

In-Line Chlorination: Kenya Pilot Results

Evidence Action recently completed a pilot of an In-line Chlorination (ILC) program. ILC devices were installed on 67 water points across three counties in western Kenya serving an estimated 13,000 people. In these communities, baseline water treatment practices were low (11%) and diarrhea prevalence in children under five was as expected (16%-18%), indicating large potential benefits of a water treatment program. After device installation, community acceptance was predominantly positive and chlorine was detected in water samples at 88% of collection points and 78% of household samples. Free chlorine was detected at 79% of collection points and 68% of household samples. Further, over the course of the pilot, Evidence Action gained confidence in its ability to identify and recruit water points, install devices, and engage with communities.

Background & Motivation

In-line chlorination (ILC) is a method for automatically treating drinking water. A small device is attached on a pipe near the point of water collection which dispenses chlorine into the water as the water is distributed. ILC is an appealing chlorination method as it addresses one of the main issues with safe water interventions: broad and sustained usage. ILC automatically treats all water coming from a source and requires no action or behavior change from beneficiaries.

In order to explore the potential of ILC as a scalable, cost-effective intervention, Evidence Action's Accelerator and Dispensers for Safe Water teams completed a pilot of ILC in late 2021 and early 2022. The pilot's objectives were to:

- 1) design and refine an implementation model that can be launched at scale, and
- 2) collect data on variables to indicate that the program's theory of change holds.

This document provides details on the pilot design and results.

The ILC Pilot

The pilot took place in three counties in western Kenya: Vihiga, Siaya, and Trans Nzoia. The pilot was managed as a collaboration between Evidence Action's Dispensers for Safe Water and Accelerator teams.

Water points were identified through surveying done in April and May of 2021 and through engagement with county water stakeholders. Evidence Action staff visited each water point, verified suitability for the pilot, explained the program to the water point owner and offered enrollment. If a water point owner enrolled, a baseline survey was completed with them and with four households in the community that use the water point. Several days after enrollment, Evidence Action and the water point owner organized a community meeting to provide information about the program, seek the community's consent and select a volunteer to serve as a community representative for the water point and the pilot.

After these meetings, Evidence Action staff together with local plumbers installed the devices and calibrated the chlorine dose. Evidence Action staff returned the following day to check the dose and make any necessary adjustment. Follow-up visits were conducted periodically in the weeks following installation. Installations occurred from late November to early January. In late January, staff returned and completed endline surveys with water point owners and users.

Methods

Surveys

In order to effectively monitor and evaluate the pilot, Evidence Action developed baseline and endline monitoring surveys for both water point owners and households served by these water points. The baseline took place between October 7th and December 20th, 2021, before installation of the ILC devices, and the endline took place between January 24th and February 16th, 2022. These surveys were administered by Evidence Action staffing using smartphones and Open Data Kit-based software.

The water point owner baseline survey focused on documenting willingness to enroll in the ILC pilot by water point owners, community use of the water point, and the management and infrastructure characteristics of the water point.

The water point owner endline survey focused on measuring acceptance of ILC devices by water point owners, the community's acceptance of the ILC, and the presence of chlorine at the point of water collection.

The household baseline survey focused on understanding the demographics and water collection practices of the target population, measuring the prevalence of household water treatment at baseline and collecting data on diarrhea prevalence in children under five.

The household endline survey focused on measuring chlorine presence in drinking water, evaluating user acceptance of water from ILC water points, and understanding water collection behavior changes after installation of ILC devices.

While a few questions overlap between baseline and endline, our sample is not designed to do pre/post comparisons on these results. In a few instances, we present comparisons that are suggestive of changes in communities after ILC installation. However, we caution against interpreting these changes as causal.

Sampling Frame

Water point owners and households that use the water point where the ILC device was installed were surveyed at both baseline and endline.

- All water point owners that were approached and offered the ILC device were surveyed at baseline, and all water point owners that had the ILC devices installed were surveyed at endline.
- Households were selected for surveys through a semi-random process of 'random walk' sampling at both baseline and endline. Households were randomly selected at the water

point level at both baseline and endline. Therefore, the exact same set of households were not surveyed at each time point.

A total of 99 water point owners and 400 households were surveyed at baseline, with 64 water point owners and 235 households surveyed at endline.

Of the 67 installations, three were broken down (e.g. broken water pump) for the entirety or vast majority of the pilot, so endline data was not collected. A further five water points had devices installed, but were later removed at the request of the water point owner. For these five water points, endline water point owner surveys were conducted, but endline household surveys were not conducted.

The total number of enrolled water points is lower than projected for several reasons. First, some water point systems used larger pipes that required the device design to be altered and new devices to be constructed. This has now been done, but was not able to be completed during the pilot period. Second, some water points were under the supervision of local utilities. All utilities that we met with were interested in the project, but we were not able to go through all the steps to get full permission during the installation timeline. Given sufficient time to recruit and obtain the appropriate approvals, we believe these water points would opt into the program. Third, when verifying water point eligibility for the pilot, we encountered discrepancies with the findings in our original water point survey in May and April. Specifically, in one county there were enumerator-driven inaccuracies when recording the number of households who use the water point. As a result, in one county, many of the water points on the original list did not serve enough households. All of these instances should not be an issue outside of the constraints of a time bound pilot. Of all water point owners who were offered the device, only three refused. Another 11 stated that the water point was already treated.¹

Pilot Results

Households Characteristics and Behaviors

Demographics and Water Sources

Two key demographic characteristics important for ILC's cost-effectiveness are the number of people per household and the number of children under five per household. In our pilot sample, both of these numbers were in line with expectations. There was an average of 4.6 people and 0.6 children under five per household. The number of people per household is slightly lower than the most recent DSW Kenya estimate of 5.2.²

The baseline survey explored users' water collection practices in order to understand how much of users' drinking water ILC would be treating. If users were collecting drinking water from a wide variety of sources, ILC might only address a portion of their water needs. However, baseline results indicate that, while use of multiple water sources is not uncommon, users collect the majority of their water from the ILC water point. Households reported collecting drinking

¹ Although these water point owners stated that their water was treated, chlorine tests showed that the water had not been chlorinated. Furthermore, no other treatment method was identified. Given ample time to recruit and sensitize, we believe some of these water point owners would opt into the program.

² 2021 Evidence Action DSW Cost-Effectiveness Model

water from, on average, 1.3 sources. Importantly, 73% of users reported collecting 100% of their water from the ILC water point and 92% report collecting 75% or more of their water from the ILC water point.³

Demographics and Water Point Use		
Variable	Value	n
Mean number of people per household	4.6	398
Mean number of children under five years old per household	0.6	398
Mean number of drinking water sources per household	1.3	400
% of households collecting 100% of their drinking water from ILC water point	73%	400
% of households collecting 75% or more of their drinking water from ILC water point	92%	400

Water Treatment Practices

At baseline, only 10.3% of households reported treating their drinking water, 54% of which did so with chlorine and 44% boiled their water.⁴ Following installation, only one household out of 225 households reported treating their water with a method other than ILC.

These self-reported household treatment rates are much lower than found in other sources. The reasons for this are unclear. It is possible that users associate the infrastructure characteristics that are common at ILC water points (storage tanks, piping) as being an indicator of safe water.

Finally, among users who treat their water, only 64% report treating that water 75% of the time or more, suggesting that ILC may be of benefit to households that already treat their water due to increased treatment consistency.

Baseline Treatment Practices		
Variable	Value	n
% of households self-reporting treating their drinking water	10.3%	377
% of households self-reporting treating their drinking water	5.6%	377

³ At endline, the same question was asked and 80% of users reported collecting 100% of their drinking water from the ILC water point and 95% reported collecting 75% or more. However, endline occurred after users were aware of the program and may have been more susceptible to social desirability bias. Baseline occurred prior to community meetings about the program.

⁴ One household stated that they treated their water, but did not know the method used.

using chlorine		
% of households self-reporting treating their drinking water by boiling	4.5%	377
Of those that self-report treatment, % that report treating their water 75% of the time or more	64%	39
% of households testing positive for TCR in sampled water	3.5%	376
Of the households that tested positive for TCR, % testing positive for FCR	85%	13

Diarrhea Prevalence in Children Under Five

While measuring diarrhea is difficult due to differing definitions, reliance on self-reporting, and seasonality, it is important to attempt to understand the disease burden in the target population. The survey asked about diarrhea in children under five using four different questions. These questions varied the definition of diarrhea and the recall period. Questions were asked starting with the least restrictive definition and moving to the most restrictive.

Diarrhea prevalence in all four measures was between 16% and 18%. This suggests that the exact framing or recall period did little to influence respondents' answers. This level of prevalence is in line with expectations. The DHS country average for Kenya is 15.5% and the county level average weighted by our sample size in each county is 15.3%

At baseline, 18% of children under five experienced diarrhea in the previous 7 days as per their caretakers' definition. In the previous 14 days, 16% of children under five experienced caretaker-defined diarrhea. The prevalence of diarrhea for children under five was similar after the WHO definition of diarrhea was provided to the respondent. Households reported that 18% of children under five had experienced diarrhea as defined by the WHO in the previous 7 day and that 17% of children under five had experienced diarrhea as defined by the WHO in the previous 14 day.

Diarrhea Prevalence in Children Under Five		
Diarrhea Definition	Value	n
Caretaker defined diarrhea in the last 7 days	18%	222
Caretaker defined diarrhea in the last 14 days	16%	222
WHO defined diarrhea in the last 7 days	18%	222
WHO defined diarrhea in the last 14 days	17%	222

Diarrhea prevalence was also measured at endline. The pilot was not created with an experimental design. Any differences between baseline and endline should be interpreted with caution. While Evidence Action programming may have influenced diarrhea prevalence, differences could also be due to seasonal variation, sampling variation, or other factors. At endline, reported diarrhea prevalence in children under five was 4% using all four measures.

Mean Diarrhea Prevalence in Children Under Five, by County							
Definition	Recall Period	Survey Period	Siaya	Trans Nzoia	Vihiga ⁵	Overall	n (Overall)
Caretaker defined diarrhea	Past 7 days	Baseline	23%	13%	5%	18%	222
		Endline	4%	3%	0%	4%	140
	Past 14 days	Baseline	20%	12%	10%	16%	222
		Endline	5%	0%	0%	4%	140
WHO defined diarrhea	Past 7 days	Baseline	25%	13%	5%	18%	222
		Endline	4%	3%	0%	4%	140
	Past 14 days	Baseline	23%	12%	10%	17%	222
		Endline	5%	0%	0%	4%	140

Water Point Characteristics

Management and Maintenance

Almost all water points were managed by either the land/kiosk owner or by a water committee. Other management structures included water users associations and schools.

Part of the ILC operating model, similar to DSW, includes having volunteers from the community support the project. Because of this, identification of individuals who are knowledgeable about, and frequently in contact with the water point is important.

Ninety-five percent of water points reported having an individual assigned responsibility for water point maintenance. Seventy-eight percent of these are responsible for water point repairs and 78% visit the water point daily. Finally, 91% of respondents (owners or managers) state that they regularly discuss water quality and treatment with water point users.

In pilot community meetings, either the water point owner or this maintenance person was usually elected as the promoter/community volunteer for ILC.

⁵ Sample sizes Vihiga are small. Baseline: 51. Endline: 23.

Water Point Management		
Variable	Value	n
% of water points managed by the landowner/kiosk owner	49%	95
% of water points managed by a water committee	40%	95
% of water points with a dedicated maintenance person	95%	100
% of maintenance people who are responsible for repairs	78%	91
% of maintenance people who conduct daily visits	78%	91
% of maintenance people who conduct visits a few times per week	13%	91
% of respondents who regularly discuss water safety and/or treatment with users	91%	95

Number of Households Per Water Point

A key to the cost-effectiveness of the program is the number of households served by each water point or ILC device. Water points serving less than ten households were not considered eligible for the program. We asked water point owners to estimate the number of households served by the water point. The average number of households served is 64.1 and the median is 40. Water points ranged from the self-imposed lower limit of 10 households to systems serving large communities of several hundred households. More than 20% of surveyed water points are used by 100 or more households. This is significantly higher than DSW water points in Kenya where the mean is 23.1.

Functionality and Other Characteristics

Only 3% of water point owners reported any type of intermittency of water supply. All of these stated that when intermittency occurred it was only for portions of the day and only a few days per month. Qualitative field experience did indicate that some water points suffer from occasional intermittency due to infrastructure issues such as a cracked pipe or a solar pump pumping insufficient water during extended poor weather.

Users were asked about seasonal changes in their water point use. Only 6% of users reported that they stop using the water point at any point in the year. Of those, when asked in which months of the year stoppage occurred, on average, users listed 1.7 months. Sixty-seven percent cite the water point drying up as the cause.⁶

Water Point Characteristics

⁶ At endline, 3% reported any stoppage. Of those, all listed one month in which stoppage happened and 83% cited infrastructure breakdowns.

Variable	Value	n
Mean number of households per water point	64.1	94
% of water points with public outlets in multiple locations	38%	89
% of water points that were boreholes or other types of wells	75%	95
% of water point owners reporting any intermittency of water supply	3%	95
% of users who stop using the water point at any point during the year	6%	398
Mean number of month listed in which any stoppage of use occurs	1.7	24
% that cite the water point the water point drying up as the cause of stoppage of use	67%	24

Endline Results

Water Point Chlorine Residuals

At endline, 88% of water points (52 of 59) had a positive total chlorine residual (TCR) reading when water was tested from the point of collection, indicating the presence of chlorine.⁷ Seventy-eight percent of all water points, and 88% percent of water points that had a positive TCR reading also had a positive free chlorine residual (FCR) reading, indicating that the chlorine present was sufficient to sanitize the water.

Two models of ILC device, named CTI-8 and Norweco LF1000, were used during the pilot. Of water points with the CTI-8, 92% tested positive for TCR and 88% for FCR. Of water points with the Norweco, 85% tested positive for TCR and 71% for FCR. While this suggests the CTI-8 might be performing better, due to the sample size, we cannot say this difference is not due to chance. However, the CTI-8 also has operational and cost advantages, and was the preferred device by field staff.

Household Chlorine Residuals

At the household level, 79% of samples from stored household water tested positive for TCR and 68% of all household samples tested positive for FCR.⁸

If we only look at households that were served by water points which tested positive for FCR, 88% of household samples tested positive for TCR and 82% tested positive for FCR.

Since chlorine residuals dissipate over time, water storage time is an important factor in detecting measurable chlorine in household water. The majority of users had stored their water for less than 24hrs at the time of sampling. We saw a general trend of a decreasing proportion of

⁷ TCR and FCR rates shown are excluding the five water points where devices were uninstalled during the pilot.

⁸ FCR was only tested for in those households that tested positive for TCR. However, the denominator used is all households on the assumption that, by definition, no household would have tested positive for FCR while having tested negative for TCR.

samples with chlorine residuals as storage time increased. 86% and 71% of samples stored 24 hours or less were positive for TCR and FCR respectively. Only 68% and 48% of samples stored more than 24 hours were positive for TCR and FCR respectively.

Chlorine Residuals		
Variable	Value	n
% of water points testing positive for TCR at the tap	88%	59
% of water points testing positive for FCR at the tap	78%	59
% of water points with a CTI-8 testing positive for TCR at the tap	92%	25
% of water points with a Norweco testing positive for TCR at the tap	85%	34
% of water points with a CTI-8 testing positive for FCR at the tap	88%	25
% of water points with a Norweco testing positive for FCR at the tap	71%	34
% of HH water samples testing positive for TCR	79%	225
% of HH water samples testing positive for FCR	68%	225
% of HH water samples testing positive for TCR (only those served by a water point that tested positive for FCR)	88%	176
% of HH water samples testing positive for FCR (only those served by a water point that tested positive for FCR)	82%	176

Chlorine Residuals by Storage Time			
Storage Time	% with +TCR	% with +FCR	n
<12 hours	80%	66%	56
12-24 hours	89%	75%	83
25-36 hours	74%	47%	19
37-48 hours	92%	72%	25
49-72 hours	40%	20%	10
>72 hours	27%	18%	11

User Acceptance

Key to the success of the program is acceptance by the water point owners and community members. Evidence Action tried to measure this issue in several ways. Endline surveys asked community members to rate the taste of the water, the smell of the water and their perception of the ILC device on a five-point scale from very bad to very good.

Ninety-six percent of households report that they were aware of the ILC device and 94% of them noticed a change in the water following ILC device installation. The majority of feedback was positive. Eighty percent of households reported that the water tastes good or very good, with 70% saying it smells good or very good. Of the 12 (5%) households that reported that the water with ILC treatment tasted bad or very bad, all indicated that it tasted like chlorine or it tasted bitter. Similarly, all 13 of the households who reported that the water smelled bad or very bad indicated that it smelled like chlorine. Overall, perception of the ILC device was very favorable, with 85% having a good or very good perception of the ILC device, with the remaining 14% reporting a neutral view. Only one household out of 222 reported a bad perception.

User Acceptance						
Variable	Very Bad	Bad	Neutral	Good	Very Good	n
User Rating of Water Taste	2%	3%	16%	72%	8%	232
User Rating of Water Smell	1%	4%	25%	64%	6%	232
User Rating of ILC Device	0%	0%	14%	73%	12%	222
Water Point Owner Rating of ILC Device	2%	2%	9%	72%	16%	64

Water Point Switching

Another key area of interest is how installation of the ILC device would impact the number of users of the water point. If installing the device caused a large number of users to stop using the water point, that would limit the reach of the program and impact program acceptance from water point owners. The endline water point owner survey asked if any users had either stopped or started using the water point.

Seventeen percent of water points had at least one household stop using the water point following ILC device installation and 39% reported at least one new household starting to use the water point. For both starting and stopping use, the mean number of households was seven and the median was four.

According to water point owners, the vast majority (92%) of households that started using the water point did so because they wanted to drink treated water. Of the owners that had households stop use, 55% cited the taste of the water and 18% cited mistrust of the device. In the

household survey, no household reported stopping use of the water point following ILC device installation.

Water Point Switching		
Variable	Value	n
% of water points with users stopping use	17%	64
% of water points with users starting use	39%	64
Average number of households stopping use	7	9
Average number of household starting use	7	24

Conclusion

Though the pilot is over, Evidence Action is continuing to support pilot water points, operate the program at small scale and develop a learning agenda to improve on our implementation model.

A key piece still under investigation is the frequency with which Evidence Action staff will need to monitor the ILC devices. Devices took longer than expected to calibrate. As a result, devices were not left unmonitored for long periods of time between installation and endline. Therefore, there is some uncertainty about how frequently devices will need to be visited for adjustment. Increased frequency of water point visits would result in increased staffing and other associated costs. Additionally, we saw more fluctuation in levels of chlorine at the water point than anticipated. Much of this appears to be due to issues that seem tractable (e.g. improving the way we secure devices to the water tank). However, it is uncertain to what extent addressing these issues will resolve chlorine fluctuations. This issue will also impact device visit and adjustment frequency.

Over the course of the pilot, Evidence Action was able to achieve its two main goals of testing and refining the implementation model and collecting data to allow for increased confidence in the program's theory of change. Evidence Action has gained confidence in its ability to execute the program from identifying and recruiting water points to installing and maintaining devices. Key data points on treatment practices, diarrhea prevalence, demographics, water collection practices, water point switching, program acceptance and chlorine residuals have all been positive.