Water treatment and handwashing practices in rural Kenyan health care facilities and households six years after the installation of portable water stations and hygiene training

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ABSTRACT

Many health care facilities (HCFs) and households in low-and-middle-income countries have inadequate access to water for hygiene and consumption. To address these problems, handwashing and drinking water stations were installed in 53 HCFs with prevention-of-mother-to-child-transmission of HIV programs in Kenya in 2005, and hygiene education was provided to health workers and clinic clients. To assess this program, we selected a random sample of 30 HCFs, observed the percentage of handwashing and drinking water stations that were functional and in use, and after that interviewed health providers and clients about hygiene and water treatment. Results indicated that, six years after implementation, 80.0% of HCFs had at least one functional handwashing station and 83.3% had at least one functional drinking water station. In addition, 60% of HCFs had soap at $\geq$ one handwashing stations, and 23.3% had $\geq$ one container with detectable free chlorine. Of 299 clients (mothers with $\geq$ one child under five), 57.2% demonstrated proper water treatment knowledge, 93.3% reported ever using water treatment products, 16.4% had detectable chlorine residual in stored water, and 89.0% demonstrated proper handwashing technique. Six years after program implementation, although most HCFs had water stations and most clients could demonstrate proper handwashing technique, water stored in most clinics and homes was not treated.

Key words | handwashing, health care facilities, integrated water and hygiene, WASH and health facilities

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INTRODUCTION

In low-and-middle-income countries, health care facilities (HCFs) lack reliable access to water, sanitation, and hygiene (WASH) infrastructure. Data from 54 countries show that 38% of HCFs do not use an improved water supply, 19% do not have access to improved sanitation, and 35% do not have handwashing facilities (WHO 2015). Consequently, health workers are unable to wash their hands between patients or provide safe drinking water for administration of oral medication. These deficiencies increase the risk of health facility-acquired infections (HAI), which occur two to 20 times more frequently than in developed countries (Allegranzi & Pittet 2007; Nejad *et al.* 2011). The recent Ebola epidemic in West Africa has highlighted the risk to health workers of poor WASH access in HCFs (Forrester *et al.*

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2014). In response to this problem, the Sustainable Development Goals include 100% coverage of HCFs with WASH infrastructure by 2030 (Joint Monitoring Program 2014).

Poor WASH conditions are responsible for an estimated 88% of diarrheal episodes, which included an estimated 502,000 deaths in 2012 (Prüss-Üstün *et al.* 2004, 2014). Among people living with HIV/AIDS, diarrhea is an important cause of morbidity and mortality, with disease rates up to six times greater than in immunocompetent populations (Lule *et al.* 2009; Yates *et al.* 2015).

Because construction of WASH infrastructure can be expensive and time-consuming, there is an urgent need to intervene in the short-to-medium term to reduce the risk of HAI in HCFs. To address this need and increase access to safe water among immunocompromised populations, in 2005, a hygiene and drinking water program, called the Safe Water Program, was initiated in HCFs in Siaya District, Nyanza Province, Kenya. At that time, households in Nyanza Province had poor access to improved water sources (34%), inadequate access to improved sanitation facilities (33%), the highest HIV/AIDS prevalence in Kenya (14%), and second highest rate of diarrhea for children under five (ICF 2010).

The Safe Water Program installed handwashing and drinking water stations, consisting of improved storage containers with a narrow mouth, lid, and spigot on a metal stand at a cost of $15 each (Figure 1) in 53 rural HCFs with prevention-of-mother-to-child-transmission (PMTCT) programs or clinics. PMTCT programming at these HCFs included HIV counseling, testing, and treatment, and antenatal services. HCF patient load determined the number of stations installed. Dispensaries and health centers received two handwashing and four drinking water stations, while larger HCFs, such as the outpatient areas of hospitals, received four handwashing and six drinking water stations. Health workers were also given a three-month starter supply of WaterGuard®, a socially marketed locally available 1.2% sodium hypochlorite water treatment solution which, for US$0.25, treats 1,000 liters of water. These health care workers also received training on proper handwashing and water treatment and were encouraged to communicate this information to their patients during PMTCT visits, as HCFs can be an important platform for teaching communities about the importance of WASH interventions (Parker 2006; Bennett 2015).

Figure 1 | Water station consisting of improved storage container with a narrow mouth, lid, and spigot on a metal stand.

In 2010, Procter & Gamble Co. provided funding for the same program to distribute locally available sachets of P&G Purifier of Water® (hereafter referred to as sachets), a powder that flocculates and disinfects water at a cost of US$0.10 per 10 liters treated, to all 53 HCFs (Chiller *et al.* 2006). Sufficient sachets were provided to treat all water in the clinic. Health workers were asked to use the sachets to treat water in the HCF and to distribute them to PMTCT clinic clients. Community health workers (CHWs) were also given 240 sachets per month to be used for demonstration purposes at households during home visits.

The intervention described in this paper can help mitigate the widespread problem of inadequate access of WASH infrastructure in HCFs in the short-to-medium term, but to be effective it must be acceptable, used regularly, and durable. In 2011, six years after the program started, and within one year of when the sachets were introduced, we assessed the acceptability, performance, durability, and use of water stations, water treatment, and hygiene practices in participating HCFs and client households in the HCF catchment areas.

METHODS

Evaluation design

We conducted an assessment of HCFs, a HCF staff survey, and a household survey in the HCF catchment areas. The

HCF assessment was performed by a member of our team, the HCF staff survey was self-administered, and the household survey was conducted by three enumerators familiar with the area.

HCF selection

We selected a random sample of 30 of 53 total HCFs in Siaya County, Kenya with PMTCT programs or clinics. We stratified HCFs into three types, as classified by the Ministry of Health: hospitals, health centers, and dispensaries (Sreenivasan *et al.* 2014). The number of HCFs of each type selected for the evaluation was proportional to their percentage among all 53 facilities targeted by this program. Due to financial and logistical constraints, we were limited to a single day of data collection at each of 30 sites, which restricted the number of households visited.

HCF assessment

The health facility assessment included unannounced visits to HCFs and interviews with the officer in charge to detail patient load, staff trained on handwashing and water treatment, reported use of the handwashing and drinking water stations, and to make direct observations of the functionality, access, and presence of water in handwashing and drinking water stations, soap for hand washing, and water treatment products. We tested water stored in handwashing and drinking water stations for free chlorine residual (FCR) using the N,N diethyl-p-phenylene diamine (DPD) method (LaMotte Co., Chestertown, MD).

We asked health care workers to identify and accompany us to all handwashing and drinking water stations and counted all stations observed in patient care areas in dispensaries and health centers, and in outpatient departments in hospitals. We defined a handwashing station as 'functional' if it had water present in a covered designated container with a working tap. Our observations of handwashing stations included whether soap was present or not. We also defined a drinking water station as 'functional' if it had water present in a covered container with a working tap, and determined whether stored water had a detectable FCR as an objective measure of treatment.

HCF staff survey

On the day of the visit to each HCF, all health workers present were asked to complete a self-administered questionnaire. The questionnaire inquired in simple language about their knowledge of proper water treatment and handwashing behaviors and client teaching practices.

Household survey

On the day of each HCF visit, three trained enumerators were guided by local CHWs to the community neighboring each HCF to make unannounced visits to ten nearby households with children under five years old. Mothers were targeted for interviews because they were the primary caretaker of children, were all PMTCT clinic clients, and were knowledgeable on household water and hygiene practices. Enumerators administered a questionnaire in the local language, Dholuo, that included questions about the family's size, household assets, use of the local health facility, knowledge of hand-washing procedures, use of water treatment products, presence of water treatment products in the home, and instruction received from health facility staff. We also observed water storage containers, water treatment products, handwashing stations, maternal handwashing procedure, presence and cleanliness of a hand towel (a towel was considered clean if it appeared free of dirt or other contaminants), and tested stored water for the presence of FCR. A water storage container was considered improved if it was covered and had a spigot or narrow opening.

Data analysis

Data were analyzed using SAS 9.4 software (SAS Institute, Cary, NC). We assessed water treatment and hand hygiene knowledge and behaviors among health facility staff descriptively (e.g., without a test for significance). We compared water storage, treatment, and handwashing variables across the three types of HCFs using design-adjusted Rao–Scott Chi Square tests. The unit of analysis for the HCFs was the health facility, but because most HCFs had more than one water station, we also used water stations as a unit of analysis to provide a more precise indication of the extent of water treatment practices.

Ethical considerations

The Institutional Review Board (IRB) of the Centers for Disease Control and Prevention determined that because this evaluation assessed a proven public health practice, it did not require IRB review. The Kenya Ministry of Health approved the assessment protocol and facilitated access to each HCF by accompanying us to each HCF. Written informed consent was obtained from participating health workers and mothers who participated. Personal identifiers were not collected.

RESULTS

HCF assessment

The 30 HCFs randomly selected for this evaluation included 2 hospitals, 11 health centers, and 17 dispensaries. The median number of health workers per facility was 5 (range: 1–42); 50% of health workers were female. The median number of patients seen per day in PMTCT clinics at the 30 facilities was 29 (range: 6–60) (Table 1).

The main drinking water sources for the 30 HCFs included rainwater catchment (46.7%), borehole (20.0%), protected spring (16.7%), and piped water (6.7%). The main drinking water source was within the grounds of 23 (76.7%) HCFs and the remaining 7 (23.0%) were within a 30-minute round-trip of their water source. All facilities reported treating water for both handwashing and drinking.

In 2011, 43 (67.2%) of 64 handwashing stations distributed in 2005 were present or replaced with comparable stations; the disposition of the missing handwashing stations is unknown. Among 30 HCFs, 24 (80.0%) had at least one functional handwashing station (Table 1). Of 43 total handwashing stations observed, 36 (83.7%) were functional, and 31 (72.1%) had soap present. Among 30 total HCFs, 18

Table 1 | Median number (range) of patients, beds, staff, and staff trained in health facilities, and total number and functional status of handwashing and drinking water stations, by facility type, PMTCT safe water and hygiene program, Siaya County, Kenya, 2011

	Dispensaries $n = 17$	Health centers $n = 11$	Hospitals $n = 2$	Total $n = 30$
Daily patient population	48 (30–90)	87 (30–150)	195 (90–300)	74 (30–300)
Daily patient population at the clinics	20 (6–45)	30 (10–60)	30 (30–30)	29 (6–60)
Beds	0 (0–0)	10 (0–16)	43 (22–65)	0 (0–65)
Staff	3 (1–6)	7 (4–10)	36 (30–42)	5 (1–42)
Improved water source	16 (94.1)	10 (90.9)	2 (100.0)	28 (93.3)
Total handwashing stations distributed	34	22	8	64
Total handwashing stations present: (functional and non-functional)*	20 (58.9)	21 (95.4)	2 (25.0)	43 (67.2)
No. of functional handwashing stations (% of total)	18 (90.0)	16 (76.2)	2 (100.0)	36 (83.7)
No. of HCFs with at least one functional hand-washing station (with and w/o soap)	15 (88.2)	8 (72.7)	1 (50.0)	24 (80.0)
No. of HCFs with at least one functional hand-washing station with soap	9 (52.9)	8 (72.7)	1 (50.0)	18 (60.0)
Total drinking water stations distributed	68	44	12	124
Total drinking water stations present: (functional and non-functional)*	26 (38.2)	27 (61.4)	6 (50.0)	59 (47.6)
No. of functional drinking water stations (% of total)	16 (61.5)	24 (88.9)	4 (66.7)	44 (74.6)
No. of HCFs with at least one functional drinking water station	13 (76.5)	10 (90.0)	2 (100.0)	25 (83.3)
No. of HCFs with at least one functional drinking water station testing positive for FCR	0 (0.0)	6 (54.5)	1 (50.0)	7 (23.3)
Reported using sachets†	15(60.0)	10 (90.9)	0 (0.0)	25(83.3)
Reported using WaterGuard	15 (88.2)	9 (81.8)	2 (100.0)	26 (86.7)

*Functional was defined as water present in container, working tap, and container covered.
†P&G™ Purifier of Water.

(60%) had at least one functional handwashing station with soap. In 2011, 59 (47.6%) of 124 drinking water stations distributed in 2005 were present or replaced with comparable stations, however the disposition of the missing water stations is unknown. Of 30 HCFs, 25 (83.3%) had at least one functional drinking water station (Table 1). Of 59 total drinking water stations observed, 44 (74.6%) were functional. Seven (23.3%) of 30 total HCFs had at least one drinking water station with detectable FCR in stored water; none of the 17 dispensaries, the smallest type of HCF, had FCR in stored drinking water. Of 44 total functional drinking water stations, 13 (29.5%) had detectable FCR.

Of 30 HCFs, 29 (96.7%) had at least one water station (for handwashing or drinking) with a cover and a working tap. One HCF used unimproved containers (lacking covers or taps) because they had not replaced improved containers with broken taps on water stations.

Respondents from 25 (83.3%) of 30 HCFs self-reported using sachets to treat HCF drinking water; 28 (93.3%) had supplies of free sachets available. Respondents for 26 (86.7%) of 30 HCFs reported ever using WaterGuard and 12 (40%) reported current use; 14 (53.8%) had product available and 5 (19.2%) reported having purchased WaterGuard. FCR was detected in at least one drinking water storage container in seven (23.3%) of 30 facilities, including six health centers, one hospital, and no dispensaries.

HCF staff survey

The 68 HCF staff members who completed a self-administered survey included 49 (71.4%) nurses, 9 (13.2%) clinical officers, 4 (5.9%) public health officers, and 6 (8.8%) 'other health worker' (Table 2). The median age of health staff was 31 years (range 23–56 years) and 43 (64.2%) were female. The time employed by the health facility ranged from one month to 21 years.

Twenty-nine (42.6%) respondents had received formal training from Safe Water Program staff about handwashing, safe water treatment, and safe water storage; 44 (64.7%) reported being trained by colleagues who had been formally trained. Of 68 staff, 76.5% could list appropriate timing for handwashing: before eating, after using a latrine, before preparing food, and after cleaning a child's bottom. Although 92.7% of health workers could list all the steps necessary for proper handwashing prior to drying (lathering with soap, rinsing), only 26.5% mentioned drying hands with a clean towel or air-drying. Of 68 clinic staff, 73.5% correctly identified characteristics of safe water storage containers;

Table 2 | Clinic staff training and knowledge of water treatment and handwashing, by facility type PMTCT safe water and hygiene program, Siaya County, Kenya, 2011

Clinic staff training and knowledge of water treatment†	Dispensary staff† $n = 25$ (%)	Health center staff† $n = 31$ (%)	Hospital staff† $n = 12$ (%)	Total† $n = 68$ (%)
Staff training				
Reported receiving training from Safe Water Program staff on water treatment, handwashing, and water storage	13 (52.0)	11 (35.4)	5 (41.7)	29 (42.6)
Reported receiving training from colleagues on water treatment, handwashing, and water storage	15 (60.0)	21 (67.7)	8 (66.7)	44 (64.7)
Staff knowledge				
Correctly identified the characteristics of safe storage containers*	21 (84.0)	22 (71.0)	7 (58.3)	50 (73.5)
Knew correct sachet water treatment procedure**	9 (36.0)	10 (32.3)	2 (16.7)	21 (30.9)
Knew correct WaterGuard water treatment procedure‡	23 (92.0)	16 (51.6)	6 (50.0)	45 (66.2)
Able to name times when handwashing is needed	21 (84.0)	20 (64.5)	11 (91.7)	52 (76.5)
Reported teaching importance of handwashing and safe water storage‡	24 (96.0)	27 (87.1)	9 (75.0)	60 (88.2)
Reported demonstrating hand-washing to patients	17 (68.0)	17 (54.8)	5 (41.7)	39 (57.4)

*Containers with a narrow mouth, a lid and a spigot.
**Correct water treatment procedure was defined as knowledge of both correct dose, stirring requirement, and correct contact time.
†For all staff training and knowledge variables at least one health care worker from all health facilities responded affirmatively.
‡Rao–Scott Chi Square test $p < 0.05$.

70.6% knew under what conditions water treatment was necessary; 66.2% knew correct water treatment procedure with WaterGuard and 30.9% with sachets; 51.5% knew where to store WaterGuard and sachets. Of 68 HCF staff respondents, 95.1% reported teaching clients about WaterGuard, 90.1% about sachets, and 88.2% about handwashing and safe water storage; 57.4% reported demonstrating handwashing to their clients at handwashing stations (Table 2). The most commonly reported reasons for not teaching included too many patients waiting (27.9%), too much to do with each patient (8.8%), and do not know enough about the topics to teach my patients (8.8%).

Client survey

Demographic information

Of 299 clinic clients interviewed, the median age was 28 years (range: 15–75 years), 100.0% were female, 86.2% were married, and 84% had, at most, a primary school education. The median number of children per household visited was 3 (range: 1–12) with a median number of children under five of 2 (range: 1–5). Household assets reported by respondents included latrine (87.7%), electricity (8.7%), radio (60%), and bike (52%).

Handwashing knowledge and practice

Overall, 70% of respondents reported learning about handwashing at a HCF, 23.1% from a CHW, and 5.7% from the radio. Of 299 clients observed washing hands, 266 (89.0%) used proper washing technique (lathered with soap and rinsed); but only 93 (31.1%) used proper washing technique and dried their hands in air or with a clean towel; 173 (65.0%) improperly dried hands with towels that did not appear clean (Table 3).

Water source and storage

Water sources reported by households included surface water (28.0%), protected well (25.8%), protected spring (23.8%), unprotected well (5.4%), and piped water (5.4%). Upon observation, 86.0% of respondents had an improved water storage container in their home and 79.6% were able to correctly identify containers with narrow mouth, lid, and spigot, as ideal for water storage.

Water treatment

Water treatment methods self-reported by households included sachets-only (17.7%), WaterGuard-only (25.7%), both sachets and WaterGuard (42.1%), and boiling (8.7%). Sachets were observed in 52.7% of homes visited and WaterGuard bottles in 29.7% of homes. Among 262 homes where stored water was present in the home and thus, available for testing, 43 (16.4%) had detectable FCR (Table 4).

Of 299 clients, 80.0% said they received sachets free during a HCF visit and 11.4% reported ever purchasing the product, while 47.8% reported receiving free WaterGuard and 57.5% reported ever purchasing it; 9.7% of clients were able to indicate the correct water treatment

Table 3 | Household handwashing knowledge and practices, by health facility type, PMTCT safe water and hygiene program, Siaya County, Kenya, 2011

Handwashing knowledge and practices	Dispensary clients *n* = 170 (%)	Health center clients *n* = 109 (%)	Hospital clients *n* = 20 (%)	Total *n* = 299 (%)
Learned about handwashing at clinic visit	114 (67.9)	83 (76.1)	11 (55.0)	208 (70.0)
Learned about handwashing from CHW	36 (21.2)	30 (27.5)	3 (15.0)	69 (23.1)
Learned about handwashing from the radio	7 (4.1)	8 (7.3)	2 (10.0)	17 (5.7)
Functional handwashing station in home*	29 (17.4)	24 (22.6)	5 (26.3)	58 (19.9)
Observed handwashing technique				
3 steps: used soap, lathered, and rinsed	154 (90.6)	92 (84.4)	20 (100.0)	266 (89.0)
4 steps: used soap, lathered, rinsed, and dried properly	56 (32.9)	29 (26.6)	8 (40.0)	93 (31.1)

*Soap and water available within 1 meter of each other.

Table 4 | Client household water storage and water treatment knowledge and practices, by health facility type, PMTCT safe water and hygiene program, Siaya County, Kenya, 2011

Water storage and water treatment by method	Dispensary clients n = 170 (%)	Health center clients n = 109 (%)	Hospital clients n = 20 (%)	Total clients n = 299 (%)
Identified containers with narrow mouth, lid, and spigot, as ideal for water storage	137 (80.6)	83 (76.1)	18 (90.0)	238 (79.6)
Improved water storage container observed in home	143 (84.1)	94 (86.2)	20 (100.0)	257 (86.0)
Ever heard about sachets	167 (98.2)	105 (96.3)	18 (90.0)	290 (97.0)
Heard from a clinic	121 (71.2)	71 (65.1)	11 (55.0)	203 (67.9)
Heard from CHW	72 (42.4)	53 (48.6)	7 (35.0)	132 (44.1)
Heard from radio	32 (18.8)	25 (22.9)	4 (20.0)	61 (20.4)
Ever been given sachets*	141 (84.4)	84 (79.2)	7 (41.2)	232 (80.0)
Ever bought sachets*	16 (9.6)	13 (12.5)	4 (22.2)	33 (11.4)
Knowledge of sachet treatment procedure	13 (7.6)	12 (11.0)	4 (20)	29 (9.7)
Ever used sachets*/Reported sachet use*	130 (77.4)	80 (75.5)	11 (61.1)	221 (75.7)
Used day of visit	15 (10.6)	8 (9.2)	0 (0.0)	23 (9.5)
Used day before visit	23 (16.2)	13 (14.9)	0 (0.0)	36 (14.9)
Used more than 1 day ago	75 (52.9)	52 (59.8)	9 (64.3)	136 (56.2)
Sachets observed in home*	103 (61.3)	60 (55.1)	5 (25.0)	168 (56.6)
Ever heard about WaterGuard	165 (97.1)	108 (96.3)	20 (100.0)	293 (98.0)
Heard from a clinic	104 (61.2)	67 (61.5)	11 (55.0)	182 (60.9)
Heard from CHW	61 (35.9)	40 (36.7)	7 (35.0)	108 (36.1)
Heard from radio	49 (28.8)	41 (37.6)	5 (25.0)	95 (31.8)
Ever been given WaterGuard*	77 (46.4)	54 (49.5)	10 (50.0)	141 (47.8)
Ever bought WaterGuard*	90 (54.5)	68 (62.9)	10 (52.6)	168 (57.5)
Ever used WaterGuard*	138 (82.6)	92 (84.4)	16 (80.0)	246 (83.1)
Proper WaterGuard treatment knowledge	89 (52.4)	67 (61.5)	10 (50.0)	166 (55.6)
Reported WaterGuard use*				
Used day of visit	8 (5.5)	6 (6.1)	0 (0.0)	14 (5.3)
Used day before visit	18 (12.3)	12 (12.1)	5 (26.3)	35 (13.3)
Used more than 1 day ago	120 (82.2)	81 (81.1)	14 (73.7)	215 (87.6)
WaterGuard observed in home	46 (27.5)	37 (33.9)	8 (40.0)	91 (30.7)
Confirmed free residual chlorine*	17 (11.7)	22 (22.2)	4 (22.4)	43 (16.4)

*Missing values were not included in the calculation of frequency percentage.

procedure for sachets compared to 55.6% for WaterGuard. The information sources about sachets reported by respondents included HCF (67.9%), CHW (44.1%), and radio (20.4%) and for WaterGuard were HCF (60.9%), CHW (36.1%), and radio (31.8%) (Table 4).

There were several barriers to use reported by survey respondents. Of 71 survey respondents who reported that they did not use sachets, 34 (47.9%) said they used another method, 8 (11.3%) indicated it had a bad taste or smell, 7 (9.9%) said they were too busy to treat, 5 (7.0%) did not know where to purchase sachets, 5 (7.0%) had no sachets in the house, 5 (7.0%) believed their water was already safe, and 3 (4.2%) said the cost was too high. Of 50 survey respondents who said they did not use WaterGuard, the most commonly reported barriers were use of another method by 15 (30.0%), bad taste or smell by 10 (20.0%), high cost by 7 (14.0%), water is already safe by 4 (8.0%), do not know where to purchase solution by 3 (6.0%), no solution in the house by 3 (6.0%), and too busy to treat by 2 (4.0%).

DISCUSSION

Findings of this assessment suggest that after approximately six years, 67.2% of handwashing stations distributed and 47.6% of drinking water stations distributed to HCFs providing PMTCT services were still present or replaced with comparable stations. These results are consistent with the findings of similar projects that have shown that health workers will maintain handwashing and drinking water stations that are essential to the hygienic delivery of health care services (Sreenivasan *et al.* 2014; Bennett *et al.* 2015). In addition, these findings provide evidence of longer-term use of these water stations. However, we do not know whether missing water stations had broken, were lost, or stolen. The higher percentage of handwashing stations still in service, compared to drinking water stations, may have resulted from greater need or perceived importance of hygiene stations.

Despite health workers' demonstrated understanding of the importance of having functioning drinking and handwashing stations, most HCFs lacked the necessary supplies to ensure adequate hygiene and safe drinking water. Only half of the HCFs had soap present at handwashing stations and only seven of 13 health centers and hospitals, and none of the dispensaries, had confirmation of water treatment as shown by the presence of FCR in stored drinking water. The lack of soap for handwashing and chlorine treatment of drinking water (despite the availability of water treatment products through free distribution or in local markets) in half or more of HCFs, increased the potential risk of HAI. In particular, the lack of water treatment exhibited in all dispensaries is of concern, and likely reflects the poor staffing and heavy patient loads that hinder overburdened health workers from taking on other responsibilities. Although there was no comparison group in this assessment, results were similar to follow-up evaluation data from a program elsewhere in western Kenya that included baseline and follow-up data (Bennett *et al.* 2015).

The discordance in reported and confirmed use of water treatment products in HCFs had several possible explanations. One possibility is courtesy bias, which typically leads to over-reporting of desirable behaviors. Second, a number of HCFs reported storing water until depletion, which could take up to several days, allowing residual chlorine to dissipate and resulting in an underestimate of water treatment. Third, the water used in some heath facilities was turbid, with high chlorine demand that would reduce the likelihood of detecting FCR in stored water (Ogutu *et al.* 2001; Lantagne 2008; Lantagne *et al.* 2008). Fourth, it is possible that free distribution of water treatment products was not sufficient on its own to create sustained behavior change. Clinic staff cited insufficient personnel, lack of time, high patient loads, and broken containers as reasons for their inability to treat facility water on a regular basis. Finally, less than a third of HCF staff could correctly describe the sachet water treatment procedure, which suggests that many of them did not frequently use the product for water treatment, or did not use it correctly.

Results of the household survey suggest that a high percentage of clients reported receiving training in handwashing and water treatment from nurses and CHWs and, consequently, similarly high percentages of clients demonstrated proper handwashing technique, water treatment knowledge, and a previous trial of water treatment products. The design of this study did not permit a determination of whether clinic-based teaching by health staff or household teaching by CHWs facilitated knowledge transfer to clients. However, other research suggests that repeated home visits by CHWs to reinforce water treatment and handwashing behaviors taught by nurses appeared to enhance adoption of the behaviors (Sheth *et al.* 2010; Loharikar *et al.* 2013). The high rates of patient teaching that took place in spite of understaffed and overburdened HCFs, underscores the importance of incorporating CHWs in water, sanitation, and hygiene programs (Skinner *et al.* 2005; WHO 2006; Kinfu *et al.* 2009).

As in the HCFs, current confirmed household use of the products, as measured by the observation of FCR in stored water, was low at 16.4%. The findings of high knowledge levels but low product use were consistent with other programs in western Kenya that attempted to integrate hygiene and water treatment into health and educational programs (Parker *et al.* 2006; O'Reilly *et al.* 2008; Freeman *et al.* 2009; Harris *et al.* 2009; Patel *et al.* 2012). The potential explanations for these findings parallel those for HCF water treatment. Courtesy bias might have led clients to overstate actual use. The custom of storing water for three to four days before refilling, or of using turbid water sources with high chlorine demand, could have resulted in depletion of chlorine residual, reducing the percentage of households with detectable FCR (Lantagne 2008; Loharikar *et al.* 2013). The complexity of treating water with sachets, which requires stirring for 5 minutes and filtering, might have discouraged use, or contributed to improper use. Several studies have documented low sachet use despite active promotion programs (Luby *et al.* 2008; Freeman *et al.* 2009; DuBois *et al.* 2010). For low-income households, purchase or use of water treatment products may not have been a priority because of scarce resources and other household activities taking precedence (Schilling *et al.* 2013). Offering a broader selection of water treatment options at the HCFs and additional behavior change interventions to increase product use might better meet consumer demand and result in higher levels of adoption (Albert *et al.* 2010).

At least one other study in western Kenya noted low levels of handwashing knowledge and practice among patients at baseline before implementation of the intervention (Bennett *et al.* 2015). The relatively high percentage of respondents in this study that were able to demonstrate proper technique and reported learning about handwashing from health workers suggests that this platform was an effective way to teach clinic clients about handwashing. Although a high percentage of household survey respondents were able to demonstrate proper handwashing technique, two-thirds dried their hands with dirty towels, at least partially negating the benefit of washing. At least one other observational study of handwashing and drying in Kenya had similar results, pointing to the need to specifically address hand drying in hygiene campaigns (Person *et al.* 2013).

Results of this evaluation, when considered along with other research, provide several important lessons about integrating handwashing and water treatment interventions into health services for vulnerable populations. First, because basic hygiene is fundamental to primary health care and the prevention of HAI, it is reasonable to expect health workers to use and maintain hygiene stations. However, although clinic staff knowledge of the importance of handwashing was high in this evaluation, 20% of HCFs did not have functional handwashing stations and soap was present in only 60% of HCFs visited. Future programs should provide sufficient orientation of health workers, prioritize maintenance and repair of water stations, and facilitate the provision of adequate supplies of soap. Second, less than half of drinking water stations distributed in 2005 were still present in HCFs and 16.7% of HCFs lacked drinking water stations, which could have resulted from either a high rate of breakage or overestimate of need. Future programs should develop criteria for optimizing coverage. Third, low rates of confirmed drinking water treatment at health care and home settings suggested that program implementation could be improved. Determining product preferences of the target population before the program is implemented, and providing greater choice of water treatment interventions, could enhance water treatment practices (Albert *et al.* 2010). Fourth, health workers have been identified by their clients as a trusted source of health information in general, and WASH in particular (Parker *et al.* 2006; Sheth *et al.* 2010; Loharikar *et al.* 2013). However, because health care workers are in short supply and often overburdened, use of CHWs to assist in the implementation of WASH interventions is recommended. Finally, because people living with HIV are at increased risk of opportunistic infections (Chan *et al.* 1995; Grant *et al.* 1997; Lule *et al.* 2009), and hygiene and water treatment have been shown to reduce risk of opportunistic infections (Yates *et al.* 2015), integration of WASH interventions into PMTCT services should be prioritized.

Projects of this type also help point the way toward Sustainable Development Goal 6, which aims for 100% WASH infrastructure coverage in HCFs by 2030 (Joint Monitoring Programme 2017), by providing basic hand hygiene and limited, but safe, drinking water services as defined by the Joint Monitoring Program. Current inadequacies in WASH infrastructure in HCFs present major challenges to the accomplishment of SDG 6, including the substantial funding and time required for infrastructure construction, which will leave patients and providers in HCFs at risk of HAI in the meantime. The intervention described in this paper has the potential to protect the health of patients and providers in the short-to-medium term while more comprehensive construction activities are planned and executed. An evaluation of interventions similar to those described in this paper cost an estimated $382 per HCF, including training and transport of supplies (Freedman *et al.* 2017), compared to $15,000 to $40,000 or more for construction of water supply and sanitation infrastructure. This approach has the additional benefit for regions that lack 24-hour per day access to water by providing on-site storage of water in containers that facilitate handwashing and safe drinking water access. In the event that SDG 6 is not reached, which would be most likely in more remote HCFs off main transport routes, the presence and use of functional water stations would provide improvements in health protection. This protection would require proper maintenance of the water stations, which would be facilitated by the use of local materials as demonstrated in other studies (Parker *et al.* 2006; Sreenivasan *et al.* 2014; Bennett *et al.* 2015) and reliable procurement and consistent use of soap and water treatment supplies.

This evaluation had several important limitations. First, because the assessment did not include a comparison group, results related to water treatment practices cannot be attributed solely to this intervention. Second, the study was limited to one county, so findings are not representative of other counties in western Kenya. Third, because of logistical and resource constraints, the household component of the evaluation was limited to one day, which only permitted data collection from ten nearby households per HCF. Consequently, populations in more remote areas were underrepresented. Fourth, household and health facility staff responses regarding program participation may have exhibited courtesy bias. Fifth, because of financial and time constraints, microbiologic water quality testing was not conducted, thereby limiting the ability to determine the actual contamination of stored water used in HCFs and in homes. However, FCR is a reasonable proxy for water quality because a number of studies have documented that chlorinated water with detectable FCR is significantly more likely to have no detectable *Escherichia coli* than untreated water (Murphy *et al.* 2016). Therefore, it is likely that the water samples with detectable FCR were potable. Finally, this evaluation only assessed knowledge and use of sachets during a period in which free supplies were available at both the facility and household level. If purchase of supplies were required, confirmed sachet use, as measured by FCR, would likely have been even lower.

CONCLUSIONS

This evaluation demonstrated that inexpensive, rapidly installed, portable water stations were in use approximately six years later, providing needed hygiene infrastructure and a platform for patient teaching. Current recommendations for similar programs are aligned with WHO recommendations (Adams *et al.* 2008) and include placement of handwashing stations where patient care is provided, within 5 meters of toilets, and in laboratories, pharmacies, and mortuaries; and placement of drinking water stations in inpatient wards, waiting areas, and where oral medicines are administered. Improvements in implementation, which would include maintenance and repair of the water stations, attention to the logistics of providing adequate supplies of soap, and greater choice of water treatment technologies, could enhance the use and impact of the water stations, and help ameliorate the problem of inadequate water and hygiene infrastructure in HCFs in resource-limited settings. This simple intervention offers a short-to-medium-term approach to protect the health of patients and providers while more permanent water supply infrastructure is constructed to meet the 2030 Sustainable Development Goal objective of 100% WASH coverage in HCFs.

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