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Sustained effectiveness of automatic chlorinators installed in community-scale water distribution systems during an emergency recovery project in Haiti

Justine Rayner, Travis Yates, Myriam Joseph and Daniele Lantagne

ABSTRACT

In 2012 and 2013, as part of relief-to-recovery programming, Child Relief International partnered with Haiti Philanthropy to install automatic tablet-based chlorinators in 79 gravity-fed water distribution systems in Southeast Department, Haiti. We carried out a mixed methods evaluation to assess sustained effectiveness of chlorinators approximately two years after installation, including 18 site assessments of chlorinators and distribution systems, 180 surveys of households served by those systems and 17 key informant interviews. We tested for free chlorine residual and *Escherichia coli* in samples collected from sources, reservoirs, water access points, and treated and untreated household stored water. We found: 83% of chlorinators were in operational condition, although water pressure was sufficient to operate chlorinators at only 56% of sites; 0% of chlorinator sites had tablet stock; and, while 86% of households reported using water from distribution systems with a chlorinator, 0% of household drinking water was safe to drink because of chlorinators. Reasons why the chlorinator project did not achieve intended sustained effectiveness included: lack of accountability for infrastructure maintenance; lack of tablet access; and lack of effective community management systems. We recommend future implementers of centralized water treatment systems in relief-to-recovery contexts consider these three components necessary for sustainability.

Key words | automatic chlorinators, centralized water treatment, evaluation, relief-to-recovery, sustained use, water quality

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INTRODUCTION

In 2010, two major emergencies occurred in Haiti, an earthquake on January 12, 2010 that killed over 200,000 and left another 2 million people homeless, and a cholera outbreak that began in October 2010 and has since infected over 750,000 and killed over 9,000 people (Gelting *et al.* 2013; Le Ministère de la Santé Publique et de la Population [MSPP] 2016). Following these two emergencies, there was significant international interest and response in providing safe water and sanitation to the Haitian population. Currently, only 48% of rural and 65% of urban households have access to an improved water source in Haiti (World Health Organization/United Nations Children's Fund [WHO/UNICEF] 2015).

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Water from improved sources, however, is not always microbiologically safe for drinking (Bain *et al.* 2014; Patrick *et al.* 2013). Household water treatment (HWT) can improve drinking water quality – from both improved and unimproved sources – until such time as reliable infrastructure is developed. The most common HWT method used in Haiti after the emergencies is chlorine. Of the 71% of Haitians who reported treating their drinking water, the majority (96%) reported using chlorine-based products (Cayemittes *et al.* 2013). In studies conducted in Haiti after the emergencies, correct use of chlorine-based HWT products was confirmed in 13–92% of households surveyed, indicating a wide range of program effectiveness (Harshfield *et al.* 2012; Lantagne & Clasen 2012, 2013;

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Patrick et al. 2013). Well-managed, centralized treatment and distribution systems can result in consistently treated water supply and reduce the burden of treating water at the household level.

In Haiti, water supply infrastructure had been installed by various organizations over time, and thus, design, quality, functionality and level of community management differed. The Haitian government agency responsible for water supply and sanitation, Direction Nationale de l'Eau Potable et de l'Assainissement (DINEPA) was established just months before the earthquake (Gelting et al. 2013). At the national level, DINEPA has the responsibility to develop and regulate the water and sanitation sector, and decentralized regional offices are responsible for existing infrastructure, policy implementation, resource monitoring, and system operator supervision. With support from department level DINEPA staff and technical advisors, local water committees (termed Comité d'Approvisionnement en Eau Potable et l'Assainissement) are responsible for community water system management.

In 2012 and 2013, during transition from emergency relief into the recovery stage, Child Relief International (CRI) partnered with local organization Haiti Philanthropy to initiate, coordinate and maintain the 'The Haiti Southeast Clean Water Project'. In this project, 79 Bio-Dynamic Model LF 500 chlorinators (chlorinators) were installed throughout the Southeast Department, selected for the prevalence of community-scale, gravity-flow water distribution systems. Systems typically comprise a concrete water reservoir, fed by a protected mountain spring, and a piped distribution network to private connections and access points such as attended kiosks or stand-alone water access points. The chlorinator technology was selected for ease of installation on existing systems, thus resulting in safe water reaching communities relatively quickly.

Chlorinators are automatic, gravity-fed tablet-feeders installed inline in a water system with intermittent or continuous flow (Figure 1). In Haiti, a diversion line with a control valve directs a portion of water to flow through the chlorinator before entering the reservoir. Up to 20, 3″ diameter, 1″ tall chlorine tablets can be loaded into the chlorinator and as water flows through, it comes into contact with the lower tablets, thus chlorinating the water. As the tablets dissolve, additional tablets in the canister fall into place. Chlorinators can theoretically operate unattended for several weeks without requiring maintenance.

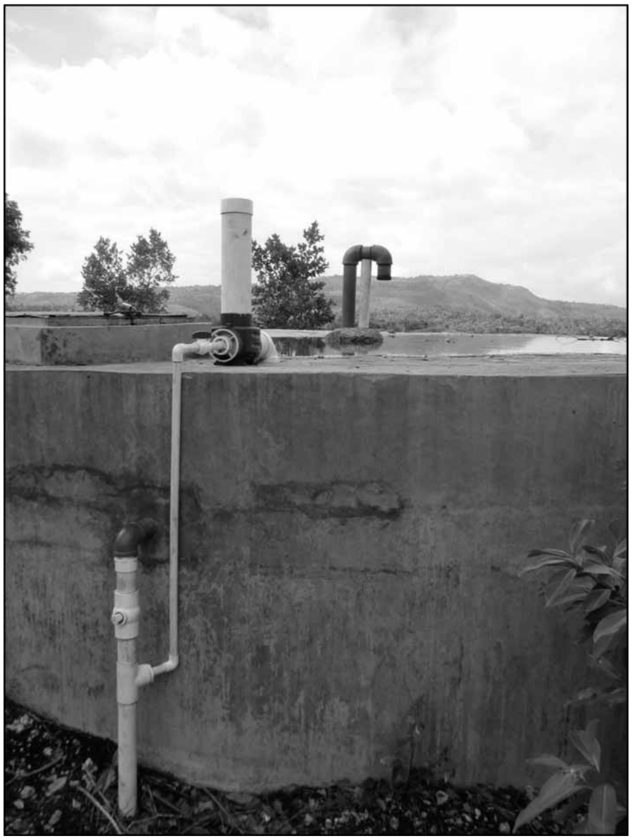

Figure 1 | A chlorinator installed on a reservoir in Southeast Department, Haiti.

In addition to chlorinator installations, the project included: (1) identification and training of chlorinator managers; (2) establishing or working with existing community water committees; (3) educating communities about chlorinators; and (4) working with DINEPA to transfer on-going operation and maintenance to DINEPA at project end in 2013. At project end, an estimated 350,000 beneficiaries were reached by the chlorinator project, although evaluation to confirm this number was not completed. The objective of this research was to assess the sustained effectiveness of chlorinators approximately two years after installation.

METHODS

A list of 48 locations where chlorinators had been installed ('sites') was provided to the research team by Haiti Philanthropy. We randomly selected 20 sites using the Excel random number generator and carried out a mixed-methods

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evaluation including site assessments, key informant interviews, household surveys and water quality testing. The study was approved by Tufts University and Haitian Institutional Review Boards. Informed consent was obtained before each interview and household survey.

Site assessments

Assessments were carried out at each selected installation site and of the associated water distribution system. We assessed the operational capacity of the distribution system (i.e. water availability, infrastructure condition, number of points in each system including source(s), reservoir(s) and water access point(s)), the chlorinator condition, and chlorine tablet stock. A chlorinator was defined as in 'operational condition' if it was installed at the time of the visit such that it was either fully operational, or could be if tablets were installed. Where available, a water sample was collected at sources, reservoirs and water access points. Water was tested on-site for free chlorine residual (FCR) using a Hach® Color Disc (range 0.0–3.5 mg/L) and DPD-1 powder reagents (Loveland, CO), and tested centrally for *E. coli* as described below.

Key informant interviews

Interviews were carried out with Haiti Philanthropy staff, chlorinator managers and government officials in Haitian Creole. Haiti Philanthropy staff coordinated meetings with chlorinator managers. Where chlorinator managers were not available during the time of visit, an individual with knowledge of systems operation was interviewed. The interview guide consisted of a maximum (depending on respondent role) of 78 open-ended questions, including personal background, water and sanitation knowledge, role in health promotion, role in chlorinator operation and maintenance and promotional activities undertaken. Answers, comments and quotes were recorded on paper forms and data were entered into Microsoft Excel and coded by theme. Key quotations were extracted for identified common themes.

Household surveys

Household surveys were carried out in Haitian Creole by trained Haitian enumerators. At each chlorinator site, enumerators started at the house nearest a water access point, selected by convenience sampling, and then visited every other house until 10 surveys were completed. At each house, a 30-minute survey was carried out, consisting of 56 questions on demographics, drinking water knowledge and practices, drinking water access and storage and knowledge about the chlorinator. After the survey, stored untreated and treated water (if available) was tested on-site for FCR by the enumerator as described above and samples were collected for *E. coli* testing as described below.

Water quality testing

Water samples from sources, reservoirs, water access points and households were collected aseptically in Whirl-Pak™ bags with sodium thiosulfate (Nasco, Ft. Atkinson, WI), stored on ice and processed within 12 hours of collection. Samples were tested for *E. coli* using membrane filtration. Samples were diluted appropriately with sterile buffered water, filtered aseptically through a 45-μm Millipore filter (Billerica, MA) using a portable Millipore filtration stand, placed in a plastic Petri-dish with a pad soaked in mColiBlue24® media and incubated at 35–37 °C for 24 hours. Sterile buffered water controls were tested every 20 plates, and 10% of samples were duplicated for quality control. Plates were considered countable at <200 colonies. Water was considered 'safe' if FCR was ≥0.2 mg/L and *E. coli* was <1 CFU/100 mL. *E. coli* results were grouped by WHO risk classification levels of: <1 CFU/100 mL as 'in conformity', 1–10 CFU/100 mL as 'low risk', 11–100 CFU/100 mL as 'medium risk' and >100 CFU/100 mL as 'high risk' (WHO 1997). Groups were compared using Fisher's exact test (due to the small sample size) for categorical variables. Lastly, *E. coli* results were analyzed by computing the geometric mean, stratified by community (with values of <1 replaced by 0.5 CFU/100 mL) and then using a paired *t*-test of log-normalized data to compare groups. Differences were considered statistically significant at $P < 0.05$.

Overall evaluation metrics

Four evaluation metrics were used to assess sustained effectiveness of the chlorinator program, including the percentage of: (1) chlorinators in operational condition;

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(2) chlorinators with chlorine tablets in them and with tablet stock; (3) households visited who used water treated by a chlorinator; and (4) household stored water that was safe to drink because of the chlorinator.

RESULTS

From July 28–August 14, 2015, 18 site assessments, 17 key informant interviews and 180 household surveys were carried out with 226 water samples tested (57 from water distribution systems and 169 from households). Two sites were not visited due to transport and time constraints.

Site assessments

Due to insufficient water supply (22%) or infrastructure damage (17%), 39% of communities visited were not being reached by the chlorinator project at the time of the site visits (Table 1). At three reservoirs, a calcium hypochlorite (HTH) powder chlorine treatment system had been installed in addition to the chlorinator. In total, the 18 sites had 140 associated water access points, averaging 7.8 access points per system (range 2–15). Of these 140 points, 34% had water at the time of visit. Please note, water may have been collected by households at a different time or day and/or from an alternate water access point in the system. The reasons for no water at access points included: damage to the distribution system and/or access point; insufficient water or water pressure; or systems being turned off due to water rationing or to encourage communities to pay for water.

At the time of the visit, 94% ($n = 18$) of chlorinators were installed, and 83% were undamaged (Table 1). There were chlorine tablets in 11% of chlorinators, but these were not functioning either because water pressure was insufficient to direct water past the tablets or the diversion valve was closed. No chlorinator site had tablets in stock (0%).

Key informant interviews

Seventeen key informant interviews were conducted. While most respondents reported multiple roles, the majority were chlorinator managers (94%) or water committee members (77%). Other respondents included DINEPA local or department level staff, a plumber and a community leader. All respondents were male, aged 18–61 and native to the community. Educational attainment ranged from seventh grade to university level. Respondents reported requiring an average of 30 tablets per month in the dry season (range 6–96) and 48 in the rainy season (range 6–160) to maintain operation. Tablets were delivered an average of 4.5 (range 1–8) times between September 2012 and April 2015. The average reported time since the last delivery was 15 months before the assessment described herein (range 4–25 months).

Several themes were identified from the interviews, including: (1) preference for the chlorinator; (2) appreciation of economic and health benefits; (3) resistance to paying for water; (4) need for compensation; and (5) need for chlorine tablet supply.

Preference for the chlorinator

All interviewees (100%, $n = 17$) specifically mentioned liking and supporting continued chlorinator use. Nearly half (47%) described chlorinators as 'safe', and all six who mentioned an alternative treatment method, such as adding Aquatabs or another centralized chlorination method, expressed preference for chlorinators. Chlorinators were considered 'easier to use' and 'more reliable' than other methods because they could function without maintenance for several days (35%), which was important because many chlorinator sites were >20 minutes by foot from the community.

Economic and health benefits

The economic benefit of not having to 'treat water at home' or 'buy Aquatabs' was mentioned by 35% of interviewees ($n = 17$). Additionally, community members were described as valuing treated water by not wanting to 'waste the treated water'. One interviewee mentioned perceived health benefits in the community: 'Before the chlorinator, there was malaria, cholera, typhoid and diarrhea, now there is much less'. Please note, health impact was not assessed during this evaluation.

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Table 1 | Site assessments

Site	Sources (#)	Reservoirs (#)	Water access points (#)	Water available/ frequency	Damage	Water access points w/ water (%)	Chlorinator installed	Tablet stock	Safe water at access point	Primary issue
1	2	2	7	No water available/ Source dry	–	0/7 (0%)	Yes	No	n/a	Source
2	1	1	11	No water available/ Source dry	–	0/11 (0%)	Yes	No	n/a	Source
3	2	2	10	Every day/Low flow*	–	2/10 (20%)	Yes*	No	No	Source
4	1	1	3	Every day/Low flow*	Reservoir/ Distribution pipes	1/3 (33%)	Yes*	No	No	Source
5	1	1	4	Limited access to source only	Reservoir/ Distribution pipes	0/4 (0%)	Yes	No	n/a	Network damage
6	1	1	8	Limited access to source only	Reservoir/ Distribution pipes	1/8 (13%)	Yes	No	No	Network damage
7	1	3	9	Rainy: every day Dry: every 4 days	Distribution system	1/9 (11%)	Yes	No	No	Network damage
8	1	1	15	Every day/Low flow	–	6/15 (40%)	No	No	No	Tablets
9	1	1	7	Every day	Chlorinator pipes	6/7 (86%)	Yes	No	No	Tablets
10	1	1	2	Every day	Chlorinator valve	2/2 (100%)	Yes	No	No	Tablets
11	1	1	3	Every other day	–	1/3 (33%)	Yes	No	No	Tablets
12	1	2	15	Every other day	–	5/15 (33%)	Yes	No	No	Tablets
13	2	1	7	Every 3 days	–	1/7 (14%)	Yes	No	No	Tablets
14	1	1	14	Rainy: every day Dry: every 3 days	–	1/14 (7%)**	Yes	No	No	Tablets
15	1	1	7	Every day	–	4/7 (57%)	Yes	No	No	Tablets
16	1	1	5	Every day	–	5/5 (100%)	Yes	No	No	Tablets
17	1	1	6	Every day	–	6/6 (100%)	Yes	No	No	Tablets
18	1	1	7	Not reported	–	5/7 (71%)	Yes	No	No	Tablets
TOTALS:	**21**	**23**	**140**	**13/18 (OK) (72%)**		**47/140 (34%)**	**17/18 (94%)**	**0 (0%)**	**0 (0%)**	

*Pressure was not sufficient for water to flow through the chlorinator diversion pipe.
**System turned off to encourage people to pay for water.

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Resistance to paying for water

Several interviewees (35%, $n = 17$) reported that while DINEPA's new regulation is for consumers to pay for water, fees are rarely collected due to a strong resistance to paying for water and distrust that payments would be appropriately used. Chlorinator managers also described that community members might be upset with, and blame them, when chlorine tablets were not available, despite an unwillingness to pay. Interviewees reported cases where water supply was shut off to 'encourage' households to pay for private taps and water supply. In one community a break in the pipes resulted in a >1-hour walk for community members to reach the source itself. When asked why each household does not contribute 50 Haitian Gourdes (HTG) (1 USD) to repair the pipe, the respondent replied, 'that's not how we do things'. The respondent continued to describe a system of exchange – when an individual would like to achieve something that is bigger than they can accomplish on their own, such as harvesting, friends and neighbors are invited to help and the recipient reciprocates with food and sometimes a small financial gift for those in greater need.

Need for compensation

Chlorinators were often located high on a mountainside requiring a >20-minute walk to reach them. While all chlorinator managers currently volunteer, 47% ($n = 17$) requested compensation to fulfill their duties.

Chlorine supply

Consistent with observations during site assessments, 76% ($n = 17$) of interviewees mentioned either the need for a consistent tablet supply or that the treatment system would be functional if tablets were available. A Haiti Philanthropy staff member was described as the sole contact for tablet supply. When there were no tablets some called DINEPA, but reported little success. The Haiti Philanthropy staff member and DINEPA knew where to buy tablets, but reported the tablets were too expensive at 0.82 USD per tablet.

Household surveys

Demographics

A total of 180 household surveys were carried out, 10 at each chlorinator site assessed. The mean household size was 5.2 people (Table 2). The average respondent age was 38 years and 69% ($n = 180$) were female. The majority of respondents had attended school (79%) and the average educational attainment was just under 10th grade. The majority of houses had concrete floors (91%) and corrugated metal roofs (91%), and 35% had wired electricity. Top reported health concerns were fever (67%) and headache (54%). It should be noted that respondents' health concerns may or may not be water related.

Knowledge, practice and water access

Nearly all respondents (99%) believe you can get sick from water; of those, 71% mentioned diarrhea and 55% mentioned cholera (Table 2). The top reported ways to prevent cholera were drinking safe water (79%) and hand washing (77%). The majority of respondents believe their water is safe to drink when 'they treat it' (90%) and 75% of respondents believed their water was safe to drink at the time of the visit.

Most respondents (91%) reported a protected source as their primary water supply. Primary water supply is from a tap at the house (16%), an access point (not at the house) (62%), directly from protected wells or springs (12%) or from unprotected wells or springs (9%). Lastly, 5% of households reported purchasing drinking water. Over two-thirds (69%) reported collecting water from multiple sources. Water collection points are generally near, with a median 5-minute reported round-trip collection time. Less than one-third (27%) of the 154 respondents who reported using water from the system with the chlorinator reported paying an average 44 Haitian Gourdes (HTG) monthly (0.83 USD) for water supply or delivery.

Chlorinator use and knowledge

Overall, 86% of households reported using water from the system with the chlorinator (Table 2). The most common reasons were, 'it's what we have' (43%), 'it is close' (26%)

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Table 2 | Survey results

Demographics	
Mean people per household (SD)	5.2 (2.3)
Female respondent, % (*n*)	69% (180)
Mean respondent age in years (SD)	38 (16)
Respondent attended school, % (*n*)	78% (180)
Mean highest grade (SD), *n*	9.7 (3.6), 139
Reports female HOH can read, % (*n*)	49% (180)
Reports male HOH can read, % (*n*)	57% (180)
House has concrete walls, % (*n*)	60% (180)
House has concrete floor, % (*n*)	91% (180)
House has metal roof, % (*n*)	91% (180)
Has wired electricity, % (*n*)	35% (180)
Most reported health problem: fever, % (*n*)	67% (180)
Second most reported health problem: headache, % (*n*)	54% (180)
Showed latrine, % (*n*)	81% (178)
Showed hand washing station, % (*n*)	10% (177)
Wash hands with soap, % (*n*)	81% (178)
Wash hands with chlorine, % (*n*)	23% (178)
WASH knowledge, practices and water access	
Thinks can get sick from water, % (*n*)	99% (180)
Top reported sickness from water: *diarrhea*, % (*n*)	71% (178)
Second most reported sickness from water: *cholera*, % (*n*)	55% (178)
Top reported way to know water is safe to drink: *I treat it*, % (*n*)	90% (180)
Believe water in house is safe to drink, % (*n*)	75% (179)
Top reported way to prevent cholera: *drink safe water*, % (*n*)	79% (180)
Second most reported way to prevent cholera: *wash hands*, % (*n*)	77% (180)
Primary point of water collection:	
Access point not at the house, % (*n*)	62% (179)
Tap at the house, % (*n*)	16% (179)
Protected spring or well, % (*n*)	12% (179)
Open spring or well, % (*n*)	9% (179)
Sometimes collects water from alternate source, % (*n*)	69% (179)
Median round-trip time (minutes) to collect water (lower, upper quartiles), *n*	5 (2, 15), 160
Average times per day water is collected (if no on-plot access) (SD), *n*	3.6 (2.6), 148
Chlorinator use and knowledge	
Reported using water from the chlorinator water system, % (*n*)	86% (179)
Frequency of use of water from chlorinator water system	
Always, % (*n*)	53% (156)
Usually, % (*n*)	30% (156)
Sometimes, % (*n*)	17% (156)

(*continued*)

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Table 2 | continued

Never, % (*n*)	1% (156)
Reason for using water from chlorinator	
It is what we have, % (*n*)	42% (158)
It is close, % (*n*)	26% (158)
It is treated, % (*n*)	22% (158)
Other, % (*n*)	15% (158)
Knows what a chlorinator is, % (*n*)	36% (180)
Received information about the chlorinator, % (*n*)	3% (179)
Reported paying for water, % (*n*)	27% (154)
Mean monthly amount in Gourdes pay for water (SD), *n*	44 (33.5), 39
Provided drinking water sample, % (*n*)	98% (180)
Reported sample from chlorinator system, % (*n*)	68% (176)
Reported HWT	
Reported treated at household, % (*n*)	24% (176)
Treatment method:	
Chlorine product, % (*n*)	60% (42)
Ceramic, % (*n*)	29% (42)
Biosand, % (*n*)	7% (42)
Don't know/Other, % (*n*)	5% (42)

HOH = head of household.

and 'it is treated' (22%). While 33% of respondents reported always collecting water from the system, nearly half (43%) reported using alternate sources when there is no water or access points are out of order. Over a third of participants (36%) reported knowing what a chlorinator is, and 3% reported having received information about it.

Water quality

Fifty-seven (57) water samples were collected from sources, reservoirs and water access points. Of 180 households visited, 98% provided at least one stored drinking water sample (Table 2). Of these, 68% were from an access point associated with a chlorinator and 24% reported HWT. Of the 42 respondents reporting HWT, 60% reported chlorination, 29% reported ceramic filtration, 7% reported biosand filtration and 5% reported other/don't know.

Twenty-eight percent (28%) of samples collected from water systems conformed to WHO and Haitian water quality guidelines (<1 *E. coli* CFU/100 mL) and 47%, 23%, and 2% were classified according to WHO risk classifications as low, medium and high risk, respectively (Figure 2). Of household stored water that had not been

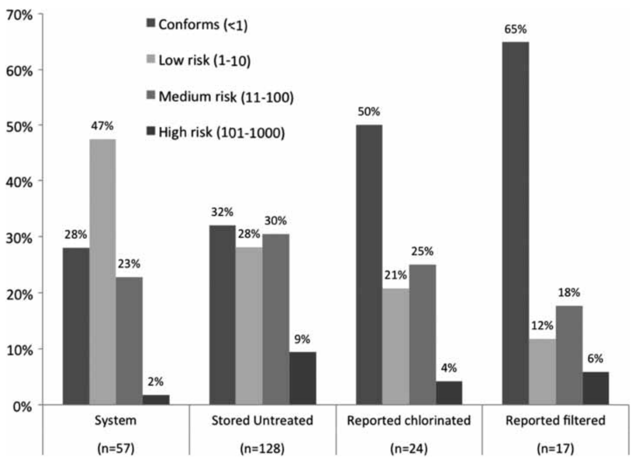

Figure 2 | Water quality classified by WHO risk classifications (*E. coli* CFU/100 mL) by point of sample collection and reported household treatment.

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reported treated at the household level ($n = 128$), 32% of samples conformed to guidelines and 28%, 30%, and 9% were low, medium and high risk, respectively. Household stored water quality results were significantly different from system results (Fisher's exact test, $P < 0.05$).

Geometric mean *E. coli* CFU/100 mL of samples collected directly from water systems was 2.6 *E. coli* CFU/100 mL (min, max: <1, 41, $n = 57$) and from household stored water from the system (not treated at the house), geometric mean was 6.9 *E. coli* CFU/100 mL (min, max: <1, 400, $n = 87$). This difference was statistically significant (paired *t*-test, $P < 0.05$), suggesting deterioration of water quality during storage.

In 72% of samples collected from the system and 68% of household stored, untreated water samples, *E. coli* was detected, thus not complying with Haitian drinking water quality standards. While 75% and 60% of samples can be classified as low risk quality or better, respectively, microbiological water quality from improved drinking water sources can be affected by seasonal variation (Kostyla *et al.* 2015). Therefore during the wet season, fecal contamination, and the risk of diarrheal disease and cholera, could increase. During presence or risk of a diarrhea epidemic, residual protection in piped drinking water supply is recommended (SPHERE 2011). FCR was not detected in any samples collected directly from the system (0%) or from household stored water, that were not reported to have been treated at the house (0%), thus no sample collected from the system or from households met the safe water definition of having <1 *E. coli* CFU/100 mL and FCR of ≥0.2 mg/L from a chlorinator. Please note, as FCR was not detected in any sample, data were not stratified.

Of the stored water samples reported to have been chlorinated at the household level, 42% had ≥0.2 FCR mg/L (mean: 0.34 mg/L, range 0–1.8, $n = 24$) and geometric mean *E. coli* was 2.6 CFU/100 mL (range <1–200). FCR was not detected in any filtered sample ($n = 17$) and geometric mean *E. coli* was 1.9 CFU/100 mL (range <1–202). Fifty percent (50%) of chlorinated and 65% of filtered samples conformed to drinking water quality guidelines, though neither group was significantly different from the household stored water that had not been treated (Fisher's exact test, $P > 0.05$), though this could be due to the small sample sizes. Of note, it is not recommended to filter chlorinated water through biosand or ceramic pot filters as it could affect filter performance or lifespan (Ceramics Manufacturing Working Group [CMWG] 2011; Centre for Affordable Water and Sanitation Technology [CAWST] 2012). Risk classifications are presented in Figure 2.

DISCUSSION

We carried out a mixed-methods evaluation to assess sustained effectiveness of chlorinators two years after installation. We found: (1) 83% of chlorinators were in operational condition, although only 56% were installed on a water system with sufficient operational pressure; (2) 0% of chlorinator sites had tablet stock; (3) 86% of households reported using water from chlorinator distribution systems; and (4) 0% of household water was safe to drink as a result of chlorinator installations. Several reasons why the chlorinator project failed to achieve the intended sustained effectiveness were identified, including: (1) lack of accountability for infrastructure maintenance; (2) lack of tablet access; and (3) lack of effective community management systems. While this project was implemented by the funder as an emergency relief to recovery project, results may have been similar had the project been implemented in a development context.

Lack of accountability for infrastructure maintenance

Chlorinators were installed on a network of gravity-fed systems, which were built over decades by various agencies. Limited water access (several years of drier than average conditions were reported), and infrastructure damage were identified as primary reasons for non-use at 39% of sites. While system maintenance may have been performed in some cases, when essential infrastructure maintenance was not performed, chlorinators by default, became ineffective. With the recent establishment of DINEPA, ownership and accountability for operation and maintenance of community water systems may not yet be well established.

Lack of tablet access

Lack of chlorine tablet access was identified as the primary reason for non-use in 61% of sites. During the program,

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tablets were provided at no cost to chlorinator managers by Haiti Philanthropy. At the project end, it was intended that DINEPA would provide tablets, and when this did not occur due to insufficient resources, Haiti Philanthropy sporadically provided tablets when funding was available. While it is DINEPA mandate that consumers pay for water, just 27% reported paying, and just 3% had received information about chlorinators, suggesting efforts to convince communities to pay for treated water supply, thus contributing to cost recovery, had not been successful.

Furthermore, the supply chain to the Southeast hinged on a single individual, which is neither robust nor sustainable and although tablets could be purchased in Port-au-Prince, no mechanism was established to ensure a supply chain in the post-project period. While it was beyond the scope of this evaluation to carry out an operational cost estimation, the purchase cost of chlorine tablets, calculated using reported seasonal monthly usage estimates extrapolated to 79 reported chlorinator installation sites, was estimated at approximately 30,400 USD annually, excluding transport and distribution costs.

In order to maintain functioning systems, both financial and distribution challenges need to be addressed. Water treatment and delivery needs to be financed through some mechanism, and while DINEPA mandate is for cost recovery through user payments, there appears a reluctance to pay for water. If financial requirements are addressed and chlorine tablet demand created, distribution challenges such as transport and storage, could then be addressed through market-based or public–private partnerships.

Lack of effective community management systems

The chlorinator project in Haiti began during the transition from relief to development, and the program implementers viewed this as a relief to development program. There is significant interest in linking relief to rehabilitation and development programs to ensure program sustainability, although few water programs have successfully accomplished this (German WASH Network 2014). Projects that did successfully transition had: (1) consistent staffing; and (2) community participation and management (Hyder 1996; Macrae *et al.* 1997; Maxwell 1999; Aubee & Hussein 2002; House 2007). Community participation and management was not present in the Southeast context. Recent government efforts to have communities self-manage and pay for water supply are nascent and contentious and, while government policies have been developed to support community participation and management, implementation, accountability and operation and maintenance remain challenging. Without ongoing support to encourage community participation and management it will be a challenge for both the water distribution and chlorinator systems to function sustainably.

The results of this evaluation are limited by lack of data from earlier in the program when chlorine tablets might have been available for comparison, potential courtesy bias from interviewees and the incomplete line list of all chlorinators installed provided to the evaluators. Further, all key informants interviewed were male. It is not clear whether this is representative of those involved in system management. Overall, we do not feel these limitations impacted the results. Although results are disappointing, several strengths were identified, including: the majority of chlorinators remained operational; chlorinated water may have been distributed in some systems when tablets were being provided at the beginning of the program; households in the region say they are receptive to chlorinated water; and there was significant support expressed for chlorinators.

CONCLUSIONS

We investigated a chlorinator program in the Southeast Department of Haiti two years after project completion and found 0% sustained use of the chlorinators due to lack of infrastructure accountability, tablet supply and effective community management systems. These challenges are largely interrelated. In Haiti, government policies have been developed to support community participation and water system management; however, policy implementation, accountability, and operation and maintenance remain challenging. We recommend future implementers of centralized water treatment systems in relief-to-recovery and development contexts consider, during program-planning stages, these components necessary for sustainability.

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