The complementarity of community-based water and sanitation interventions: evidence from Mozambique

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Introduction

- UN Sustainable Development Goals #6: Access to safe water and sanitation for all

- In 2015, of the rural population in low income countries (World Bank Database)
  - 32% practiced open defecation
  - 44% had no access to improved water sources

- In 2010, of the rural population in Mozambique
  - 55% practiced open defecation (World Bank Database)
  - 35% was using improved water sources (WHO)

Introduction

Complementarity of water and sanitation interventions:

1. Combination can break all the main transmission pathways of fecal contaminants, thereby reducing the disease burden on the population

2. Combination can lead to higher adoption rate of desired hygienic sanitation and water use practices

Here, we only focus on #2: “hygienic practices” (and not on health outcome)

Introduction

Community-Led Total Sanitation (Kar and Chambers, 2008)

- Confrontational approach ("walk of shame", fecal-oral transmission demo)
- Community pledge to build toilet facilities without subsidies
- Open Defecation Free communities campaign and award

- RCT studies of CLTS in recent years found 12% effect on average on the use of toilet facilities (95 CI: -2%, 27%) (e.g. Cameron et al. (2013), Crocker et al. (2017), Pickering et al. (2015), Whaley and Webster (2011))
- These studies investigated the sanitation component (CLTS) only

Research questions and contributions

1. What was the effect of the CLTS sanitation intervention on sanitary practices (latrine ownership and handwashing) among the beneficiaries (ATT) and among the general population (ATE) of the program in Mozambique?
   - We apply a novel identification strategy following Vigh and Elbers (2017) due to the non-randomized intervention allocation

2. Was there a synergy effect between the CLTS and water supply intervention?
   - Uniquely, we estimate the treatment effect of CLTS on the use of improved water points conditional on access
   - We investigate whether the water supply intervention affects the effectiveness of CLTS

Preview of findings

1. Effect of CLTS

- CLTS increased latrine ownership among the beneficiaries (ATT) by 8pp. However, these effects would not carry over to the general population (ATE). The effect was only significant when combined with the water supply intervention (12pp vs 7pp).
- CLTS increased handwashing with soap/ash after defecation by 11pp. We find no evidence of a selection effect (ATT=ATE).

2. Synergy effects

- CLTS increased the use of improved WPs by 15pp conditional on access (36pp in combination with WP intervention).
- Access to improved WP increases the ATT of CLTS on the sanitary outcomes (irrespective of the WP intervention)

The program

The One Million Initiative (2006-2013) interventions in Mozambique:

Water point (WPI)

before

after

Sanitation (CLTS)

before

after

Data collection and interventions

Data collection for the evaluation of the program:

- 3 survey rounds: 2008 (Aug-Oct), 2010 (Aug-Oct), 2013 (Jul-Aug)
- 1600 households in 80 communities
- Random sampling of communities was stratified by their probability of receiving a program intervention (Intended Treatment/Intended Control) and by district

Intervention outcome:

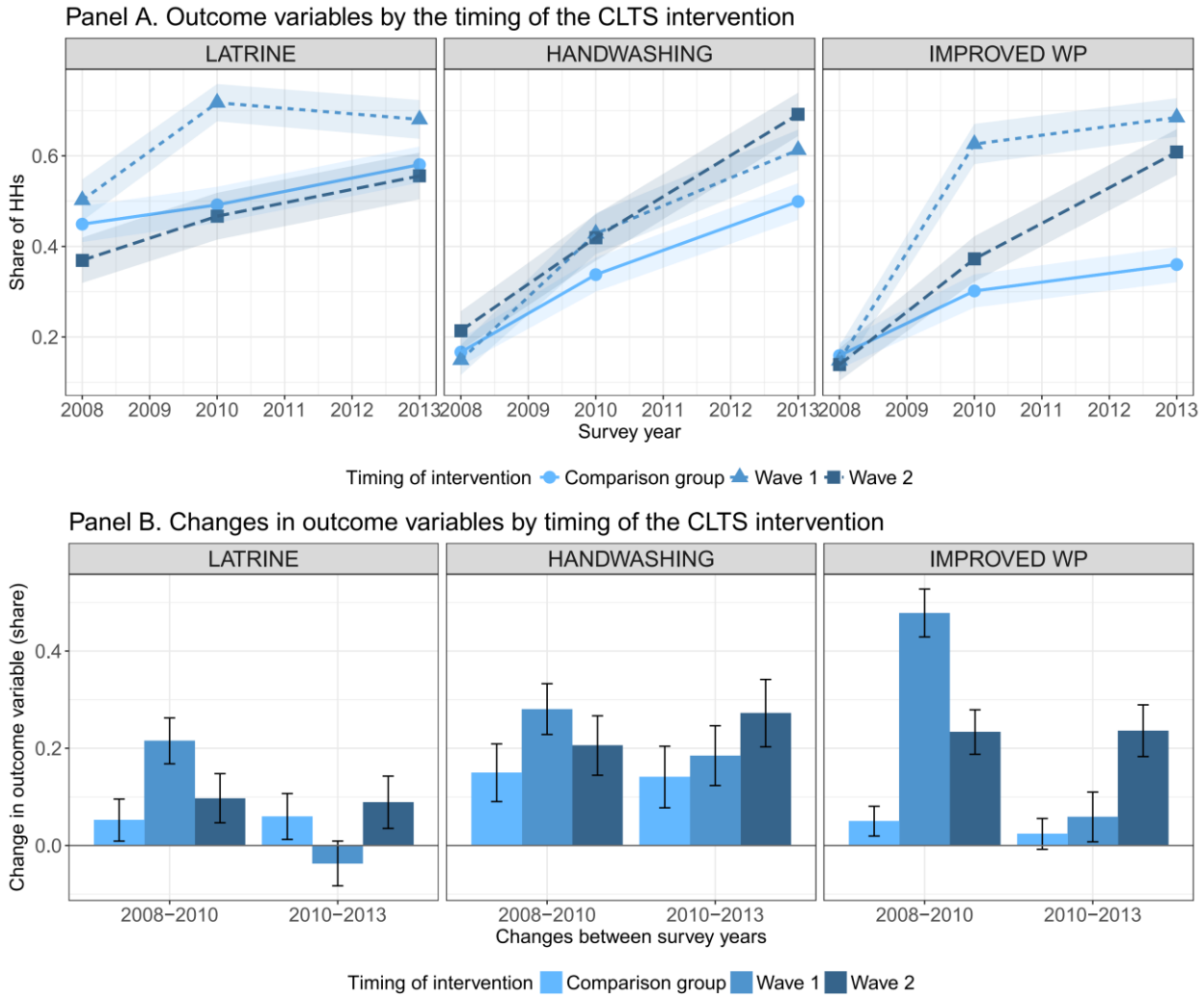
Tables: Cumulative distribution of intervention variables

Year/#Com	CLTS (overall)	WPI (overall)
2008	0	0
2010	23	35
2013	41	47

Year/#Com	CLTS	CLTS&WPI	WPI	Control
2008	0	0	0	22
2010	8	15	20	22
2013	20	21	26	22

Main outcome variables at a glance

Figure 4: Changes in the outcome variables by the period of the CLTS intervention



Panel C. Testing common trend assumption for Wave 2 CLTS intervention between 2008–2010

Identification strategy

Regression model:

$$Y_{it} = \alpha_t + D_{ct}\beta_c + X_{it}\theta + \eta_i + \varepsilon_{it}$$

- Heterogeneous treatment effect in communities (β_c) with $cor(\beta_c, D_{ct}) \neq 0$
- $D_{ct} = 1$ if intervention has been implemented in community *c* before time *t*

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Average Treatment Effect in the population (ATE):

- Assuming that selection is based on the order of the expected size of the treatment effect
- Estimate using correlated random slopes method (Wooldridge, 2010) following Vigh and Elbers (2017):
  - CRS: $E(Y_{it}|D,X) = \alpha_t + D_{ct}\beta + X_{it}\theta + D_{ct} \otimes (\overline{D}_c - \mu_{\overline{D}})\xi + D_{ct} \otimes (\overline{X}_c - \mu_{\overline{X}})\psi + E(\eta_i + \varepsilon_{it}|D,X)$
- $ATE = \beta$

(where $\overline{D}_c = \frac{1}{T}\sum D_{ct}$, $\mu_{\overline{D}} = \frac{1}{N_c}\sum \overline{D}_c$ and $\otimes$ is all cross-products of terms)

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Average Treatment Effect on the Treated (ATT):

- Estimate using difference-in-difference regression (within or first difference transformation):
  - DD: $Y_{it} = \alpha_t + D_{ct}\tilde{\beta} + X_{it}\theta + \eta_i + \varepsilon_{it}$
- $ATT = \tilde{\beta}$
- ATT contains effect of strategic/selective intervention allocation

Effects of CLTS on sanitary outcomes

Effect of CLTS on sanitary outcomes

Table 6: Effect of CLTS was higher when implemented together with the WP intervention

	Treatment effect estimates					
	Latrine ATT	Latrine ATT	Latrine ATE	HW ATT	HW ATT	HW ATE
	(1)	(2)	(3)	(4)	(5)	(6)
CLTS	0.069	0.079	−0.059	0.097**	0.070	0.091
	(0.048)	(0.057)	(0.078)	(0.049)	(0.053)	(0.104)
CLTS&WPI	0.115**	0.122*	0.010	0.157***	0.133**	0.085
	(0.049)	(0.063)	(0.072)	(0.054)	(0.061)	(0.136)
WPI	0.029	0.009	0.038	−0.013	−0.042	−0.136
	(0.030)	(0.030)	(0.075)	(0.045)	(0.050)	(0.092)
Mean dep.var.	0.541	0.077	0.541	0.379	0.202	0.379
Observations	4206	2667	4206	4170	2632	4170
R^2	0.068	0.051	0.072	0.181	0.105	0.182
Regression model	DD	DD	CRS	DD	DD	CRS
Estimator	FE	FD	FE	FE	FD	FE
P-value($H_0 : \beta_{CLTS} = \beta_{C\&W}$)	0.428	0.566	0.516	0.287	0.336	0.973
P-value($H_0 : \xi_{CLTS} = 0$)			0.078			0.970
P-value($H_0 : \xi_{C\&W} = 0$)			0.169			0.511

Note: *p<0.1; **p<0.05; ***p<0.01

Notes:
Latrine = latrine ownership
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Standard errors corrected for clustering at community level. All regressions control for HH size, wealth index, education and year.
Sample includes HHs participating in at least 2 survey rounds.

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Effect of CLTS on the use of improved WP (conditional on access)

WP intervention increased access to improved WPs

Table 8: WP intervention increased the percentage of communities with a functioning improved WP

	2008 (%)	2010 (%)	2013 (%)	Sample size
No WPI	42.4	45.5	46.9	33
Wave 1 WPI	20	82.9	91.4	35
Wave 2 WPI	8.3	33.3	75	12

Notes:
Table reports the percentage of communities with a functioning improved WP accroding to the period of the WP intervention (WPI).

Table 9: Not all households used the improved WP when it was available

	2008 (%)	2010 (%)	2013 (%)	Total (%)
Manica	44.1	63.1	73.8	63.2
Sofala	36	71.8	73.8	66.6
Tete	55.8	74.1	74.5	71.9
Total	45.5	68.8	74.1	67.1
Sample size	440	960	1,119	2,519

Notes: Table reports the percentage of households using an improved WP conditional on its availability in the community.

Effect of CLTS on use of improved WP (conditional on access)

Table 14: Effect of CLTS was higher when implemented together with the WP intervention (conditional on the availability of improved WPs)

	Dependent variable:			
	Use of improved WP			
	(1)	(2)	(3)	(4)
CLTS	0.145*	−0.101	0.149	−0.225*
	(0.086)	(0.104)	(0.152)	(0.125)
CLTS&WPI	0.363***	0.490***	0.368***	0.342***
	(0.118)	(0.106)	(0.070)	(0.093)
WPI	−0.002	−0.345		
	(0.091)	(0.245)		
Mean dep.var.	0.709	0.709	0.573	0.575
R^2	0.121	0.131	0.195	0.206
Controls for traditional WP	No	No	Yes	Yes
Treatment effect	ATT	ATE	ATT	ATE
P-value($H_0 : \beta_{CLTS} = \beta_{C\&W}$)	0.095	0.000	0.176	0.000
P-value($H_0 : \xi_{CLTS} = 0$)		0.057		0.000
P-value($H_0 : \xi_{C\&W} = 0$)		0.365		0.917
Observations	1,642	1,642	1,071	1,068

Note: *p<0.1; **p<0.05; ***p<0.01

Notes:
All regressions control for IWP characteristics, HH size, wealth index, education, year and community fixed effects.
Standard errors are robust to clustering, heteroskedasticity and serial correlation.
Sample includes all HHs in communities where an improved WP (1&2) and both improved and traditional WP (3&4) were available in the given survey round.

Effect of CLTS on use of improved WP (conditional on access)

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Synergy effects between the CLTS and WP interventions

Possible explanations of synergy

1. Access to improved WP motivates households to invest in more hygienic practices
   - Hypothesis: Households living closer to improved WP are more likely to start using it, and then also more likely to adopt more hygienic sanitation practices

2. Improved WPs reduce the time and effort it takes to fetch water, which free up resources to adopt more hygienic sanitation practices
   - Unlikely in this study because most households fetch water from less than 1 km

3. Water and sanitation interventions reinforce one another
   - Hypothesis: Households adopt multiple of the desired outcomes jointly when CLTS and WP interventions are delivered together

Effect of CLTS & WPI on joint outcomes (conditional on access)

	Treatment effect estimates						
	LO	HW	IW	LO&HW	LO&IW	HW&IW	LO&HW&IW
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
CLTS (alone)	0.135**	0.102	0.150*	0.126**	0.202***	0.178***	0.178***
	(0.065)	(0.068)	(0.085)	(0.063)	(0.071)	(0.054)	(0.051)
CLTS&WPI	0.131*	0.138	0.414***	0.169*	0.271***	0.242***	0.195**
	(0.074)	(0.096)	(0.134)	(0.103)	(0.096)	(0.086)	(0.091)
WPI (alone)	−0.006	−0.023	0.035	−0.0004	0.093**	0.136	0.100
	(0.043)	(0.121)	(0.078)	(0.080)	(0.044)	(0.115)	(0.075)
Trend 2008-2013	0.069	0.299***	0.060	0.237***	0.054	0.177***	0.139***
	(0.050)	(0.070)	(0.071)	(0.055)	(0.058)	(0.053)	(0.041)
Mean dep.var.	0.568	0.438	0.708	0.280	0.441	0.336	0.225
Observations	2190	2182	1645	2182	1645	1641	1641
R^2	0.065	0.122	0.132	0.141	0.087	0.119	0.119
Regression model	DD	DD	DD	DD	DD	DD	DD
Estimator	FE	FE	FE	FE	FE	FE	FE
P-value($\beta_C = \beta_{C\&W}$)	0.966	0.723	0.065	0.693	0.514	0.480	0.860

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WPI (alone)	−0.006	−0.023	0.035	−0.0004	0.093**	0.136	0.100
	(0.043)	(0.121)	(0.078)	(0.080)	(0.044)	(0.115)	(0.075)
Trend 2008-2013	0.069	0.299***	0.060	0.237***	0.054	0.177***	0.139***
	(0.050)	(0.070)	(0.071)	(0.055)	(0.058)	(0.053)	(0.041)
Mean dep.var.	0.568	0.438	0.708	0.280	0.441	0.336	0.225
Observations	2190	2182	1645	2182	1645	1641	1641
R^2	0.065	0.122	0.132	0.141	0.087	0.119	0.119
Regression model	DD	DD	DD	DD	DD	DD	DD
Estimator	FE	FE	FE	FE	FE	FE	FE
P-value($\beta_C = \beta_{C\&W}$)	0.966	0.723	0.065	0.693	0.514	0.480	0.860

Note: *p<0.1; **p<0.05; ***p<0.01

Dependent variables: LO = latrine ownership, HW = handwashing with soap or ash after defecation, IW = use of improved water point.

Summary of findings

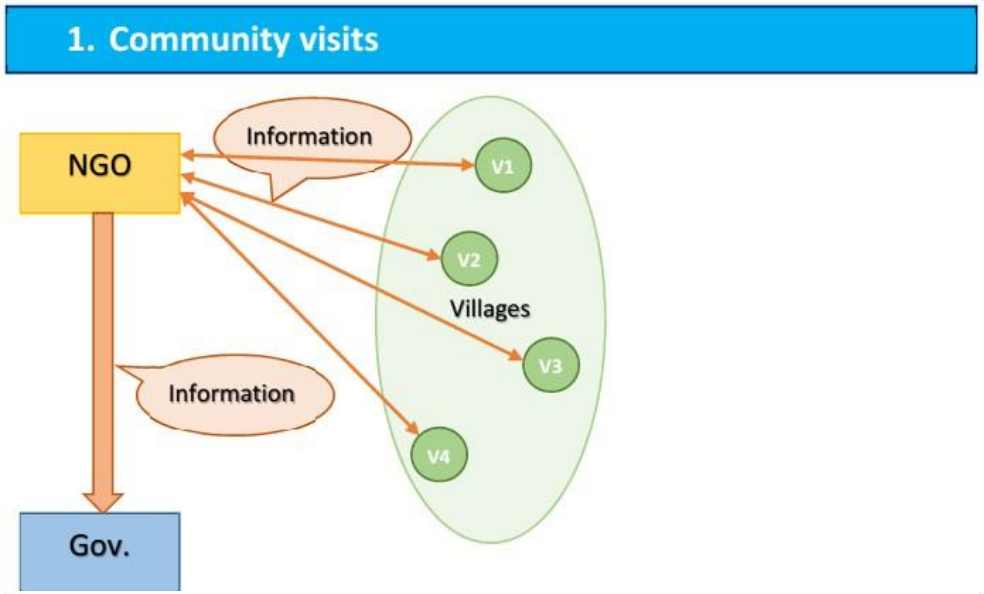
- The treatment effect of CLTS on latrine ownership is affected by selective intervention placement. ATT=8pp reduced to essentially zero ATE.
- Strategic placement of the CLTS interventions increased its effectiveness on beneficiaries.

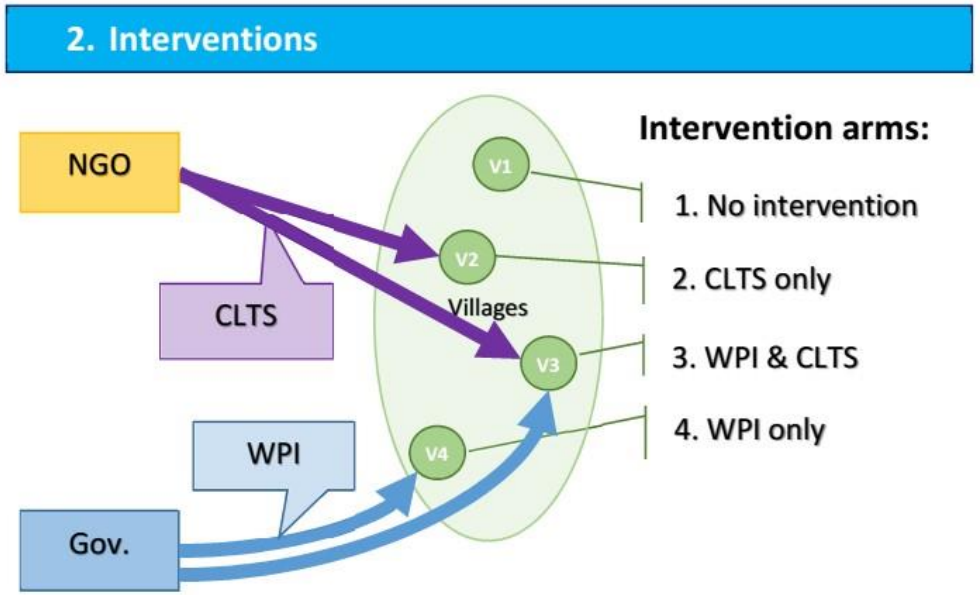
- CLTS is associated with a 11pp increase in handwashing with soap after defecation, and a 15pp increase in the use of improved WPs. The treatment effects were higher when implemented together with the WP intervention (particularly for the use of improved WP=36pp).
- The effect of CLTS on handwashing and use of improved WPs changed little over time, suggesting that these effects would carry over to the general (eligible) population in the program area.

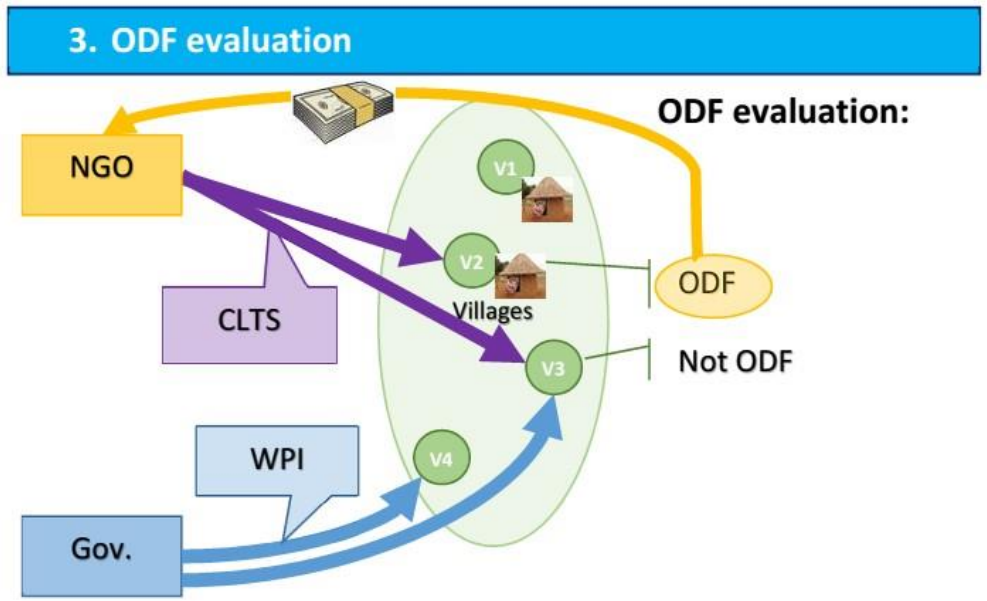
- These results are indicative of a synergy effect between the CLTS and WP interventions.
- The higher treatment effects on sanitary practices (especially latrine ownership) are most likely attributable to access to improved WPs.

Supplementary slides

The program







NGOs were incentivized to select communities with higher expected treatment effect on latrine ownership

Selectivity of interventions

Program design:

- WP interventions were targeted based on communities need for an improved WP
- CLTS implementing NGOs facilitated application for WP and water committee trainings after WP installation
- NGOs selected CLTS communities on unobservable characteristics (for the researchers), in agreement with the community

Findings for selective intervention placement:

- Program districts selected based on need for improved WP (DHS data)
- WP intervention communities selected based on need for improved WP

- CLTS intervention follows location of WP intervention
- Wave 1 CLTS intervention allocated to small communities and communities with higher latrine ownership

Regression model for use of improved WPs

- Households can only choose to use an improved WP when it is available in their community ($W_{it} = 1$).
- WP intervention was the most important factor for increasing the availability of improved WP.

➢ **Analysis of use of improved WP is conditional on its availability in the community.**

We model the households' decision problem on choosing to use of improved WPs (IWP) as:

$$IWP_{it}^{**} = \gamma_3 DI_{it} + \gamma_4 DT_{it} + \gamma_5 QI_{it} + \gamma_6 QT_{it} + \gamma_8 X_{it} + \eta_i + \varepsilon_{it}$$

$$IWP_{it}^{*} = \begin{cases} 1 & \text{if } IWP_{it}^{**} > 0 \\ 0 & \text{if } IWP_{it}^{**} \leq 0 \end{cases} \tag{9}$$

$$IWP_{it} = \begin{cases} IWP_{it}^{*} & \text{if } W_{it} = 1 \\ 0 & \text{if } W_{it} = 0 \end{cases}$$

where DI_{it} and DT_{it} stand for household i's distance to the closest improved and tradtional WP in cluster at time t, respectively. QI_{it} and QT_{it} represent the perceived water quality at the improved and traditional sources.

Effect of CLTS on use of improved WP

	Dependent variable:			
	Use of improved WP			
	(1)	(2)	(3)	(4)
CLTS (overall)	0.184***	0.153**	0.149	0.104
	(0.062)	(0.071)	(0.152)	(0.135)
WPI (overall)	0.106	0.069	0.219	0.083
	(0.070)	(0.089)	(0.162)	(0.133)
Distance to improved WP	−0.130***	−0.132***	−0.301***	−0.311***
	(0.027)	(0.046)	(0.040)	(0.043)
Distance to traditional WP			0.210***	0.211***
			(0.044)	(0.044)
Mean quality at improved WP	0.153***	0.169**	0.018	0.032
	(0.054)	(0.073)	(0.069)	(0.069)
Mean quality at traditional WP			−0.123***	−0.121**
			(0.047)	(0.048)
Mean dep.var.	0.709	0.709	0.573	0.575
R^2	0.117	0.128	0.195	0.206
Treatment effect	ATT	ATE	ATT	ATE
P-value($H_0 : \xi_{CLTS} = 0$)		0.045		0.000
Observations	1,642	1,642	1,071	1,068
Note:				*p<0.1; **p<0.05; ***p<0.01

All regressions control for HH size, wealth index, education, year and community fixed effects. Standard errors are robust to clustering, heteroskedasticity and serial correlation.
Sample includes all HHs in communities where an improved WP (1&2) and both improved and traditional WP (3&4) were available in the given survey round.

Findings:

- Conditional on the availability of improved WP in the community, the WP intervention does not significantly affect its use.
- CLTS increased the prob. of using an improved WP by 18pp among beneficiaries (ATT). Similar effects in the general population (ATE=15pp).
- Effect size is reduced and s.e. is increased in subsample of communities where there are HHs still using traditional WP.
- Including interventions does not change the coef. estimates of the other regressors.