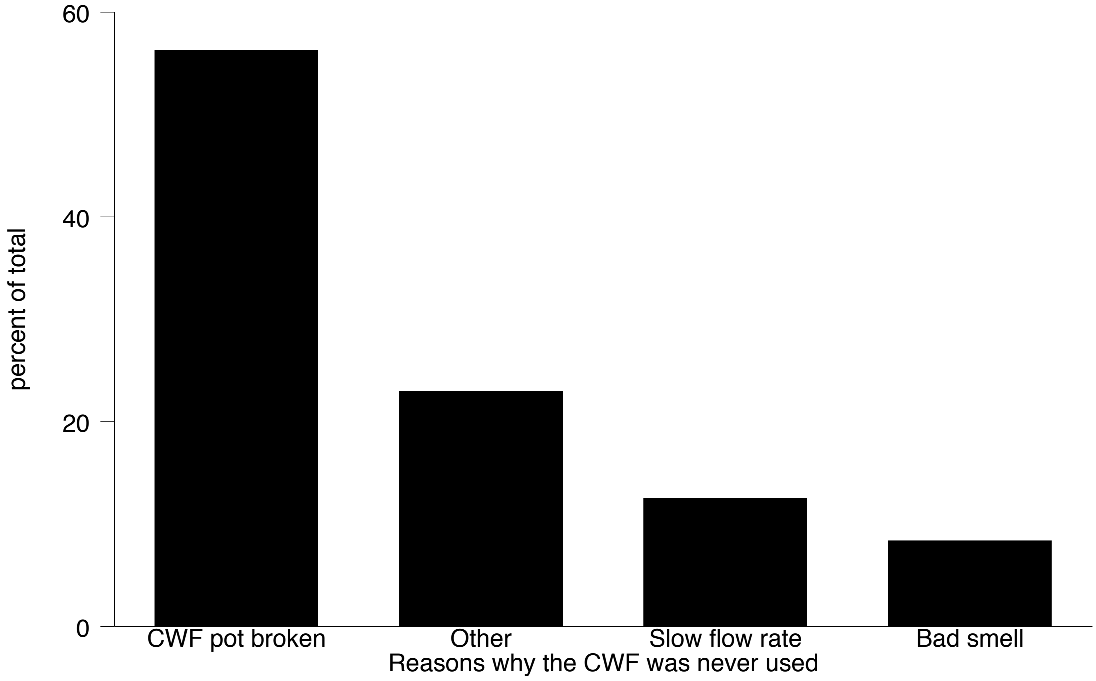

Figure 7 – Reasons why the CWF was never used (n=48)

A total of 80 households (24%) were classified as former CWF users – having used it for some time and then stopped. Reasons for households stopping to use the CWF are detailed in Figure 8.

The most common reason why households stopped using the CWF was that the CWF pot broke (75%), followed by slow flow rates (6%) and a broken bucket (4%). Other reasons included having a broken tap, the CWF was lost or stolen, the CWF was given away or sold, the household did not have a good place to put it, or disuse due to cold weather and preference for boiled hot water.

Among households that were not found to be using the CWF, 26% and 90% of households reported that the CWF pot and the plastic bucket remained at the household during the day of the survey, respectively. Among households that no longer had the CWF pot in the home, 95% reported that it had been disposed.

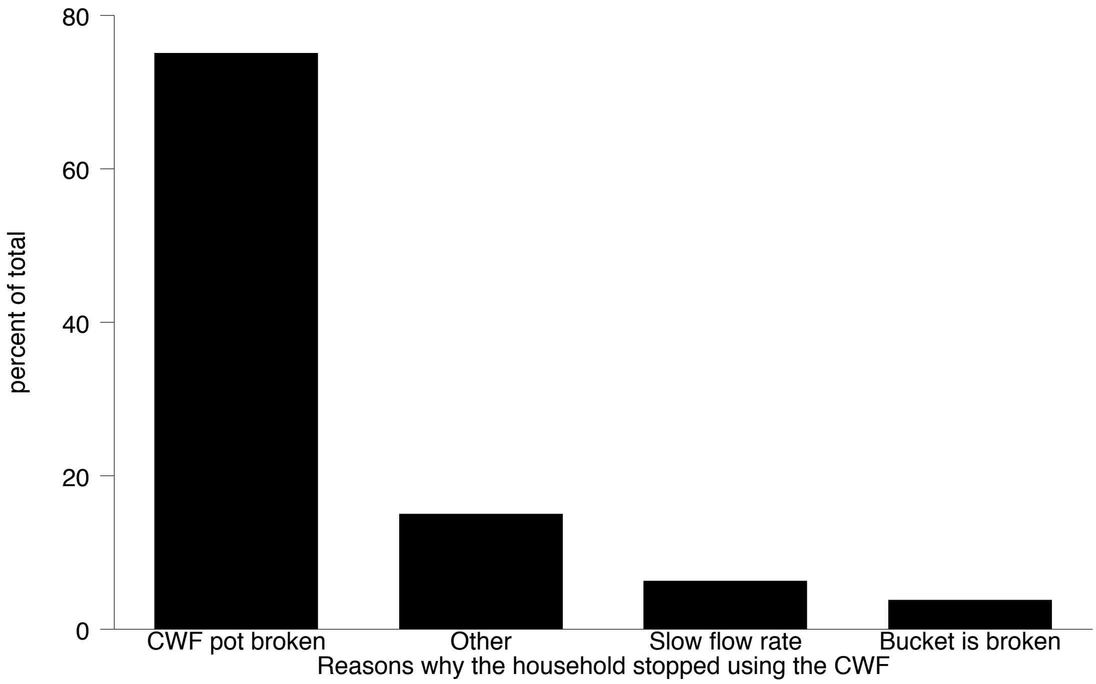

Figure 8 – Reasons why households stopped using the CWF (n=80)

3.4 Duration of CWF use

The duration of CWF use was calculated from the time of delivery (agency reported for each site) until: the day of the survey (if the household was a current user); or, the day that the household stopped using the CWF (self-reported by the respondent).

Figure 9 presents what is known as a *survival curve* for CWF disuse. This survival curve indicates the proportion of CWFs remaining in use over time since distribution. Note that this graph does not included households that never used the CWF – for which the duration of use would be 0 days.

Figure 9 demonstrates that most filters remain in use for the first 300 days since distribution – with a drop-out rate of approximately 15% over this time period. However, from Day 300 to 400, the dropout rate increases more dramatically – by approximately 20% over the 100 day period. This results in an overall usage rate of approximately 65% after 400 days since distribution – the maximum time for which there is sufficient data. After a time period of exactly one year (365 days) since CWF distribution, the usage rate was found to be 73% (95% CI: 67-79%).

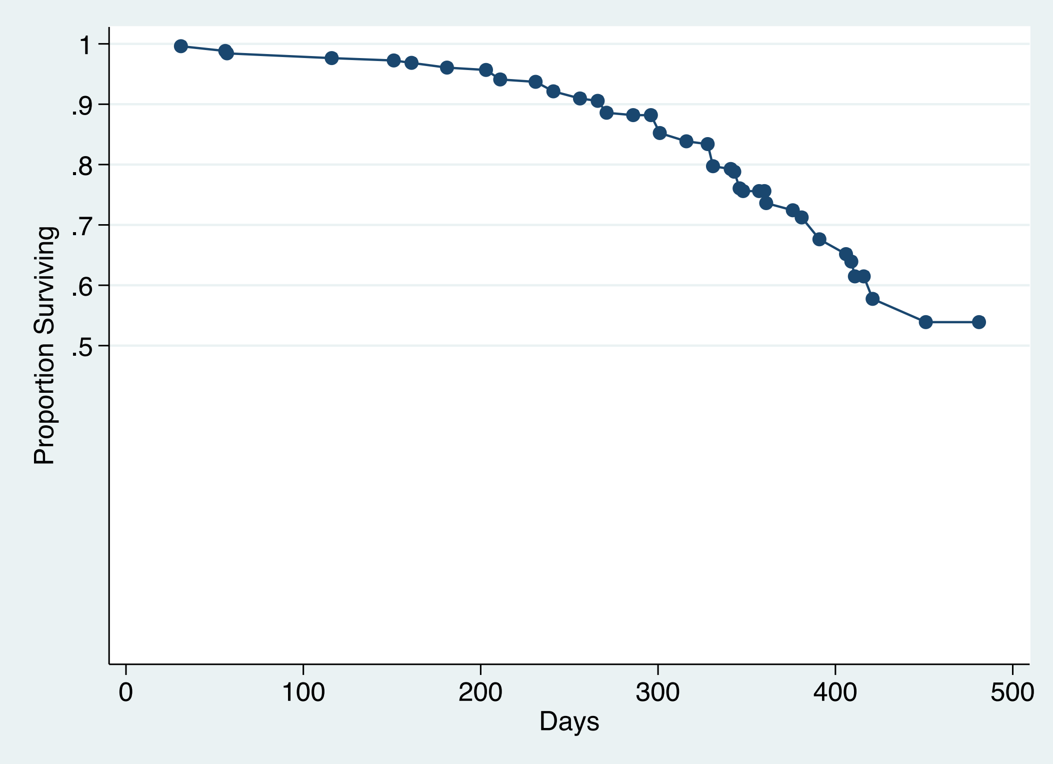

Figure 9 – Proportion of CWFs remaining in use over time since distribution (n=254 at Day 0)

Potential associations between rate of disuse over time and other variables were explored, including site type, site location, literacy of primary caretaker, socio-economic status, household size, households ever receiving CWF education at the household, total CWF education time, and primary water supply type. Notable trends were observed for socio-economic status (Figure 10), primary caretaker literacy (Figure 11), and highest completed education level in the household (Figure 12). The reader should take note that the y-axis does not always extend down to zero in order to provide space to visually observe the differences in the graphs.

There was an insufficient sample size to present data for the *high* socio-economic group, however, a clear trend was observed as households with a decreasing socio-economic status appear to be less likely to continue using the CWF over time. CWF use appears to be consistently high for all socio-economic groups up to approximately Day 250 since distribution, after which the curves diverge.

A literate primary caretaker in the household also appears to be associated with more prolonged use – in particular after one-year of CWF use where the curves diverge.

Finally, higher levels of completed education among all members of the household appears to be associated with prolonged CWF use. There was an insufficient sample size for the high education group – which is not presented.

It should be noted that the aforementioned comparisons did not take into account potential confounding (see more on confounding in Section 3.6).

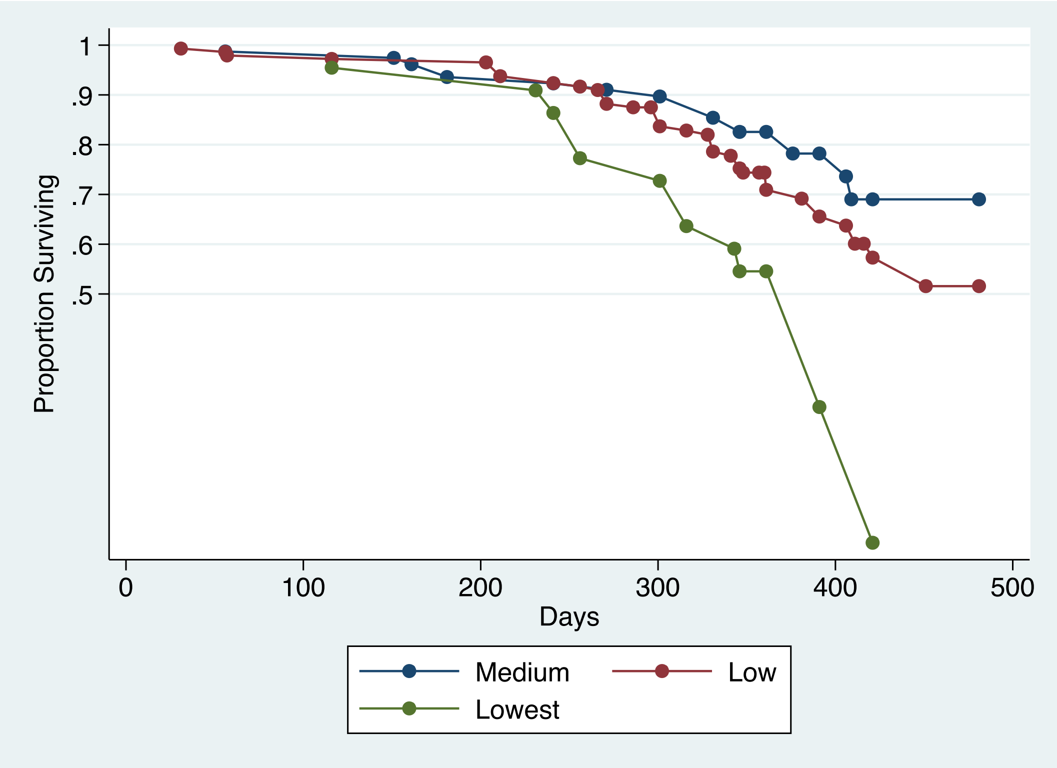

Figure 10 – Proportion of CWFs remaining in use over time since distribution by socio-economic status

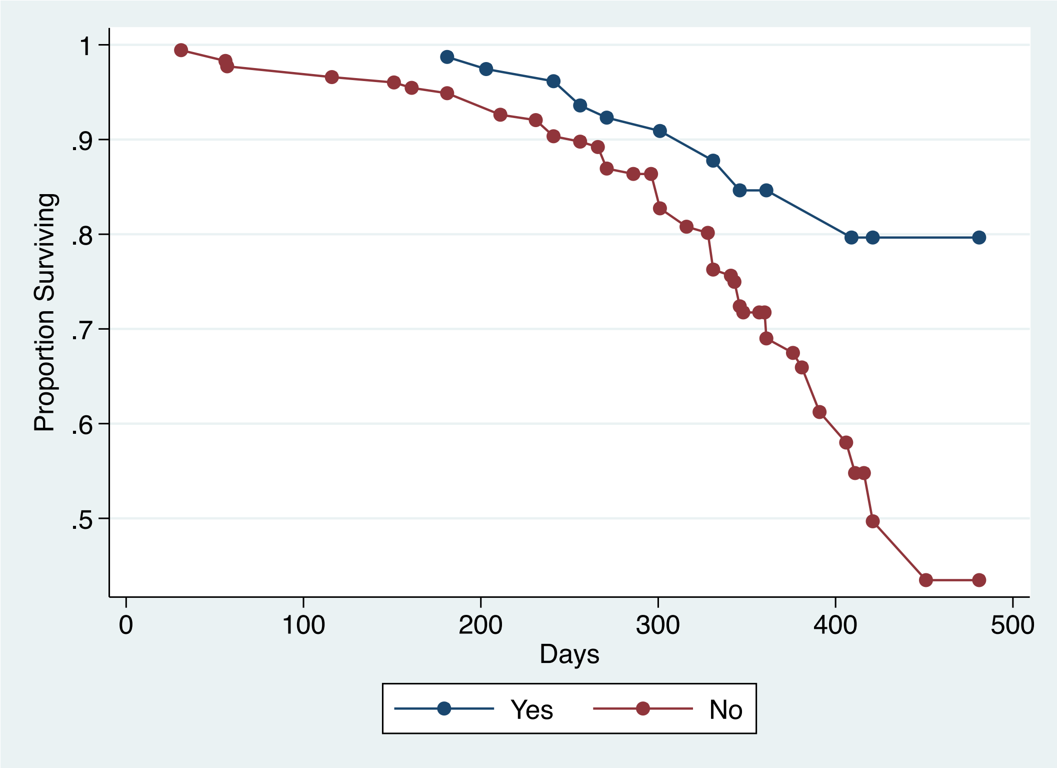

Figure 11 – Proportion of CWFs remaining in use over time since distribution by primary caretaker literacy

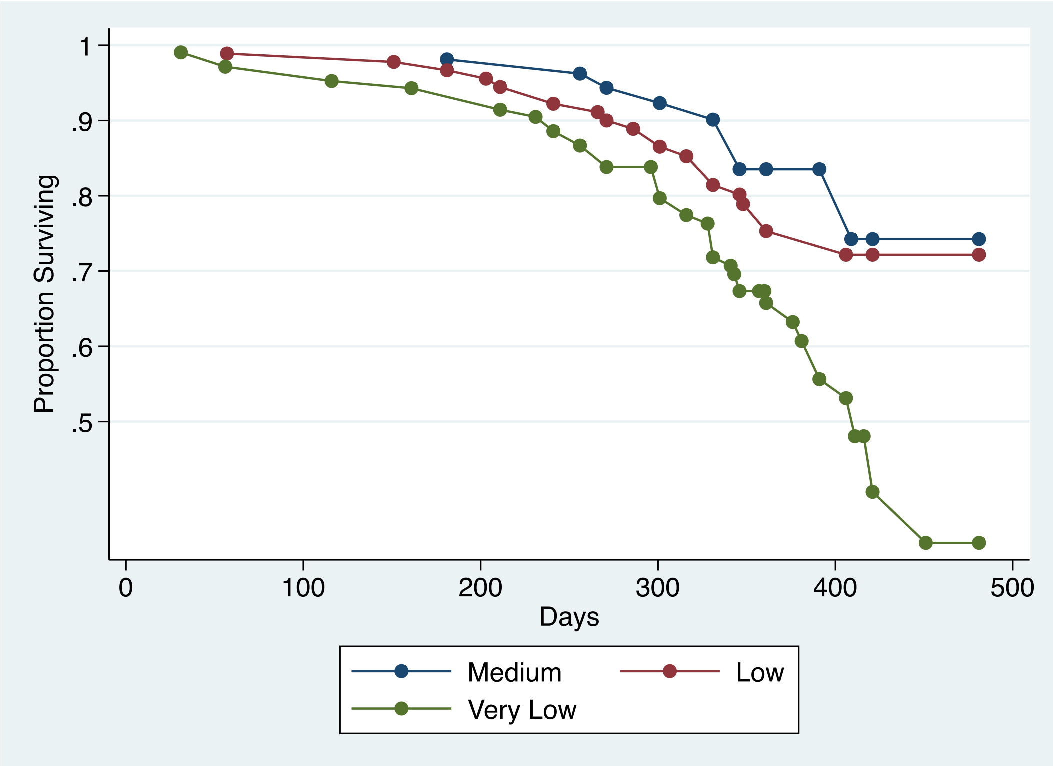

Figure 12 – Proportion of CWFs remaining in use over time since distribution by highest completed education level in the household

3.5 Attitudes, perceptions, and practices of current and former users

Table 5 presents the attitudes, perceptions, and practices associated with CWF use among current users and for former users during the time of previous use.

Both groups were highly satisfied with the CWF during the time period when it was used – with the only minor exception being satisfaction with flow rate among former users (90% satisfaction). Perceptions that the CWF delivered improved and safe water were also very high. Untreated water was reportedly clear (low turbidity) for nearly all households.

Nearly all households reportedly cleaned their CWF pot – but slightly fewer among former users. Reported cleaning frequency was on average every 6.1 and 6.6 days for current and former users, respectively. Among current users, nearly all households reportedly cleaned their CWF bucket and nearly all did so with soap. Reported cleaning frequency of the plastic bucket was on average every 6.4 days.

Table 5 – Characteristics, beliefs, and satisfaction of current and former CWF users

	Current Users (n=210)		Former Users (n=80)	
	N	%	N	%
Untreated water was clear	204	97.1	79	100.0
Overall satisfaction with CWF use	-	-	78	97.5
Reported sufficient drinking water made available	206	98.1	76	95.0
Belief that CWF increases safety of the water	210	100.0	80	100.0
Belief that CWF improves the quality of the water	209	100.0	80	100.0
Belief that using the CWF makes the family more healthy	209	100.0	79	98.8
Satisfied with flow rate	208	99.1	72	90.0
Satisfied with effort needed to use	209	99.5	79	98.8
Satisfied with taste of the treated water	209	99.5	80	100.0
Satisfied with quality of the CWF pot	210	100.0	78	100.0
Satisfied with the space the CWF occupies	209	100.0	79	98.8
Satisfied with the hygienic protection of the water that the bucket provides	209	99.5	80	100.0
Ever cleaned the CWF pot	210	100.0	74	92.5
Used brush to clean CWF pot	209	99.5	74	100.0
Used soap to clean CWF pot	4	1.9	-	-
Ever cleaned the CWF plastic bucket	208	99.1	-	-
Used soap to clean CWF plastic bucket	206	99.0	-	-

3.6 Factors associated with CWF disuse

A secondary objective of the study was to examine variables and characteristics associated with households that received a CWF but are currently not using it. Do to limited sample sizes, *never* and *former* users were combined for this analysis. Figure 13 shows the unadjusted odds ratios for CWF disuse for various location and household specific factors.

The marker in the middle of each horizontal line represents the calculated crude odds ratio compared to the baseline. For example, the first odds ratio for villages vs. camps is 1.67 with the baseline being camps. Therefore, with an odds ratio of 1.67, a household in a village is 67% more likely to not be using a CWF than a household in a camp. The markers on the left and right of the horizontal line represent the lower and upper 95% confidence intervals around the odds ratio, respectively. Therefore we can be 95% confident that the true odds ratio in the target population is somewhere within this band. The vertical dotted line indicates the odds ratio of 1 – which represents no difference between the variables analyzed. For comparisons where the horizontal line crosses the vertical dotted line, we can say that there is insufficient statistical evidence that there is a difference in CWF use between the variables being compared.

Factors observed to have a significant or nearly significant association with CWF disuse include households that: reside in villages (OR 1.7), reside in Pauktaw township (OR 2.8), have an illiterate primary caretaker (OR 2.3), have a lower socio-economic status (OR 1.5), have a lower maximum completed education among all household members (OR 1.4), a non-borehole water supply (OR 2.1), a longer time since receiving the CWF (OR 2.7), never received any CWF education at the household (OR 1.9).

However, such findings do not account for confounding. Confounding occurs when two variables under comparison (i.e. variables A & B) are both associated with a third variable (C). For example, the apparent relationship between A & B may actually be caused by variable C that is related to both variables. For an example in the context of the study, the perceived association between CWF disuse and households residing in Pauktaw *could* be due to the fact that Pauktaw is dominated by different types of water supply than Sittwe. Water supply type in this example could be related to both Pauktaw and CWF disuse, therefore creating a false but apparent association between Pauktaw and CWF disuse. However, this is just an illustration to describe confounding.

To address confounding between all relevant variables, a statistical procedure called *logistical regression* was performed which accounts for the relationships between and amongst all variables with one another. Therefore the effects of confounding are removed and true relationships may emerge – if there is enough statistical power (sufficient sample size). The results of the logistical regression are presented in Figure 14.

After adjustment for confounding, several variables remain associated with disuse and their effects are strengthened (higher OR compared to unadjusted analysis), including: time since delivery of the CWF (OR 2.4), villages (OR 3.2), and sites in Pauktaw (OR 3.6). An illiterate primary caretaker and lower socio-economic status are also marginally significant factors. It should be noted however that the sample size for this analysis is quite small and confidence intervals are generally wide. There may also be some factors associated with disuse that were not included in the survey or that are difficult to measure. Therefore some true associations may not be adequately revealed in the analysis.

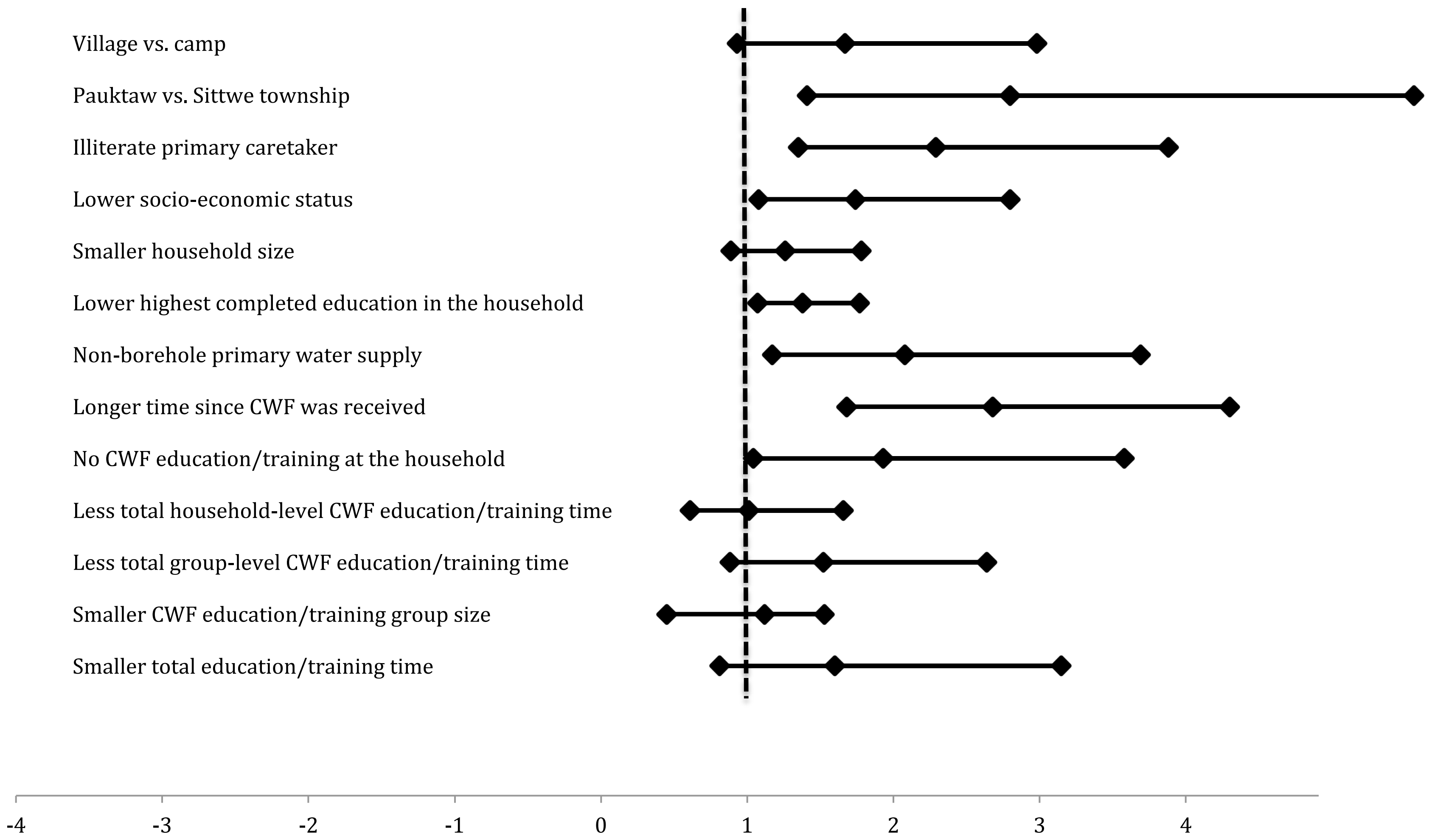

Figure 13 - Unadjusted odds ratios for CWF disuse (including their 95% confidence intervals)

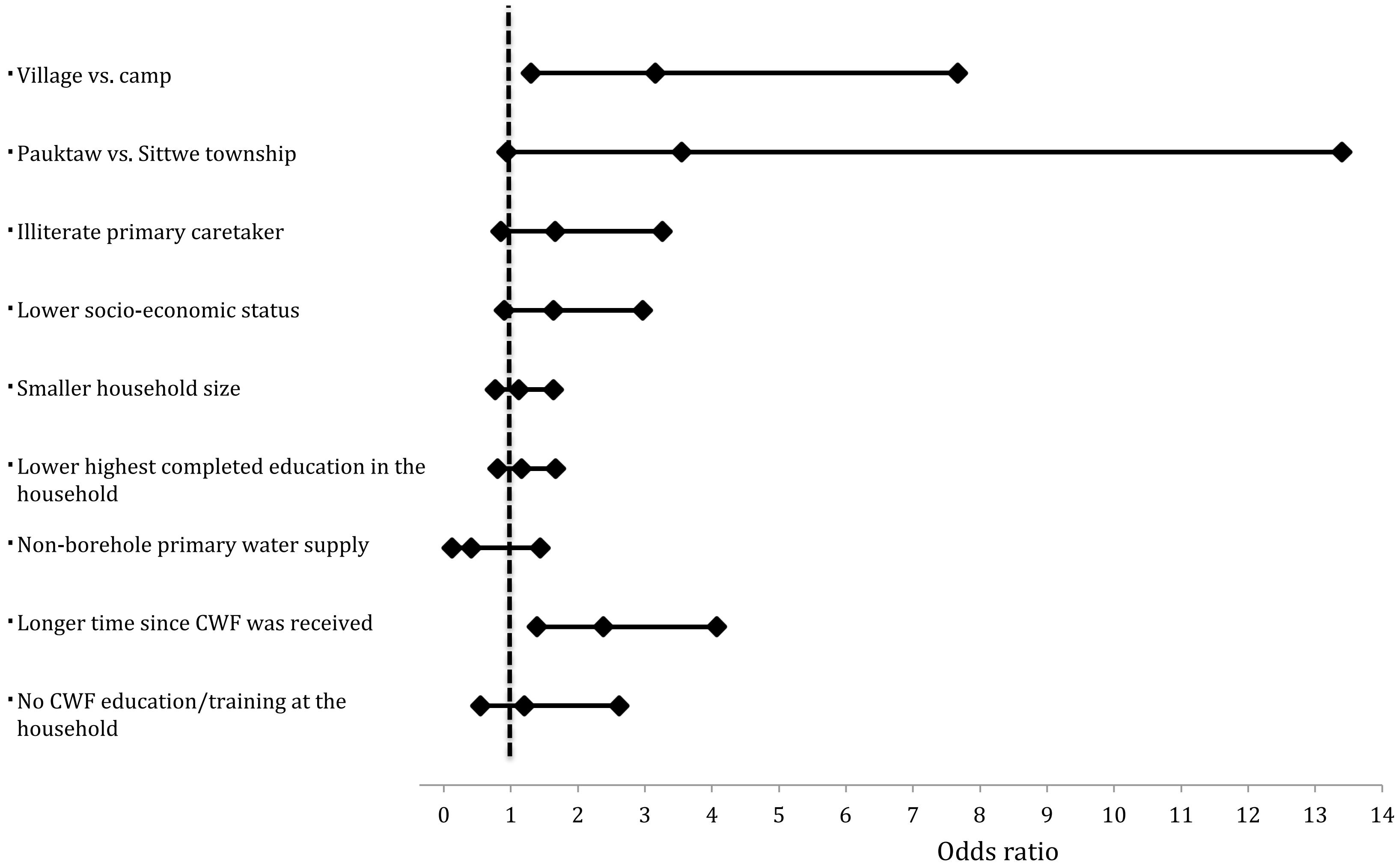

Figure 14 - Adjusted odds ratios for CWF disuse (including their 95% confidence intervals)

3.7 Characterization of current CWF users

Most *current users* reported using their CWF for more than one year (88%). Among these households, all reported using the CWF during the dry season, wet season, every month over the past year, every week over the past year, and over 90% of the days over the past year. Use of the CWF therefore appears to be consistent and persistent among current users. A total of 98% of current users reportedly filled their CWF pot with water at least once over the past 24-hours, as shown in Figure 15.

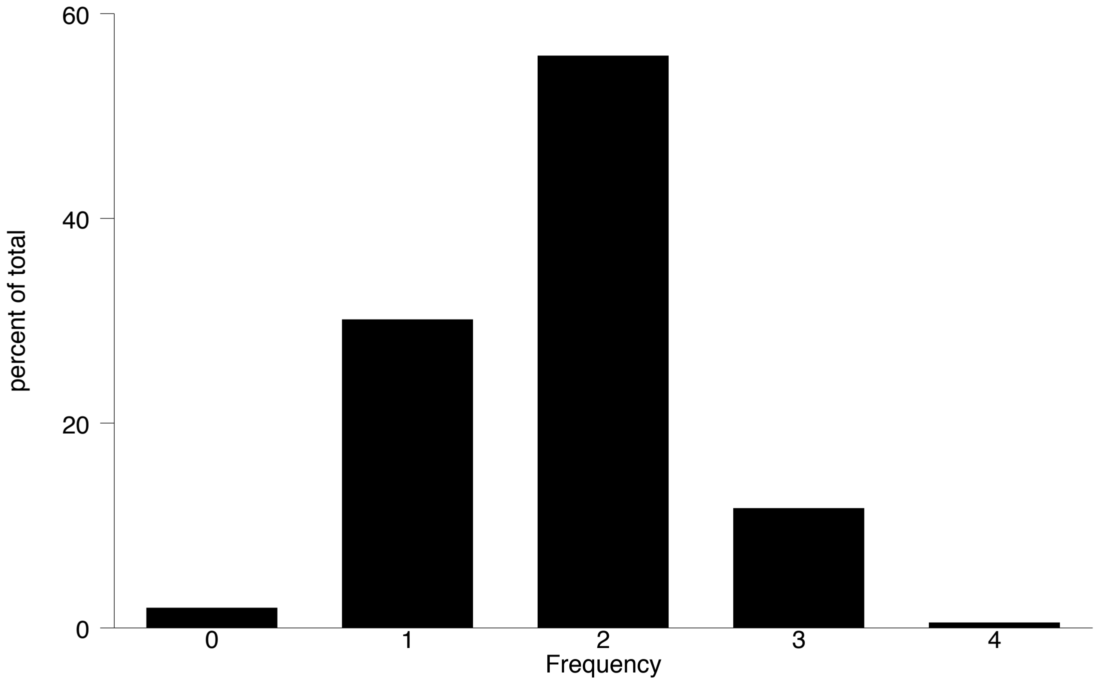

Figure 15 – Frequency of filling the CWF pot in the past 24 hours among current users

The average reported frequency of filling the CWF pot with water was 1.8 times over the 24-hour period before the survey.

3.7.1 Visual inspection of the CWF and water testing results

All households that currently used the CWF allowed the interviewers to visually inspect it (n=210). However, upon request to see the filter, four households (1.9%) did not actually have a complete CWF to observe. Of the 206 households with a complete CWF, all were covered with a lid, 79% had water visible in the pot (indicating very recent use), and 94% had water visible in the bucket. Additionally, two households reported that the water in the bucket was not actually filtered.

Water samples were collected from the tap of CWFs that were demonstrated to be correctly and completely assembled and had water present in the bucket that was confirmed to have passed through the filter (n=190). Water samples were also collected from raw/untreated water that was reportedly used to fill the CWF pot (n=148), if it was available. The source of sampled water on the day of collection is presented in Figure 16.

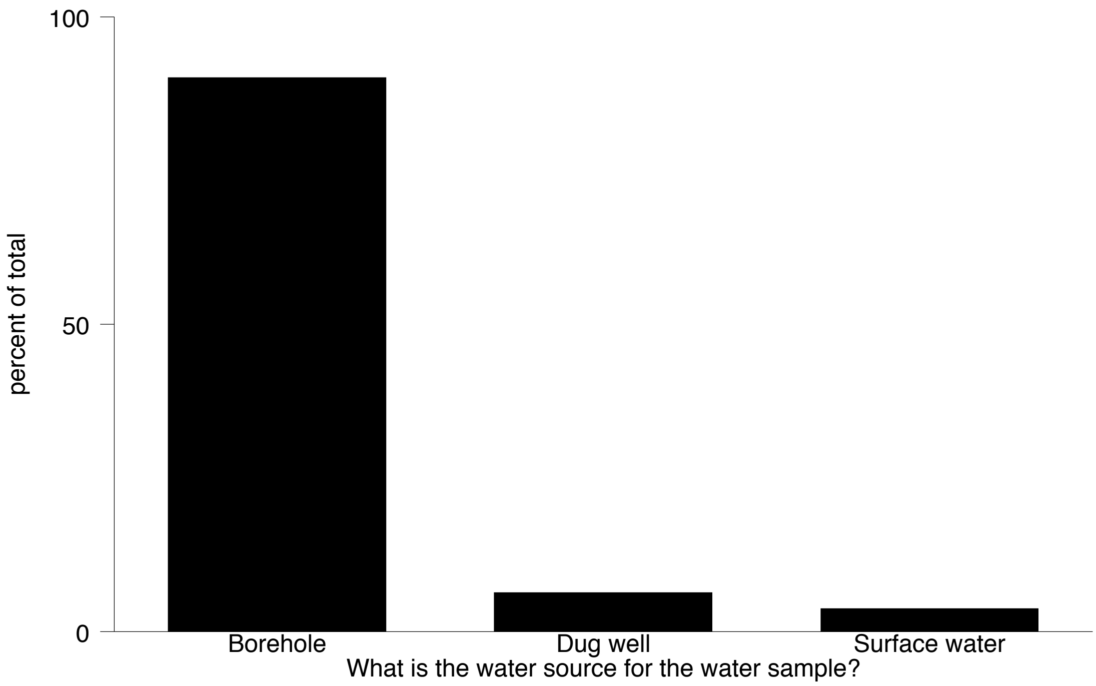

Figure 16 – Water source type for the treated water sample collected

The majority of the water samples collected for the study originally came from boreholes (90%), followed by dug wells (6%), and surface water (4%).

Transfer of filtered water from the plastic bucket to a secondary container was reported by 10% of households. When observed, all of these secondary containers were found to be covered, closed, or sealed.

Figure 17 presents FC concentrations for both pre-treated and CWF-treated water, classified by diarrheal disease risk categories published by the World Health Organization (15).

The majority of treated water samples had FC concentrations in the no risk (56%, n=105) and low risk levels (23%, n=44). However, 22% of treated samples had FC concentrations in the medium or high-risk levels combined (n=41).

A significant number of households demonstrated raw/untreated water in the no risk level (36%, n=53) and low risk level (23%, n=34) indicating that untreated waters are of a high quality at more than half of all surveyed households. However, raw water was demonstrated to have FC concentrations in the high-risk level at a moderate proportion of households (23%, n=34).

Overall, waters that were treated with a CWF were more likely to have fewer FCs than untreated waters.

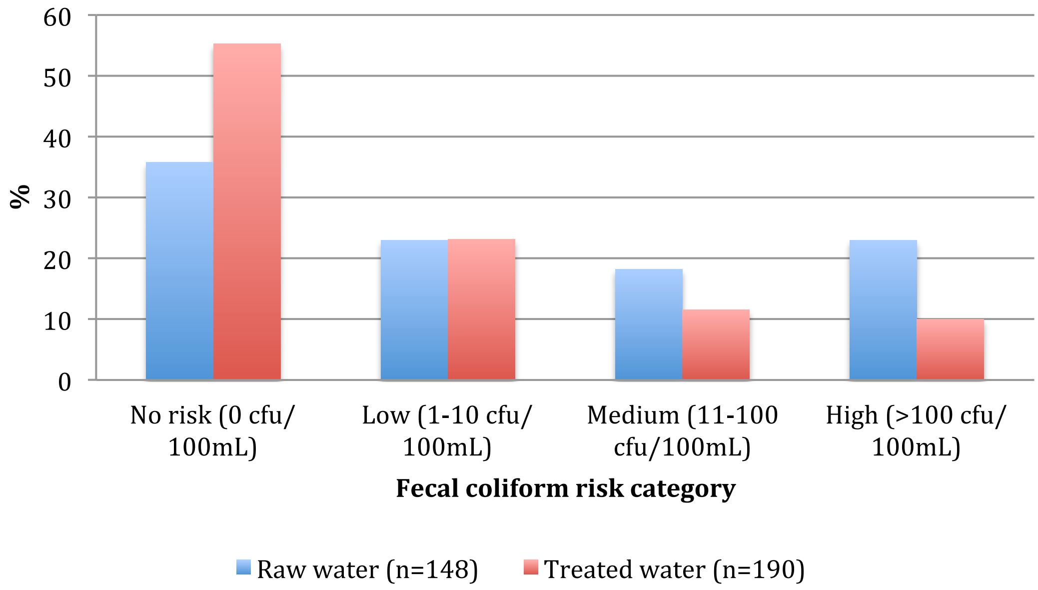

Figure 17 – Distribution of FC concentrations of pre and post treated water by risk category

Figure 18 compares the difference in risk category between the raw/untreated sample and CWF treated sample at each household. Positive differences represent an improvement in risk category while negative differences represent a degradation of quality.

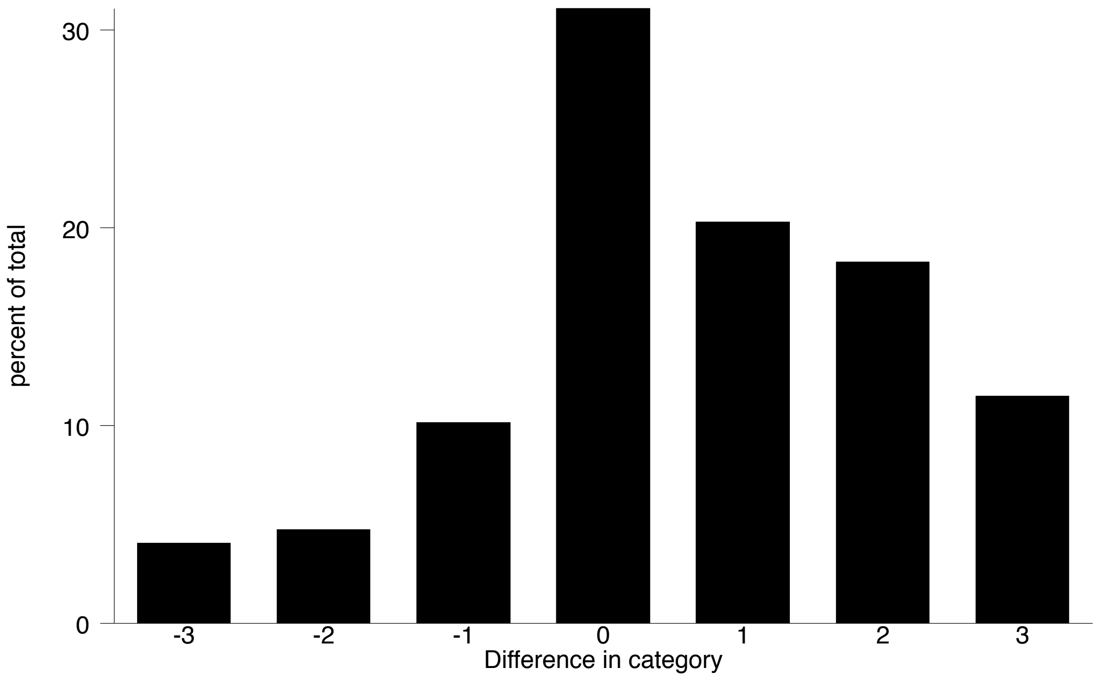

Figure 18 – Change in risk category between raw and treated sampled waters (n=148)

The results of Figure 18 should be interpreted with caution as the concentration of FC in raw water at the time of the survey may not have been the same as the that in the water used to fill the CWF pot to produce the sampled water that was treated. Considering the FC concentrations classified by risk level, approximately 50% of households demonstrated substantially better treated water quality compared to raw water quality including 12% of households demonstrating an improvement of 3 risk categories (high risk raw water and no risk treated water). No change to the risk classification level between raw and treated waters was observed in 31% of households while 28% of households demonstrated a worse risk category for treated water compared to raw/untreated water (however in some cases this was from 0 cfu in raw water to <10 cfu in treated water).

FC concentrations for raw and treated waters by water supply type are presented in Figure 19, including medians (horizontal lines), 25th & 75th percentiles (bottom and top of box), upper and lower adjacent values (bottom and top whiskers), and outliers (dots). Upper and lower adjacent values represent statistical measures to define the boundary between potentially acceptable data or outliers. Outliers are data that reside extremely far from the majority of the observed values, and may simply be correct and extreme anomalies or may represent incorrect or inaccurate data.

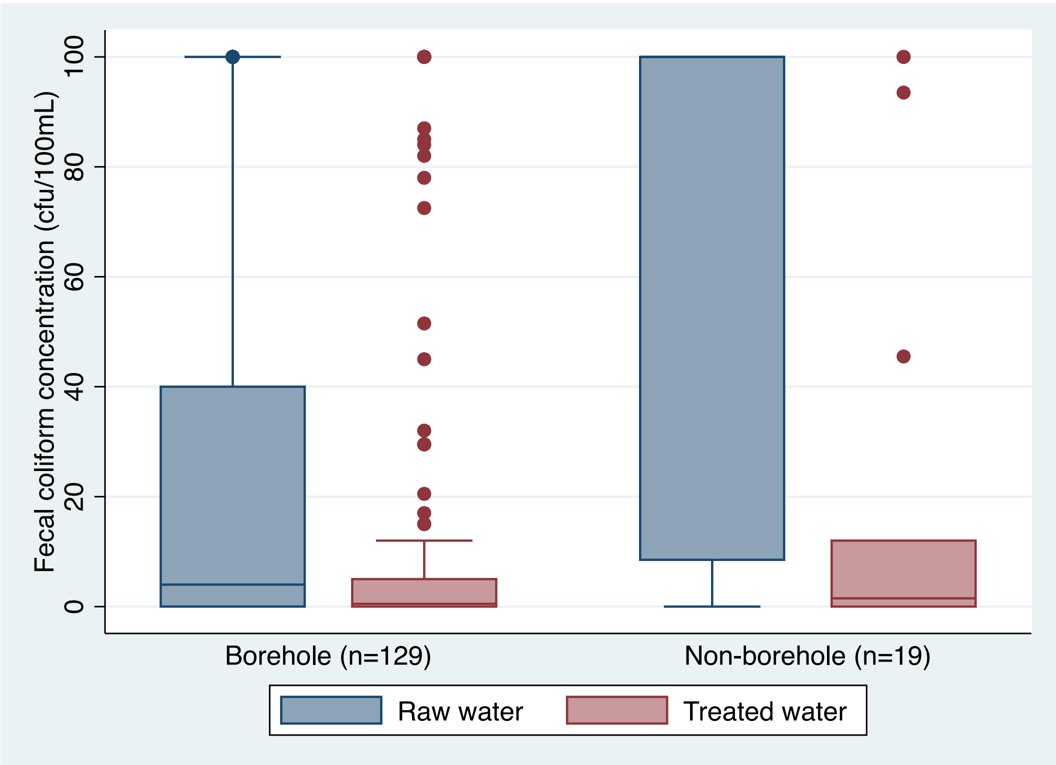

Figure 19 – Concentrations of FC for raw and treated waters by water supply

FC concentrations ranged from 0 to 100 cfu/100mL for borehole and non-borehole supplies and for both raw and treated waters. Despite the small sample size for non-borehole supplies (n=19), raw water appears to be of better quality in boreholes than non-boreholes. Mean and median FC concentrations for raw and treated waters from borehole and non-borehole water supplies are presented in Table 6.

Table 6 – Characterization of FC concentrations in raw and treated samples by water supply type

	Borehole		Non-borehole	
	Raw (n=129)	Treated (n=171)	Raw (n=19)	Treated (n=19)
FC Concentration (cfu/100mL)				
Mean	26.4	15.4	63.0	19.8
Median	4	0.5	100	1.5
25^{th}- percentile	0	0	8.5	0
75^{th} - percentile	40	5	100	12

Mean and median FC concentrations are highest in raw water samples from non-boreholes, followed by raw water samples from boreholes, treated water from non-boreholes, and treated water from boreholes. There may be some evidence to suggest that treated borehole water may be of better quality than treated non-borehole water – however the sample size in the non-borehole sub-group is too small to confidently test this hypothesis.

Results from the visual inspection of the CWF are presented in Table 7.

Table 7 – Visual inspection of the CWF

	Response n (%)	
	Yes n (%)	No n (%)
Visual cracks in the CWF pot	201 (97.6)	5 (2.4)
Any discoloration of the CWF pot	190 (92.2)	16 (7.8)
Visually clean bucket	193 (93.7)	13 (6.3)
Visually clean treated water in the bucket	194 (94.2)	12 (5.8)

Cracks and discoloration of the CWF pot were uncommon. Most buckets and the treated water within were visually clean upon inspection.

The time since the reported last cleaning of the CWF pot and bucket averaged from 5.8 and 3.9 days ago, respectively. Most households reported cleaning both the pot and the bucket during the past week (91% and 92%, respectively). Frequent cleaning of the plastic bucket was defined as being within the past 48 hours while infrequent cleaning was more than 2-days ago. A significant association was observed between bucket cleaning frequency category and FC concentrations in the treated water in the bucket – but only for FC risk classification categories 1 and 2 (OR=2.40, $p<0.05$). No effect may have been observed at higher concentrations due to small sample sizes. This evidence suggests that less frequent bucket cleaning may be associated with higher levels of contamination in treated waters.

3.7.2 Quality control of FC results

Laboratory, field blank, and duplicate samples were analyzed to assess quality control of water sampling and testing activities. All water testing in the laboratory was performed in duplicate. Relative Percent Difference (RPD) is a measure of the reproducibility of duplicate data with a value of 0 representing no difference between the two duplicate values. The average RPD for the laboratory duplicate tests was 35.5 but with a median of 0. A total of 66% of duplicate pairs (n=414) had an RPD of 0 indicting the same result for both duplicate tests. Overall laboratory reproducibility and precision was sufficiently high for FC analysis (RPD<40) (16).

Laboratory blank tests were performed for every 20 filtrations using locally available bottled drinking water (in the absence of typical lab-grade water production equipment). Three of the 37 blank tests (8%) tested positive for FCs, but with an average of 1.8 cfu/100mL FCs. Laboratory blank results indicated that methods and practices for disinfection and prevention of cross-contamination were sufficient.

Interviewer teams were instructed to collect field blank and field duplicate samples at every 20th household. However, there may have been some confusion between blanks and duplicates recorded on the log-sheet for some teams. As a result, 9 out of 20 field blank samples (45%) tested positive for bacteria with an average of 7.9 cfu/100mL – skewed significantly by two samples that had more than 25 cfu/100mL. It is unclear whether these results are due to some confusion with the interviewer teams in writing down the sample codes for blank and duplicate samples or whether they are the result of some external contamination during sampling or storage in the coolers. Field duplicate data also revealed poor reproducibility (average RPD of 137), and again it is believed that this is the result of confusion among some of the field teams. Only 5 of the 16 duplicate samples produced an RPD less than 50.

4. Discussion

Achieving consistently safe drinking water that is trusted by its consumers remains a key challenge in developing countries around the world – and even more so in emergency situations. While centralized water treatment and distribution into households remains the ideal drinking water scenario, it remains a challenge in most developing country settings – especially in rural areas. HWTS therefore remains an important step towards improving water quality at the point-of-use in contexts where water quality is impaired at the supply or contamination occurs during handling/storage.

CWFs have been demonstrated in various contexts around the world to improve drinking water quality at the household-level and reduce incidences of diarrheal disease. However, the sustained and consistent use of HWTS methods like the CWF remains a challenge – particularly due to the training and sensitization process needed to ensure that a user will value and correctly operate and maintain the filter – and the external support needed to ensure that replacement parts are obtainable into the future. Performance and use of CWFs in Myanmar have previously received minimal study.

In emergency settings, it may be critical to establish a water treatment mechanism quickly and efficiently to reduce the risks of outbreaks. In the case of Rakhine State, the emergency situation has continued for several years and CWFs have been promoted as a potentially durable solution that is more likely to be taken up and sustained than other previously trialed alternatives such as chlorination. While approximately 25,000 CWFs have been distributed at various sites throughout the State in recent years, a holistic assessment of use, performance, and potential impacts of the intervention had yet to be conducted until now. This section discusses and methodology employed for the study, its limitations, and interpretation and relevance of the results for decision-makers and planners.

4.1 Methodology and limitations

The methodology of the study was designed to characterize the sites where the majority of the CWFs have been deployed (84%) – however, it was confined only to Sittwe and Pauktaw townships due to logistical and time constraints. Rathedaung, Minbya, and other remote townships were not included, but it is believed that they may have characteristics more similar to Pauktaw township – which is dominated by non-borehole supplies and more difficult accessibility (typically by boat). It should also be noted that the sites in Sittwe township reside very close to Sittwe town where most humanitarian agencies are based. As a result they may receive more contact time with agencies than the more remote sites. As the results have indicated, CWF use was certainly lower in Pauktaw than in Sittwe. Therefore it could be anticipated that CWF use in the non-included parts the State may be lower than what was observed in this study.

Some consideration was given towards weighing the site sampling more heavily towards Pauktaw in order to ensure sufficient sample sizes to make statistically significant comparisons between Sittwe and Pauktaw and also ensure sufficient sample sizes for households not using boreholes. However, as human resources, time, and budget for transportation were extremely limited, it was decided that this approach would not be feasible and instead the sample was randomly and proportionally allocated without any weightings. As a result, only 12% (n=40) households were surveyed in Pauktaw and only 19 households had water quality samples characterized – typically from non-borehole supplies. As such, statistical comparisons between borehole and non-borehole supplies are extremely weak and this is a key limitation of the study.

The sample size was split into 42 clusters of 8 households – 1 cluster assigned to each group per day. This approach was designed to minimize time for travel and mobilization between sites. However, as the 42 clusters were randomly allocated to the sites in the sampling frame, the population characteristics of the sampling frame and the surveyed households were not exactly the same. Most notably, villages and the Rakhine ethnic group appear to be under-represented due to the random selection process. To avoid such issues in future surveys, the clusters could be randomly allocated using a stratified approach – i.e. allocating a number of clusters to each ethnic group or each site type proportionally to their distribution in the study population.

Overall data collection quality amongst the six interviewers teams was satisfactory, however several groups demonstrated some struggles and confusion with some questions during the initial field days. Thanks to the functionality of KoboToolbox and the tablets, data from each field day was made available for review at the end of each day and inspections were made to assess the data for consistencies and ambiguities. Identified issues were resolved through re-training – as the field groups met together at the beginning of each day to brief and discuss any issues from previous days. Any incorrect values or data were flagged as *missing data* in the database to ensure that only valid entries were analyzed. This deletion of data may have contributed to some minor levels of bias – but incorrect entries were not widespread and were identified and addressed early on.

The survey was translated into Myanmar and back-translated into English to strengthen the translation and ensure that the proper meaning of the questions was correctly conveyed. However, the respondents at some Muslim households did not speak Myanmar and therefore the survey was administered in the local Muslim language – either by the interviewers if they had such capacity or by site-based staff who spoke both languages and provided support. This language issue may have affected the quality of the responses and thus the data received for the households that could not respond in Myanmar – as the questionnaire was not translated and tested in the local Muslim language.

Respondents were generally reported to be cooperative with the interviewers, however it has been widely reported amongst humanitarian agencies that survey fatigue is an issue as many agencies are active in the area and data collection and monitoring exercises are intense across all sectors. This dissatisfaction with reoccurring data collection may have contributed to poorer data quality as some respondents may have wished to complete the survey as quickly as possible and move on with their day. Another potential issue is that Rakhine staff based in Sittwe were charged with administering the survey to respondents – 94% of which were Muslim. Responses may not have been fully transparent as there may in some cases have been distrust or apprehension between Muslim respondents and Rakhine interviewers.

To minimize survey time, interviewers were instructed to conduct a rapid visual inspection of the household assets in order to classify socio-economic status. Such a method offers some advantages and disadvantages, as socio-economic indicators and calculations based on indicators are often unable to fully capture socio-economic status, while such rapid assessment methods may be prone to interviewer bias.

To maximize consistency of the definition of diarrhea, the Bristol Stool chart was utilized. However, misunderstandings and misconceptions of what constitutes a case of diarrhea were still possible. Underreporting may also be possible due to the fact that the respondent reported cases on behalf of all household members – some of which they may be unaware. Inaccurate reports of the duration of time since usage of the CWF ended (for *former users)* are certainly feasible – particularly when CWF use ended long ago. Best estimations were requested and utilized for analysis.

Water samples were collected at the respondent's household and were transported back to the centralized laboratory at the Save the Children office in Sittwe. Samples were collected from locally available drinking water bottles but complete sterilization of these bottles could not be ensured. Additionally, the laboratory followed standard operating procedures using Delagua field test kits as per their day-to-day internal protocols. However, no external laboratory testing was performed to compare the Delagua methods employed against a "gold standard" laboratory method. Quality control data revealed a strong level of precision of the FC concentrations and results but discrepancies were observed with the duplicates and blanks prepared in the field and this is likely due to some confusion among the interviewers.

4.2 Use and performance of the CWF among current users

Elapsed time since CWF deployment averaged approximately 13-months – at which point 62% of households were found to be using the CWF. Nearly all current users reportedly use the CWF consistently and comprehensively (as nearly all households reported using the filter every week and every month over the past year, nearly all current users reported filling up their filter at least once in the past 24 hours, and had stored treated water visible in the plastic bucket). Such high usage practices correspond with the very high satisfaction rates reported. It can be generally concluded that in the context of this study and during periods of CWF use, satisfaction and usage levels are typically very high. Non-turbid water from boreholes is the predominant water supply in the study area and usage and satisfaction levels may be different in alternative contexts. At least part of the high adoption and practice rates can be attributable to large-scale training programmes – with each household averaging 192 minutes of training at the household and/or in large groups. Such trainings also were likely to influence the high confidence, understanding, and maintenance levels observed among past and present users.

Raw household waters were of surprisingly high quality with 59% of households exhibiting FC concentrations <10 cfu/100mL in water stored in the home and used to fill-up the CWF pot. Correspondingly, 79% of households demonstrated treated post-filtered waters of high quality. It is clear that usage of the CWF results in a smaller, but not yet negligible, likelihood of household members consuming water at moderate or high risk levels. The water quality improvements are limited by the ~60% of households that already have high quality unfiltered water and the ~20% of households that demonstrate poor CWF-treated water quality. Examining the change in risk category between treated and untreated waters at each household, 50% of CWF users exhibited an increase of at least one category. However, 28% of households experienced a decrease in quality. Some association was observed between the hygienic conditions of the storage bucket and post-treated water quality – indicating that the 20% of households with poor CWF performance may not be cleaning their plastic receptacle regularly or properly. Particular attention should be given to the cleanliness of cloths or rags used to wipe the plastic bucket. There is limited evidence suggesting that households not using a borehole are more likely to have contamination in their post-treated waters – and this is significantly limited by a small sample size (n=19).

No impacts were observed relating to current CWF use and incidences of diarrheal disease – as rates were too low across all usage categories to make valid comparisons. Overall population-based diarrhea incidence rates were estimated to be 1% over the 1-week period preceding the survey – however this may be subject to some underreporting as respondents answered on behalf of all household members and may not be aware of all cases of diarrhea in the family. As would be expected, the majority of diarrheal cases were amongst children under the age of 5 years. The incidence of diarrheal disease appears to be very low in study area, and considering that sanitation and hygiene also contribute to disease incidence, the health-benefit potential of CWFs may be limited based on the conditions studied. Untreated water quality conditions and diarrheal disease incidence rates may conceivably be different during the rainy season months, or during atypical events such as cyclones, floods, or outbreaks.

Putting the findings into context, of the approximately 25,000 CWFs that have been deployed, and applying the data and assumptions from this study, we can infer the following estimated results and generalizations related to use and performance.

- Approximately 15,000 CWFs may remain in use at the time of the study;
- Approximately 8,000 CWFs may be substantially improving, and 3000 CWFs substantially degrading drinking water quality by at least one risk category compared to raw water;
- Approximately 3,500 CWFs may be delivering drinking water with high levels of FCs in the medium or high risk category;
- Approximately 3,500 CWF may have been deployed in highest-risk households (untreated water FC levels in the high risk category) during dry season conditions.

4.3 CWF disuse

Approximately 38% of surveyed households received a CWF but were not actively using it during the seven days prior to the survey. Somewhat troublingly, 14% of households reported that they never used the filter and such households were more likely to reside in Pauktaw, in a village, not be using a borehole, had the CWF distribution occur more than one year ago, and had less quality and quantity of training. There is some evidence to suggest that participation in CWF education/training sessions may be an important factor towards getting a household to begin to use the CWF, but may not be as important towards sustaining use once it has begun. It would have been interesting to further explore factors that are specifically attributable to *never using* the CWF by conducting an isolated logistical regression – however the sample sizes of *never users* was too small. Only 50% of households that never used the CWF currently practice some form of household water treatment – most commonly cloth filtration. The quality of drinking water among *never users* and the treatment efficacy of cloth filtration were not assessed as part of this study.

A total of 24% of households used the CWF for a period of time and then stopped usage. There may have been some initial confusion amongst several interviewer teams and/or respondents regarding the survey question on whether the CWF was *ever* used. This may have resulted in some overestimation of *never users* who were actually *former users*. Additionally, some households may not have wanted to admit to interviewers that they never used the CWF by choice, and may have falsely stated that it was due to the CWF pot being broken. Households that resided in Pauktaw, had an illiterate primary caretaker, had a lower socio-economic status, had a lower level of completed education, did not use a borehole, and had a longer time since CWF distribution, were more likely to have stopped using the CWF. However, direct associations with CWF use are subject to potential confounding by a third variable.

Therefore, a logistical regression was carried out to control for the complex associations between variables that may be responsible for potential confounding. Due to the limited sample size, *never users* and *former users* were grouped together and compared to *current users*. However, the nature of never and former users may be significantly different and their grouping together may have resulted in some trends not being apparent. After logistical regression, the parameters most strongly contributing to overall disuse were: residing in Pauktaw; residing in a village; and longer duration of time since distribution. A weaker association was also observed with lower socio-economic status and education. Due to the small sample size and low statistical power, confidence intervals are generally wide which results in some difficulty establishing which factors are attributable to CWF disuse. Strong associations appear to be valid between Pauktaw and village sites and CWF disuse – however the exact reasons behind why Pauktaw and villages may cause disuse are not clear. There appears to be a set of variables all negatively associated with CWF use that are grouped together (all households sharing the same potentially negative traits). However, the fact that they are grouped together among the same households does not allow each individual variable to be isolated and analyzed. For example, households in Pauktaw consist of almost all of the non-borehole water supplies in the study, received the CWFs the longest time ago, and received the least training. Therefore there is limited statistical ability for pulling apart these variables from one another.

The main reported reason for being a *never user* or *former user* was due to breakage of the CWF pot. However, the limited flow rate of the CWF also contributes partially to disuse and particularly as a factor that can lead to a household never using the CWF. It is clear that most households are satisfied with using the CWF and want to continue using it. However, this is not always possible as the fragility of the CWF pot will eventually lead to breakage and the proportion of CWF's that remain in operation will continue to decrease over time (on average by approximately 2% per month). Such rates of disuse observed in the Myanmar context are comparable to other studies in the international literature (17). Disuse appears to be lower during the first 300 days since distribution and increases after this point in time. It is not clear how the drop-out rate will evolve past 400 days of use as most distributions within the study area have not occurred more than one year ago. Lower breakage rates during the initial months of use may be due to the fact that households may be more careful about handling the CWF pot. However, disuse rates begin increasing drastically after 300 days, perhaps due in part to the fact that households fall into the routine of CWF operation and maintenance and are not as careful. It is not clear whether the CWF pot actually becomes more fragile over time. Agencies involved in programme design need to incorporate a mechanism for CWF pot replacement if sustained usage is desired – in particular after 1 year since distribution. Pot breakage is the major contributor to disuse in the study context, and with usage satisfaction so high among current and former users, not having a pot replacement mechanism in-place represents a major inefficiency.

5. Conclusions and recommendations

A significant quantity of human and financial resources have been spent on the hardware (CWF package) and software (distribution, training, and monitoring) components of CWF promotion in Rakhine State – in response to the emergency and humanitarian situation that began in 2012. The majority of CWF distributions have occurred in late-2014 and early-2015. The study revealed that 62% of households were currently using the CWF at the time of survey and 31% of all households appear to be experiencing notable improvements to their drinking water quality (factoring non-use over time and comparing raw and treated water quality). Nearly 80% of all *current users* experienced drinking water quality in the *low* to *no* microbial risk category. Self-reported diarrheal disease rates were found to be very low among the study population and no differences in incidence rates were observed between households that treat and did not treat their water, nor those that use and do not use the CWF. It should be well noted that the findings are indicative of dry seasons and exposure pathways to disease causing pathogens and incidences of diarrhea may be higher in the wet season.

Generally, CWF practices and the performance of the filter itself are very high and enhanced due to extensive and thorough household training and follow-ups. Thorough training and follow-ups appear to be a key factor towards getting households to start using the CWF. The CWF (as an HWTS method) is most limited by moderate breakage rates over time. Flow rate and sufficiency of filtered drinking water does not appear to be major limitations in the study area. The hygienic conditions of the storage bucket could also be improved through focused hygiene training.

It is not possible to estimate the number of diarrheal diseases prevented by the intervention as a control group was not studied (a group of households that never *received* the CWF). However, such CWF programme impacts may be limited by overall high quality untreated water (typically from boreholes) and apparent low underlying incidences of diarrheal disease (including among *non-users*). Impacts and performance of such an intervention could increase further under different contextual conditions than that observed during this study – such as locations where boreholes are not readily available, during the early stages of a humanitarian response, or if a highly dynamic disease outbreak (i.e. cholera) were to occur. The impact of high turbidity source waters on filter performance and user satisfaction remains poorly understood as such conditions existed only at sites outside of the study area.

Considering the significant investments in hardware and software made to-date and the high level of knowledge and satisfaction towards CWF use, the Rakhine

WASH cluster should strongly consider implementing an ongoing CWF pot replacement scheme – in particular at sites where distribution has occurred more than 300 days ago. Replacement should be conducted on a household-by-household and as-needed basis to ensure cost-efficiency. Planning can be conducted based on the assumption of a 2% drop-out rate per month. Complete CWF pot replacement should occur after the design life of 2-years is reached. Breakage of plastic buckets and spigots may begin to increase in frequency after 1-year of use.

In settings where agencies and/or government are for the first time considering HWTS interventions and promotion and distribution of CWFs, pre-intervention diarrheal disease incidence and raw water quality should first be understood to ensure relevancy and to develop realistic performance and impact targets. The limitations of the CWF method (and other treatment alternatives) must also be well understood during the design and decision-making phase.

Future research is needed to assess the performance and use CWFs in non-boreholes and high turbidity settings. Pre-treatment techniques such as cloth filtration or *stand-and-settle* may sufficiently remove large turbidity particles prior to loading of the CWF. Such practices should be explored in relevant contexts to ensure sufficient flow rates, high user satisfaction, and continued use.

Efficacy and performance of the CWFs produced in Myanmar should be formally evaluated as part of a controlled laboratory study and covering a range of measurable pathogen indicators. If the CWFs are likely to be scaled-up in Myanmar in the future, and potentially marketed as consumer good (as in other countries such as Cambodia), the government and development partners should eventually consider a formal mechanism for regulation and monitoring of production quality. International CWF networks and working groups, and a national NGO are available to assist with such endeavors.

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