

## DISPENSERS FOR SAFE WATER



## Optimizing Access to Safe Water Through Chlorinated Dispensers in Rural Kenya, Uganda and Malawi

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## Table of Contents

Executive summary	2
1.1 Study Objectives	4
2.0 Methodology	4
2.1 Study design and sampling	4
2.2 Study variables	5
2.3 Model specification and analysis	6
3.0 Study Results	7
3.1 Background Characteristics	7
3.2 Trend analysis of adoption rate of chlorine dispensers for water treatment	8
3.3 Factors affecting chlorine adoption	8
3.4 Household characteristics	9
3.5 Water treatment	9
3.6 Community sensitization	11
3.7 Promoter's engagement with community members	11
3.8 Chlorine dispenser status	11
3.9 Dispenser promoter characteristics	12
4.0 Discussion of Findings, Conclusion, and Recommendations	12
4.1 Discussion of findings	13
4.2 Conclusion	15
4.3 Recommendations	15

## Executive summary

The use of unsafe water has been the primary cause of diarrhea, the main child- Mortality contributor causing 1 in every 10-child deaths (WHO, 2009), yet 58% of diarrhea cases can be averted through safe-drinking water, sanitation and hygiene (WHO, 2014). Use of chlorine treatment reduces diarrhea risk by 40% for regular users. Evidence Action is implementing a community-based “Dispensers for Safe Water (DSW)” program aiming at improving community access to safe drinking water by installing chlorine dispensers at communal water points in rural areas. The installed free chlorine dispensers currently provide 4.7 million people across Kenya, Uganda, and Malawi with access to quality household safe drinking water. This study utilized a cross-sectional design with multi-stage stratified sampling techniques to assess chlorine adoption among communities in Kenya, Uganda, and Malawi. The sample consisted of 73,513 households and 8,319 water points across three countries. Two-stage sampling technique was used to select water points and households to be visited; stratified sampling method where Uganda, Malawi, and Kenya were treated as strata and used a simple random sampling method to select 1.5% water points within each stratum. The simple random sampling method was used to select eight households per water point that were visited every two months to assess; dispenser hardware functionality, community Chlorine adoption rates and availability of chlorine. Results indicated that; female respondents from Uganda and Malawi were respectively 4.3% and 3.7% more likely to chlorinate their water. Educated households were 18% more likely to use chlorinated water than the uneducated. Households with children under 5 years were more likely to chlorinate their water in Kenya and Uganda, unlike in Malawi ( $p=0.001$ ). Furthermore, community knowledge about the chlorine dispensers and other water treatments methods contributed significantly ( $p<0.001$ ) to a household using chlorine across the three countries. In Kenya, households that attended Village Community Sensitization forums were 3.2% more likely to treat their water, while in Uganda and Malawi, households who attended Community Education Meetings were 2.5% and 7.0% respectively more likely to chlorinate their water, unlike in Kenya. Community members who heard from promoters (within 30 days) were 32% in Kenya and 89% in Malawi more likely to chlorinate their water. Rural community adoption of chlorine safe water treatment is associated with gender, education level, community dispenser knowledge, social clubs attendance and access to promoters. Future programs need to prioritize increasing Community’s knowledge and skills of chlorine water treatment mechanism through strengthening community Promoter model, extending water treatment education to children ensuring adequate Chlorine supply chain and leveraging on call centers/ text message as communication channels.

**Keywords:** Dispenser, Chlorine, Mortality, Promoters, Treatment, Logit

## **1.0 Background of the study**

Although access to safe drinking water, sanitation, and good hygiene are fundamental to health, survival, growth, and development; over 1.1 billion people globally do not have access to safe water sources. It is estimated that 3.4 million people annually die globally as a result of water-related diseases hence a leading cause of morbidity and mortality. Waterborne diseases are characterized by diarrhea which involves excessive stooling, often resulting in dehydration and possibly death. Diarrheal disease accounts for about 4.1% of the total daily global disease burden and causes about 1.8 million deaths every year. According (WHO, 2014).

Worldwide, about 780 million people lack access to improved water sources; 66% of the affected live in rural areas where the cost of delivering safe water is high (WHO/UNICEF, 2012). Often, rural inhabitants are underserved with water projects and therefore resort to using water from doubtful sources. Most of community water catchment sites are not usually fenced making them prone to animal and human contamination (Bodzewan, 2014). Even protected wells and communal standpipes fail to deliver safe drinking water in areas with poor sanitation due to fecal infusion contamination. Additionally, rural communities lack trained personnel to carry out health education on the dangers of water-borne diseases.

Water treatment plays an important role in improving the livelihoods of community members by reducing waterborne diseases and mortality rates especially among children under 5 years. A report by WHO (2014) indicated that 58% of the diarrhea cases can be averted through safe-drinking water, sanitation, and hygiene. A number of water treatment methods have been promoted amongst rural households including sedimentation, filtration, disinfection and boiling with different success levels. Historically, water disinfection for the inactivation of waterborne pathogens using chlorine was a preserve for big water supply projects which are usually biased to urban centers. Studies have shown that water treatment using chlorine reduces diarrhea risk by 40% for regular users (Arnold & Colford, 2007). Chlorine residuals prevent water from recontamination up to 72 hours which otherwise would have led to microbial infiltration.

Over time, studies by Evidence Action have proved that water chlorination can be a relatively simple and cost-effective process capable of enabling rural communities to access safe drinking water. The Dispensers for Safe Water (DSW) program provides free chlorine at the water point with an aim of reducing diarrhea rate in children. The program ensures improved access to safe drinking water to community members by installing chlorine dispensers at communal water points in rural areas. Currently, installed chlorine dispensers provide 4.7 million people across Kenya, Uganda, and Malawi with access to safe drinking water. Communities with access to a chlorine dispenser are able to improve the microbiologic quality of their household drinking water by dosing with dilute sodium hypochlorite (chlorine) (treatment at the point of use). The program utilizes a model that incorporates community-based promoters responsible for maintaining the dispensers as well as community sensitization for increased adoption.

Different studies provide evidence for the Dispenser for Safe Water approach in treating water at the point of use. Cochrane Review (2013) evaluated water interventions at point-of-use as well as more traditional water source improvements and concluded that such interventions are more effective in reducing episodes of diarrhea than interventions at the source. According to Arnold and Colford (2007), the point of use of chlorine drinking water treatment reduces the risk of childhood diarrhea by 40% among users. Additionally, a review by the International Initiative for Impact Evaluation (2012) using meta-analysis established that point-of-use water quality interventions are highly effective than water supply or source treatment in reducing diarrhea.

Although point-of-use water quality interventions are highly effective than water supply or source treatment in reducing diarrhea, such is only attainable if high adoption rates are maintained. Although chlorine dispenser has a much higher adoption rate compared to other treatment options,<sup>1</sup> Evidence Actions' DSW program data indicates varying adoption<sup>2</sup> rates averaging at 36% for Kenya, 57% in Uganda and 76% in Malawi as indicated in figure 1. Despite the underlying benefits of eliminating microbial pathogens through water chlorination, continuous provision of chlorine and maintenance of dispensers, experiential program data shows varying success levels over time and across countries. This paper aims at informing the program implementing team on country-specific factors that influence community uptake of chlorine. Additionally, the paper contributes to the existing body of literature on the effectiveness of various water treatment methods.

## **1.1 Study Objectives**

This study aimed at assessing the use of chlorine dispensers for water treatment among rural communities in Kenya, Malawi, and Uganda. Specifically, the study intended to achieve the following objectives;

1. To assess the adoption rate of chlorine dispensers for water treatment among the rural communities in the target areas of in Kenya, Uganda, and Malawi
2. To identify the factors influencing the adoption of chlorine for water treatment among rural communities in Kenya Uganda and Malawi.

## **2.0 Methodology**

### **2.1 Study design and sampling**

The study adopted a repeated cross-sectional design and a stratified sampling technique. The study uses program monitoring data collected bi-monthly between January 2013 and February 2017. Each country; Kenya, Uganda, and Malawi formed a stratum. During every monitoring period, simple random sampling was used to select 1.5% of all water points fitted with a chlorine dispenser from

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<sup>1</sup> Arnold, B. F.; Colford, J. M., Treating water with chlorine at point-of-use to improve water quality and reduce child diarrhoea in developing countries: A systematic review and meta-analysis. *The American Journal of Tropical Medicine and Hygiene* 76, (2), 354-364

<sup>2</sup> Adoption is the proportion of households whose drinking water tested positive for chlorine

each stratum. From each water point sampled, a promoter<sup>3</sup> survey was conducted as well as a spot check was conducted to assess dispenser hardware functionality and water point use. Eight households collecting water from each sampled water point were randomly selected to assess chlorine adoption. Overall 8,319 water points and promoters as well as 73,513 households were interviewed across and Kenya, Uganda and Malawi during the monitoring period.

**Table 1: Sample Description**

	<b>Kenya</b>	<b>Uganda</b>	<b>Malawi</b>
Time period	Apr 2013 – Jan 2017	Aug 2013 – Jan 2017	Jun 2014 – Jan 2017
No. of Households interviewed	49,202	16,768	7,543
No. of water points visited	5,713	1,798	808

*Note: Some of the water points were visited more than once in the different year of evaluation*

## 2.2 Study variables

The dependent variable in the econometric model was chlorine adoption depicted by presence or absence of total chlorine residual (TCR) in sampled water. Powder DPD (N, N-diethylparaphrnylenediamine) reagent causes the water turn pink color upon reacting with chlorine. The variable was coded as 0 when a household tested negative (absence) for chlorine residual and 1 for household testing positive (presence) for chlorine residual. Other variables to be included in the model were selected based on a detailed literature review and bivariate association analysis of the explanatory variables with dependent variable using a chi-square test<sup>4</sup>. Independent variables were drawn from household characteristics, water treatment options, promoter engagement with community members, promoter characteristics and chlorine dispenser hardware status. The variables were a mixture of continuous and categorical variables<sup>5</sup>. Dummy variables<sup>6</sup> were created for categorical variables with more than 2 levels.

Household characteristics included the gender and education level of the household member who is responsible for collecting household water and household size. A household wealth index<sup>7</sup> was also calculated as a proxy of the household economic status. Education level was coded 1 if the member had at least attained primary education while literacy of the household head was coded as 1 if the member was able to read a newspaper and 0 for not able to read. Primary sources of information on water treatment included promoter, community health worker, radio, neighbors/relatives, school, church and village elder. Since this was a nominal variables with more than two categories we set

<sup>3</sup> A promoter is volunteer responsible for filling chlorine in the dispenser and sensitizing the community to chlorinate their drinking water

<sup>4</sup> Chi-square test is used to determine relationship between two categorical variables e.g. adoption (Positive or negative) and gender.

<sup>5</sup> Continuous variable is a variable with infinite number of possible values e.g. age in years. Categorical variable is a variable with finite number of categories/distinct groups e.g. gender

<sup>6</sup> Dummy variable takes the value of 0 or 1

<sup>7</sup> Household wealth index was constructed using principal component analysis as suggested by: Seema.V & Lilani K (2006). Constructing socio-economic status indices: how to use principal component analysis. *Health Policy and Planning*, 21: 459-468

up dummy variables with promoter as the reference. Households with children responsible for water collection were assumed less likely to have treated their water with chlorine. Knowledge about dispenser and the benefit of consuming safe water is also important in understanding community dispenser use.

Knowledge was generated as a score including several variables like use of water points with an installed chlorine dispenser; whether households treated water or not; whether households knew the benefits of drinking chlorinated water; action taken by the household when a dispenser is found empty; households knowledge on the chlorine dosage required to treat 20litre jericans of water; household knowledge of the correct wait time before using chlorinated water after chlorinating the water and household knowledge on correct steps when using chlorine dispenser to assess community knowledge of the dispenser.

Community members who interact with promoters more frequently are more likely to adopt chlorine. Household participation in village community sensitization community education meeting meetings were assumed to likely adopt chlorine. The gender, education level and use of chlorine dispenser by the promoter were also considered key determinants of community chlorine adoption. Having functional chlorine dispensers would increase the likelihood of chlorination by the community. In addition to functionality, the program's chlorine supply chain should be efficient ensuring that dispensers have a sufficient supply of chlorine the monitoring team checks if there is chlorine in the dispenser tank during unannounced visits to the dispenser.

### 2.3 Model specification and analysis

Principal Component Analysis (PCA) were used to compute the household wealth index and data reduction method to determine the weighted linear combination of variables. Key variables used for calculation of wealth index included ownership of a mobile phone, radio, livestock (sheep/goat and cattle) and materials making the house walls, roof and floor. Bivariate analysis of independent variables and total chlorine adoption rates was done through comparing means for continuous variables and cross-tabulation of categorical variables to check variables distribution. A multiple logistic regression model was used to identify factors influencing chlorine adoption.

$$\log it(p) = Ln\left(\frac{p}{1-p}\right) = \beta_0 + \beta_1 x_1 + \beta_2 x_2 + \dots + \beta_k x_k$$

where  $(x_1, x_2, \dots, x_k)$  are the independent variables, and  $(\beta_0, \beta_1, \dots, \beta_k)$  are regression coefficients of independent variables.  $p$  is the proportion testing positive for chlorine residual and  $1 - p$  is the proportion testing negative for chlorine residual. Marginal effects were calculated to quantify the contribution of one independent variable to adoption when controlling for other variables in the model and statistical significance of 10% was used. Variables collinearity and confounding variables were explored before fitting the model using the Pearson correlation for continuous variables and tetrachoric correlation for binary variables. Highly correlated variables ( $p >= 0.8$ ) were omitted in the model while those with a small count were either left out of the model or interacted with other variables.

Logistic regression predicted probability formula and Excel Solver were used to achieve the second objective of optimization adoption. All coefficients of independent variables were used in the formula. Required levels of variables which were statistically significant and can be controlled by the program team were then determined. Levels of independent variables were determined simultaneously. The predicted probability formula is as follows;

$$\Pr(y = 1) = \frac{\exp(\beta_0 + \beta_i x_i)}{1 + \exp(\beta_0 + \beta_i x_i)}$$

where  $\Pr(y = 1)$  is the chlorine adoption probabilities predicted by the fitted model.  $(x_1, x_2, \dots, x_k)$  are the levels of independent variables; mean values of independent variables in the study data were used.  $(\beta_0, \beta_1, \dots, \beta_k)$  are the regression coefficient of independent variable obtained from the regression model. Excel Solver: Constraints of identified variables used were greater than or equal to zero and less than or equal to one;  $0 \leq x_1 \leq 1$ . The minimum chlorine adoption rates used were adoption targets for 2017; 55% in Kenya, 65% in Uganda and 70% in Malawi. This will give the minimum levels of input needed that will result in 2017 target adoption rates.

### 3.0 Study Results

#### 3.1 Background Characteristics

Study results show that majority of respondents were male and over 72% had attained at least primary education across all the three countries, while only 44% of households in Uganda could read. Uganda had the highest household size (5.8) while Malawi (4.7) registered the lowest. Assessment of time taken to fetch water revealed that households in Malawi had the highest proximity to the water source. On average, it took a household member about eight minutes to fetch water in Malawi compared to 18 minutes in Uganda. There more Children under five years in Uganda (1.0 Children) and more Children in Uganda (17%) fetched water from the water source.

Dispenser for Safe Water Project uses rural based promoters to sensitize community to chlorinate their water. In terms of Promoters, in Kenya and Malawi, promoters were mostly women compared to Uganda. At least 9 in 10 promoters across countries had attained at least primary education. More promoters in Malawi treated their water with Chlorine than any other country. In terms of hardware of the dispensers, less dispensers in Malawi had hardware problems (1%) and this is because the program had just started and most dispensers had just been installed.

**Table 1: Distribution of Study Background Characteristics by country countries**

Characteristic		Kenya	Uganda	Malawi
Household can read		74%	44%	83%
Gender of respondent_1= male		91%	84%	95%
Respondent attained primary school		86%	72%	82%
Children mainly collecting water		8%	17%	5%
Dispenser with hardware problems		20%	19%	1%
Time taken to draw water		15	18	8
Source of information about chlorination	1) CHW	7%	6%	79%
	2) Radio	11%	26%	7%
	3) Neighbor/Relative	22%	34%	2%