Water, Sanitation, and Hygiene Characteristics among HIV-Positive Households Participating in the Global Enteric Multicenter Study in Rural Western Kenya, 2008–2012

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Abstract. Diarrheal illness, a common occurrence among people living with human immunodeficiency virus (PLHIV), is largely preventable through access to safe drinking water quality, sanitation, and hygiene (WASH) facilities. We examined WASH characteristics among households with and without HIV-positive residents enrolled in the Global Enteric Multicenter Study (GEMS) in rural Western Kenya. Using univariable logistic regression, we examined differences between HIV-positive and HIV-negative households in regard to WASH practices. Among HIV-positive households, we explored the relationship between the length of time knowing their HIV status and GEMS enrollment. No statistically significant differences were apparent in the WASH characteristics among HIV-positive and HIV-negative households. However, we found differences in the WASH characteristics among HIV-positive households who were aware of their HIV status ≥ 30 days before enrollment compared with HIV-positive households who found out their status < 30 days before enrollment or thereafter. Significantly more households aware of their HIV-positive status before enrollment reported treating their drinking water (odds ratio [OR] confidence interval [CI]: 2.34 [1.12, 4.86]) and using effective water treatment methods (OR [CI]: 9.6 [3.09, 29.86]), and had better drinking water storage practices. This suggests that within this region of Kenya, HIV programs are effective in promoting the importance of practicing positive WASH-related behaviors among PLHIV.

INTRODUCTION

Worldwide in 2016, an estimated 36.7 million people are infected with HIV, with an estimated 25.5 million living in sub-Saharan Africa.¹ Approximately 2.1 million children (< 15 years) are infected with HIV, most of whom reside in sub-Saharan Africa.^{1,2} Nationally in Kenya, approximately 5.9% of adults are infected with HIV.³ An estimated 98,000 children < 15 years old are living with HIV in Kenya.³

HIV weakens the immune system of infected persons increasing their susceptibility to other infections. Diarrheal illness is a common occurrence among people living with HIV (PLHIV), and often results from ingestion of contaminated food or water. In developing countries, contamination of water and food occurs as a result of unsafe water supplies and sanitation facilities, and poor hygiene practices.² Certain enteric pathogens, especially intestinal parasites, have been more commonly identified among PLHIV where they cause more severe and longer-lasting illness than in immunocompetent persons.^{4–6} Furthermore, PLHIV may require greater amounts of water to take medications (including anti-retroviral treatment), to reduce the risk of dehydration, and to prevent opportunistic infections.^{7–9}

Because of the increased risk of adverse consequences of diarrheal illness, improving access to adequate water and sanitation facilities for PLHIV is especially important.¹⁰ Improving drinking water quality, sanitation, and hygiene (WASH) practices among PLHIV have demonstrated health benefits.^{11,12} In 2013, a systematic review of seven studies examining the health effects of WASH interventions among

PLHIV¹¹ found that water quality interventions reduced diarrheal illness among PLHIV by 43% (relative risk [RR] = 0.57, 95% confidence interval [CI]: 0.38–0.86).^{13–19} The review included only one study of a handwashing intervention which found a reduction in diarrheal illness of 58% (RR = 0.42, 95% CI: 0.33–0.54) associated with handwashing.^{11,20} In 2015, another study reported the health impact of WASH interventions among PLHIV and concluded that both water quality and handwashing interventions reduced morbidity.¹² It also found that PLHIV residing in households with improved water supplies had less diarrheal morbidity and lower prevalence of intestinal parasites, and that having a household sanitation facility (as compared with open defecation or sharing a facility) reduced the risk of diarrhea.¹²

The evidence suggests that improved WASH is important for PLHIV; however, numerous barriers limiting access to these services and facilities have been identified. Lack of knowledge, attitudes, cost, and debilitating illness have all been noted as factors that inhibit access to or usage of improved WASH services and facilities by PLHIV.^{21,22} Discrimination and social stigma have also limited access to WASH for PLHIV, who have reported being shunned from using certain water sources and sanitation facilities, and have had to travel further to access alternative water sources and sanitation facilities as a consequence.^{22–25}

Many studies have reported the health impact of WASH interventions among PLHIV^{10–20}; however, limited knowledge exists on WASH access and practices among HIV-positive individuals in rural Western Kenya where the rate of HIV among adults is high, about 15%.²⁶ Furthermore, we know little about the differences in WASH practices between HIV-positive and HIV-negative households. We explored WASH characteristics and practices among a subset of households with and without

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HIV-positive individuals enrolled in the Global Enteric Multicenter Study (GEMS) in Kenya.

MATERIALS AND METHODS

The GEMS. Global Enteric Multicenter Study was a case-control study of moderate-to-severe diarrhea (MSD) in young children in seven sites in Africa and Asia, designed to estimate the burden, etiology, risk factors, and complications of MSD in children < 5 years old. Detailed information about the clinical and epidemiological methods of GEMS are described elsewhere and summarized in the following text.²⁷

All case and control children resided within the Health and Demographic Surveillance System (HDSS) boundaries. Census and surveillance data were collected by the Kenya Medical Research Institute (KEMRI)/Centers for Disease Control and Prevention (CDC) Kenya HDSS routinely.²⁸ All case children met the case definition for MSD and were < 5 years old. Moderate-to-severe diarrhea was defined as three or more, looser than normal stools per day, for 7 days or less, with one or more of the following signs indicative of dehydration: sunken eyes, loss of skin turgor, intravenous rehydration administered or prescribed, dysentery, or hospitalization for diarrhea or dysentery. Control children were matched to cases on age, gender, and geographic location.

At enrollment, demographic information, household level characteristics, and risk factors for diarrheal disease were obtained. Between 50 and 90 days, a home visit was conducted during which time similar information was collected. In addition, HIV status and related data were collected for a subset of cases, controls, and their biological parents. Risk factors for diarrheal disease assessed here focus on household WASH characteristics including information about the household's water source, water treatment and storage practices, sanitation facilities, and handwashing practices. Data collected on WASH characteristics at the follow-up visit were reported by the caregiver and confirmed through observation by a trained community interviewer. For the purposes of this analysis, if the same data were collected at enrollment and at follow-up, the follow-up data were used as they were more often confirmed through observation.

Study area and study population. The GEMS-Kenya enrollment period was from January 31, 2008, to January 29, 2011—known as GEMS-1—and from October 31, 2011, through September 30, 2012—known as GEMS-1A. The study site was located in rural Western Kenya in Siaya county (formerly Nyanza Province) in the areas of Gem, Asembo, and Karemo, close to Lake Victoria. Within GEMS-Kenya, six sentinel health centers (Figure 1) enrolled case children. About 230,000 persons, of whom 36,000 were < 5 years old, resided within the catchment area of these health centers, that is the HDSS.^{27,29} This area has higher rates of HIV (15.1% among adults 15–64 years old) and child mortality in both infants (27 per 1,000 live births) and children < 5 years old (73 per 1,000 live births) when compared with most other areas in Kenya.^{30,31} Within the HDSS the crude prevalence among adults 15–34 years old was 9% in 2016.³²

Data on HIV were collected by two programs implemented by the CDC Kenya Division of Global HIV/acquired immunodeficiency syndrome (AIDS) (DGHA) and the International Emerging Infections Program: Home-Based Counseling and Testing (HBCT) and Provider-Initiated HIV Testing and Counseling (PITC). Protocols established by the Ministry of

Health for HIV testing and counseling were followed for both HBCT and PITC.³³ Figure 2 shows a timeline of HBCT and PITC within the regions of Gem, Karemo, and Asembo. Home-Based Counseling and Testing was conducted on a rolling basis within the HDSS. Voluntary HIV tests were conducted by trained counselors at the homes of people living within the HDSS. Children < 5 years old living in the home were only tested if the biological mother tested HIV-positive, or was already known to be positive (living with HIV) or was deceased. For PITC, voluntary HIV tests were conducted on any patient and their caretakers attending sentinel health facilities regardless of the purpose of their visit to the facility. Adults and children ≥ 18 months were tested using rapid HIV antibody tests. For children < 18 months old, DNA-polymerase chain reaction was used as the confirmatory test (Figure 3). All participants who tested HIV-positive were referred to HIV care and treatment. The President's Emergency Plan for AIDS Relief (PEPFAR) as administered by DGHA Kenya funded all HIV counseling, testing, and treatment activities within the Kenya HDSS at the time of this study.

Data collected through HBCT and PITC were linked to GEMS-Kenya data using a unique identification number assigned to each person living in the KEMRI/CDC HDSS and available within each data source. Where available, HIV status and other data related to HIV such as treatment information and participation in prevention of mother to child transmission interventions at birth and thereafter were linked to GEMS case and control children and to their biological mothers and fathers. For case children and their parents, HIV-related data were collected in both HBCT and PITC, whereas for control children and their parents data were primarily collected via HBCT. Provider-Initiated HIV Testing and Counseling results were primarily available for cases and not controls as these results were prospectively linked to children and their parents presenting to a health center, whereas HBCT results were obtained community-wide and linked retrospectively.

Home-Based Counseling and Testing data were linked retrospectively and actively for case and control children and their parents. Retrospective data collection spanned the entire GEMS study period. Provider-Initiated HIV Testing and Counseling was abstracted in real time by trained GEMS-Kenya staff members at the health facility level using an approved, standardized chart abstraction form. Provider-Initiated HIV Testing and Counseling began within GEMS sentinel sites in January 2010 and continued through to the end of GEMS-1A enrollment.

Definitions. HIV-positive households were defined as households where HIV test results were available for both the child and the biological mother, and where either or both had a positive HIV test. HIV-negative households were defined as households where HIV test results were available for both the child and the biological mother, and where both the child's and the mother's HIV test were negative. Households where HIV status was unknown for the mother, the child, or both the mother and child were not included in the analysis. The father's HIV test results were not considered when determining the status of a household because a high proportion had missing test results as compared with mothers and children.

Water and sanitation facilities were defined as unimproved or improved as outlined by the World Health Organization/United Nations International Children's Emergency Fund Joint

Footnote:

GEMS 1 health facilities enrolled into GEMS for the first 3 years of GEMS

GEMS 1 and 1A health facilities enrolled into GEMS for all 4 years of GEMS

GEMS 1A health facilities only enrolled into GEMS in year 4

FIGURE 1. Map of the Global Enteric Multicenter Study (GEMS) area, including the sentinel health facilities where GEMS enrollment and Provider-Initiated HIV Testing and Counseling were carried out. Footnote: GEMS-1 health facilities enrolled into GEMS for the first 3 years of GEMS. GEMS 1 and 1A health facilities enrolled into GEMS for all 4 years of GEMS. GEMS 1A health facilities only enrolled into GEMS in year 4. This figure appears in color at www.ajtmh.org.

Monitoring Program for Water Supply and Sanitation.³⁴ Water treatment practices were defined as effective based on treatment methods proven to improve the quality of drinking water and to reduce diarrheal illness as outlined by the World Health Organization.³⁵

Statistical analysis. We present a descriptive analysis of the differences between HIV-positive and HIV-negative households with regard to their WASH practices. We also present results of univariable logistic regression exploring differences between the WASH characteristics of HIV-negative and HIV-positive households. To explore whether WASH practices and behaviors among persons who were tested for HIV earlier were different from those who were tested more recently, we examined the dichotomized time between the mother's test date and the GEMS enrollment date. The test results were made available shortly after the test date; however, that information was not available, therefore, we used the HIV test date as a proxy for the length of time knowing their test results. Among HIV-positive households

with a test date available, the median test date was 23 days before enrollment. We choose to dichotomize this variable as tested ≥ 30 days before GEMS enrollment date versus tested < 30 days before GEMS enrollment or after GEMS enrollment. To explore this relationship, we conducted a separate univariable logistic regression analysis. For both analyses odds ratios (OR), CIs, and *P* values are presented. Data were analyzed using SAS® 9.3 (SAS Institute Inc., Cary, NC).

Scientific ethics. All participants provided written informed consent before participating in this study. The GEMS protocol, inclusive of the linking to HIV status data collected by the CDC Kenya Division of Global HIV/AIDS within the HDSS, were reviewed and approved by the following institutions: the KEMRI Scientific and Ethical Review Committee (KEMRI protocol no. 1155); the Institutional Review Board (IRB) at the University of Maryland, School of Medicine, Baltimore, MD (UMB Protocol no. H-28327); the CDC, Atlanta, GA (CDC Protocol no. 5038), formally deferred to the IRB at the University of Maryland for review.

FIGURE 2. Timeline of Home-Based Counseling and Provider-Initiated HIV Testing and Counseling in Global Enteric Multicenter Study population and in sentinel health facilities, Kenya, 2008–2012. This figure appears in color at www.ajtmh.org.

RESULTS

Study enrollment and participants. Between January 31, 2008–January 29, 2011, and October 31, 2011–September 30, 2012, 4,226 children were enrolled into GEMS-Kenya; of

these 1,778 were enrolled as cases. Data from the 60-day follow-up visits were incomplete for 60 case children; another seven children were followed-up outside the required 50–90 day window, and were therefore excluded from the analysis. Two hundred and fifty-seven observations that were

Provider-initiated HIV testing and counseling	Home-based HIV counseling and testing
-Conducted in health facilities within the HDSS	-Conducted at home s of people living within the HDSS
-Voluntary tests conducted on any person and their caregivers attending the health facility, regardless of the purpose of their visit	-Voluntary tests conducted on adults and any child < 5 years old living in the home, if the biological mother tested HIV-positive or was deceased
Testing Strategy	Testing Strategy
<i>Adults:</i>	<i>Adults:</i>
-DETERMINE™ Rapid Test	-DETERMINE™ Rapid Test and BIOLINE® Rapid Test completed at same time
-All positive tests confirmed with BIOLINE® Rapid Test	-Tie breaker: UNIGOLD® Rapid Test
-Tie breaker: UNIGOLD® Rapid Test	
<i>Children < 18 Months Old:</i>	<i>Children < 18 Months Old:</i>
-Confirmatory test: DNA PCR test	-Confirmatory test: DNA PCR test, if antibody test was positive

FIGURE 3. Testing strategy for Home-Based HIV Counseling and Testing and Provider-Initiated HIV Testing and Counseling within the Kenya Health and Demographic Surveillance System (HDSS).

associated with children who were enrolled more than once as a GEMS case were excluded. Among the remaining 1,454 case children, HIV test results were available for 842 case children, 967 mothers of case children, and 467 fathers of case children. In 798 households, HIV test results were available for both the child and mother. One hundred and seventy two (27%) of the 798 households met the criteria for HIV-positive households, and 626 (78%) met the criteria for HIV-negative households (Figure 4). We noted 21 (2.6%) instances where the father was HIV-positive, but the household was classified as HIV-negative.

Descriptive data on study participant educational and wealth characteristics. Among the 798 case households included within our analysis, caretakers living in HIV-negative households reported similar levels of educational attainment (attended less than primary school) ($N = 304$, 49%) when compared with HIV-positive households ($N = 78$, 45%) ($P > 0.05$). HIV-positive and HIV-negative households were similar in regard to their wealth indices; no statistically significant differences were identified between the wealth index categorizations on univariable analysis.

FIGURE 4. Flow chart of Global Enteric Multicenter Study (GEMS) Kenya study population, case children, 2008–2012. This figure appears in color at www.ajtmh.org.

Drinking water: source, treatment methods, storage, and availability. On univariable analyses, we found no statistically significant differences in the drinking water characteristics of HIV-positive and HIV-negative households. Approximately 48% of HIV-negative households reported obtaining their water from an unimproved source as compared with 41% of HIV-positive households. Approximately 62% of both HIV-positive and HIV-negative households reported usually treating their drinking water. We also explored the relationship between a household's HIV status and drinking untreated surface water or untreated water from an unimproved source, but found no statistically significant differences (data not shown). At enrollment, 27% of HIV-positive households and 34% of HIV-negative households reported giving their child untreated drinking water. Among those who reported usually treating their drinking water, effective treatment methods were reported by approximately 68% of HIV-positive households and 63% of HIV-negative households. Chlorine was the most commonly reported water treatment method in both HIV-positive and HIV-negative households. Reported use of chlorine was 54% in HIV-positive households and 49% in HIV-negative households, and positive free chlorine residuals were found in 20% of HIV-positive homes as compared with 12% HIV-negative homes (Table 1).

About 16% of HIV-positive households and 15% of HIV-negative households reported fetching water every day. Water was reportedly not available on a daily basis for nearly 11% of HIV-positive households and about 8% of HIV-negative households. The time it took to get water was reported as being 30 minutes or more, roundtrip, by 27% of HIV-positive households and nearly 32% of HIV-negative households. At enrollment, a significantly higher proportion of HIV-negative households reported giving their children stored water (91% versus 86%, OR [CI]: 0.58 [0.35, 0.97], $P = 0.04$). At follow-up, most of both HIV-positive (99%) and HIV-negative households (98%) had drinking water storage containers in use within the home. Among those with storage containers observed, 77% of HIV-negative households and 79% of HIV-positive households had containers that were considered to be unsafe because of being uncovered or having large openings that allow for potential contamination.

Household sanitation facilities and disposal of child's feces. We examined the relationship between household sanitation practices among HIV-positive and HIV-negative households and found no statistically significant differences on univariable analysis. A similar proportion of households reported using unimproved sanitation facilities. Sharing a sanitation facility with one or more households was commonly reported by both HIV-positive and HIV-negative households (80% versus 79%, respectively). Approximately 41% of HIV-positive households and 40% of HIV-negative households reported disposing of their child's feces in a way that would be considered unimproved such as dumping in a bush, field, stream, or on the ground. We further examined the relationship of open defecation or disposing of the child's feces in the open, both at enrollment and follow-up, and found no statistically significant differences between HIV-positive and HIV-negative households (data not shown). At the 60-day follow-up interview, feces were observed in the specified defecation area of about one third of HIV-positive and HIV-negative households. Feces were observed in the home or in the yard in less than 10% of HIV-positive and HIV-negative households.

Hand hygiene. We found no statistically significant differences between reported hand hygiene practices of HIV-positive and HIV-negative households. The overwhelming majority of households reported washing their hands with soap and water at enrollment (HIV-positive households: 91%, HIV-negative households: 95%); however, at the 60-day follow-up interview soap was observed in only 52% of HIV-positive households and 45% of HIV-negative households. When asked about when hands were typically washed, responses reported by HIV-positive and HIV-negative households were similar.

Influence of length of time knowing HIV status. Among HIV-positive households, we explored whether being tested for HIV ≥ 30 days before enrollment into GEMS was associated with improved WASH practices, because promotion of such practices is an integral part of HIV counseling services for PLHIV.¹⁰ Of the 172 households that were classified as HIV-positive, 66 (38%) were tested ≥ 30 days before enrollment, 67 (39%) were tested < 30 days before enrollment or after enrollment, and the test date was missing for 39 (23%) households (Figure 2).

A higher proportion of HIV-positive households tested within 30 days of GEMS enrollment reported using unimproved water sources as compared with households who were tested ≥ 30 days before enrollment (42% versus 29%) (Table 2). In addition, a significantly higher proportion of households tested ≥ 30 days before GEMS enrollment reported usually treating their drinking water (74% versus 55%, OR [CI]: 2.34 [1.12, 4.86], $P = 0.02$) compared with households who were tested more recently. Households tested for HIV ≥ 30 days before enrollment were statistically significantly more likely to have reported treating their drinking water using an effective treatment method as compared with households who were tested < 30 days before enrollment or after enrollment (92% versus 56%, OR [CI]: 9.6 [3.09, 29.86], $P < 0.0001$). Drinking water storage containers were classified as unsafe in significantly fewer homes which were tested ≥ 30 days before enrollment as compared with homes which were tested < 30 days before enrollment or thereafter (70% versus 85%, OR [CI]: 0.41 [0.17, 0.96], $P = 0.04$).

There were no significant differences in sanitation practices or characteristics of HIV-positive households who were tested < 30 days before enrollment or after, and those tested earlier.

With one exception, no statistically significant differences were found in handwashing practices or characteristics of households who were tested ≥ 30 days after enrollment and those tested < 30 days before enrollment or after enrollment. People in households who were tested ≥ 30 days before enrollment more often reported handwashing after cleaning a child after defecation (41% versus 22%, OR: 2.4 [1.13, 5.11], $P = 0.02$) (Table 2).

DISCUSSION

In our study population of a subset of GEMS-Kenya case households, we found that HIV-positive and HIV-negative households had similar WASH characteristics overall. In general, HIV-positive households seemed to have higher proportions of positive WASH-related behaviors as compared with HIV-negative households. However, few, if any of these

TABLE 1

Reported drinking water characteristics and sanitation facilities assessed at enrollment and at the 60-day follow-up interview among HIV-positive and HIV-negative case households—Global Enteric Multicenter Study-Kenya, 2008–2012

	HIV-positive households <i>N</i> = 172 <i>n</i> (%)	HIV-negative households <i>N</i> = 626 <i>n</i> (%)	Crude OR and 95% CIs	<i>P</i> value
Drinking water: source, treatment methods, and storage				
Main water source obtained from unimproved source*†	71 (41.3)	302 (48.2)	0.75 (0.54, 1.06)	0.11
Usually treats drinking water‡	108 (62.8)	385 (61.5)	1.06 (0.75, 1.50)	0.76
Reported water treatment method effective†§	104 (68.4)	355 (62.9)	1.28 (0.87, 1.87)	0.21
Reported water treatment with chlorine product	92 (53.5)	307 (49.0)	1.46 (0.82, 2.63)	0.20
Chlorine test result (HIV-positive household <i>N</i> = 92, HIV-negative household <i>N</i> = 307)**				
Negative	69 (75.0)	239 (77.9)	—	—
Positive	18 (19.6)	36 (11.7)	1.73 (0.93, 3.24)	0.09
Refused test	1 (1.1)	3 (1.0)	—	—
No water in container	4 (4.4)	29 (9.5)	—	—
Child given untreated water	29 (27.1)	136 (34.0)	0.72 (0.45, 1.16)	0.18
Time to get water ≥ 30 minutesmin	40 (27.2)	179 (32.2)	0.79 (0.52, 1.18)	0.25
Water fetched daily	17 (15.9)	62 (14.7)	1.10 (0.61, 1.97)	0.76
Water not available daily	19 (11.1)	51 (8.2)	1.40 (0.80, 2.44)	0.24
Child given stored water	148 (86.1)	572 (91.4)	0.58 (0.35, 0.97)	0.04
Observed containers in use in home‡	170 (98.8)	616 (98.4)	0.78 (0.25, 2.48)	0.68
Main type of container observed is considered unsafe‡¶	134 (79.3)	475 (77.2)	1.13 (0.74, 1.71)	0.57
Main container is covered‡				
Yes	146 (85.9)	493 (80.0)	1.50 (0.84, 2.68)	0.17
No	15 (8.8)	78 (12.7)	—	—
Mixed	9 (5.3)	45 (7.3)	—	—
How water is removed from container‡				
Scoop with cup	133 (77.3)	480 (76.7)	1.04 (0.69, 1.55)	0.86
Pour (spigot or spout)	42 (24.4)	164 (26.2)	0.91 (0.62, 1.35)	0.64
Sanitation				
Disposal of child's feces considered unimproved#	69 (40.8)	242 (39.8)	1.04 (0.74, 1.48)	0.81
Household waste facility considered unimproved‡	38 (22.2)	167 (27.0)	0.77 (0.52, 1.16)	0.21
Household waste facility considered unimproved, and shared	144 (83.7)	518 (82.8)	1.07 (0.68, 1.69)	0.76
Sanitation facility shared	113 (80.1)	403 (78.7)	1.09 (0.69, 1.74)	0.71
Observed feces in defecation area‡	61 (35.5)	203 (32.4)	1.15 (0.80, 1.63)	0.45
Observed feces elsewhere in house or yard‡	14 (8.1)	56 (9.0)	0.90 (0.49, 1.66)	0.74
Hand hygiene				
Wash hands with				
Water and soap†	89 (51.7)	281 (45.0)	1.31 (0.94, 1.84)	0.11
When do you typically wash your hands				
Before eating	141 (82.0)	515 (82.3)	0.98 (0.63, 1.52)	0.93
Before cooking	60 (34.9)	230 (36.7)	0.92 (0.65, 1.31)	0.65
Before nursing	57 (33.1)	210 (33.6)	0.98 (0.69, 1.40)	0.92
After defecating	130 (75.6)	493 (78.8)	0.84 (0.56, 1.24)	0.37
After handling animals	21 (12.2)	61 (9.7)	1.29 (0.76, 2.18)	0.34
After cleaning child	53 (30.8)	192 (30.7)	1.01 (0.70, 1.45)	0.97
After cooking	2 (1.2)	2 (0.3)	3.67 (0.51, 26.25)	0.20
After handling soil	13 (7.6)	52 (8.3)	0.90 (0.48, 1.70)	0.75

CI = confidence interval; OR = odds ratio.

* Unimproved source included: open well in house/yard, open public well, pond or lake, shallow tube well, unprotected spring, river or stream, dam or earth pan, or bought.

† Assessed both at enrollment and follow-up, follow-up measure used.

‡ Assessed at follow-up.

§ Effective water treatment methods include: leaving water in the sun, using chlorine, boiling, or filtering water through ceramic filter or other type of filter.

|| Assessed at enrollment.

¶ Unsafe storage container defined as a wide-mouth container or a mixture of wide-mouth and narrow-mouthed containers.

Traditional pit latrines considered improved sanitation facility as we did not know whether the latrine had a slab or not.

** OR, 95% CI and *P* value calculated for those with a chlorine positive test result.

differences were statistically significant. For example, we found a higher proportion of HIV-positive households using an improved water source as their main source of drinking water and slightly more reported treating their drinking water. Among those reporting treating their drinking water, more reported using effective methods, and among those who reported treating their drinking water, a higher proportion had detectable free chlorine residual.

According to data collected in the Kenyan Demographic and Health Survey (DHS),³⁶ rates of using unimproved water sources among households in our study population were similar to those in other rural Kenyan households. Approximately 46% of rural Kenyan households reported using unimproved water sources, and in our sample, 41% of HIV-positive households and 48% of HIV-negative households reported using unimproved water sources. In our population,

TABLE 2

Reported water, sanitation, and hygiene characteristics among HIV-positive households that were tested for HIV at least 30 days before enrollment into Global Enteric Multicenter Study and HIV-positive households that were tested for HIV within 30 days of enrollment or thereafter, Western Kenya, 2008–2012

	HIV-positive households			
	Tested ≥ 30 days before enrollment N = 66 n (%)	Tested < 30 days or after N = 67 n (%)	Crude OR and CI	P value
Drinking water: source, treatment methods, and storage				
Main water source obtained from unimproved source†	19 (28.8)	28 (41.8)	0.56 (0.27,1.16)	0.12
Usually treats drinking water†	49 (74.2)	37 (55.2)	2.34 (1.12, 4.86)	0.02
Reported water treatment method effective†‡	48 (92.3)	35 (55.6)	9.60 (3.09, 29.86)	< 0.0001
Reported water treatment with chlorine product	43 (87.7)	31 (83.8)	1.39 (0.41, 4.71)	0.60
Chlorine test result positive§	10 (25.0)	6 (20.0)	1.33 (0.42,4.19)	0.62
Child given untreated water	13 (28.3)	10 (27.0)	1.06 (0.40, 2.80)	0.90
Time to get water ≥ 30 minutes	17 (34.0)	12 (20.3)	2.02 (0.85, 4.78)	0.11
Water fetched daily	3 (7.3)	9 (21.4)	0.29 (0.07, 1.16)	0.08
Water not available daily	4 (6.1)	8 (11.9)	0.48 (0.14, 1.66)	0.25
Child given stored water	58 (87.9)	58 (86.6)	1.12 (0.41, 3.12)	0.82
Observed containers in use in home§	66 (100.0)	66 (98.5)	—	—
Main type of container observed is considered unsafe§¶	46 (69.7)	56 (84.9)	0.41 (0.17, 0.96)	0.04
Main container is covered§	62 (93.9)	59 (89.4)	1.84 (0.51, 6.61)	0.35
How water is removed from container§				
Scoop with cup	44 (66.7)	57 (85.1)	0.35 (0.15, 0.82)	0.02
Pour (spigot or spout)	24 (36.4)	11 (16.4)	2.91 (1.28, 6.59)	0.01
Sanitation				
Disposal of child's feces considered unimproved†	21 (32.3)	29 (43.9)	0.61 (0.30, 1.24)	0.17
Household waste facility considered unimproved†	10 (15.4)	18 (26.9)	0.49 (0.21, 1.17)	0.11
Household waste facility unimproved and shared	58 (87.9)	57 (85.1)	1.27 (0.47, 3.45)	0.64
Sanitation facility shared	45 (84.9)	43 (81.1)	1.31 (0.47, 3.63)	0.61
Observed feces in defecation area§	21 (31.8)	26 (38.8)	0.74 (0.36, 1.50)	0.40
Observed feces elsewhere in house or yard§	5 (7.6)	2 (3.0)	2.66 (0.50, 14.23)	0.25
Hand hygiene				
Wash hands with				
Water and soap†	35 (53.0)	41 (61.2)	0.72 (0.36, 1.43)	0.34
When do you typically wash your hands				
Before eating	56 (84.9)	55 (82.1)	1.22 (0.49, 3.06)	0.67
Before cooking	28 (42.4)	20 (29.9)	1.86 (0.90, 3.83)	0.09
Before nursing	28 (42.4)	19 (28.4)	1.73 (0.85, 3.54)	0.13
After defecating	49 (74.2)	53 (79.1)	0.76 (0.34, 1.71)	0.51
After handling animals	5 (7.6)	9 (13.4)	0.53 (0.17, 1.67)	0.28
After cleaning child	27 (40.9)	15 (22.4)	2.40 (1.13, 5.11)	0.02
After handling soil	6 (9.1)	4 (6.0)	1.57 (0.42, 5.86)	0.50

CI = confidence interval; OR = odds ratio.

* Unimproved source included: open well in house/yard, open public well, pond or lake, shallow tube well, unprotected spring, river or stream, dam or earth pan, or bought.

† Assessed both at enrollment and follow-up, follow-up measure used.

‡ Effective water treatment methods include: leaving water in the sun, using chlorine, boiling, filtering water through ceramic filter or other type of filter.

§ Assessed at follow-up.

|| Assessed at enrollment.

¶ Unsafe storage container defined as a wide-mouth container or a mixture of wide-mouth and narrow-mouthed containers.

more households reported treating their drinking water as compared with rural Kenyan households in the DHS. In our community, approximately 63% of HIV-positive and 62% of HIV-negative households reported treating their drinking water, whereas in rural Kenyan households, only about 41% reported treating their water. Sanitation facilities in our sample were quite similar to those reported by rural Kenyan households in the DHS. In our sample, unimproved sanitation facilities shared by > 1 household were reported in 84% and 83% of HIV-positive and HIV-negative households, respectively; in rural households in the DHS, unimproved sanitation facilities shared by > 1 household were reported by nearly 80% of respondents.

We had initially hypothesized that HIV-positive households may have poorer WASH access and practices than HIV-negative households because of the additional burden and barriers that PLHIV have to overcome, such as disability due to illness, cost, stigma, and discrimination.^{21–25} Although we did not collect information on specific barriers to WASH access or usage in this study, we believe that barriers noted by others were minimized within our study population given the strikingly

similar WASH characteristics identified between HIV-positive and HIV-negative households. This may result from successful government, multilateral, and non-governmental organization programs for HIV diagnosis and treatment in the region, and decreasing stigmatization of PLHIV within the population. As a result, HIV-positive households in this population that receive effective health care and education may have less illness and better WASH practices, such as treating and safely storing drinking water.

To explore this hypothesis, we used the HIV test date as a proxy to examine the influence of the length of time knowing their HIV status on WASH characteristics and behaviors in the HIV-positive households. In particular, we examined whether the amount of time from HIV testing to GEMS enrollment affected their WASH characteristics and behaviors. We found that HIV-positive households that were tested ≥ 30 days before GEMS enrollment had better WASH-related behaviors than households that had more recently received a HIV test. These results suggest that PLHIV within this population are aware of the importance of WASH, and are making efforts to

improve their household WASH practices. Although our numbers were restricted to the subset of GEMS households with an HIV-positive child or mother, we detected statistically significant results on univariable analysis for some key characteristics including drinking water treatment with an effective method. HIV-positive households that were tested for HIV < 30 days before enrollment or after enrollment were more likely to have drinking water storage containers that were considered unsafe, and more of these homes reported removing water from the container by scooping with a cup, as opposed to those households tested for HIV $\geq$ 30 days before enrollment, who were more likely to report removing water from the container by a safer method such as pouring through a spigot or spout.

Although our study was not designed to look at why the length of time knowing one's HIV status might influence WASH characteristics, it is reasonable to consider that programs and services being provided to HIV-infected individuals in this area may be an influencing factor. All HIV testing and counseling programs in Kenya offer pre- and post-test counseling. During post-test counseling all persons who have tested HIV-positive are referred to comprehensive, evidence-based patient support and care services.^{8,37,38} One of these services involves improving WASH-related practices such as treating water, promoting safe drinking water storage, improving disposal of feces, and promoting handwashing with soap.³⁸ The integration of WASH activities, including provision of household water treatment products and soap to PLHIV is supported through PEPFAR-funded programs and these essential WASH goods have been incorporated into some basic care packages provided to PLHIV.^{8,39,40} Furthermore, much work has been completed in this region focusing on the promotion of low-cost, simple-to-use, household water treatment interventions and safe storage along with safe water handling, sanitation, and hygiene practices among not only PLHIV, but also in schools, health clinics, and at the household level.^{17,41–46} Findings from a recent investigation among HBCT participants in this part of rural Western Kenya support our assumption that HIV-positive households are seeking services to improve their health. In this investigation, researchers noted that after finding out their HIV status, HIV-infected individuals sought care more frequently and suffered fewer episodes of acute febrile illness and diarrheal disease.⁴⁷ Limited research has focused on health care seeking behaviors among recently tested individuals, and this warrants further investigation.

This study was subject to a number of limitations. For one, HIV-related data were collected from two different programs and subsequently linked to the GEMS-Kenya data. Inconsistencies in data collection between the two programs limited the HIV-related data we were able to link to GEMS-Kenya data. However, each program followed the Kenya National Guidelines, and we felt confident in the data collection methods for the linkable data.³⁸ Second, because of the nature of this study, we examined data at the household level rather than at the individual level, and we only included households where both the mother and child both had test results available. The father's HIV test results were not considered when determining the status of a household because a high proportion had missing test results as compared with mothers and children. There was a small proportion (2.6%) of households who were classified as HIV-negative when the father was HIV-positive, therefore our estimates among HIV-positive households may be conservative. Third, although we used

observed practices and behaviors wherever possible, some of the WASH characteristics we explored, especially those collected at enrollment, were reported and not observed by the interviewer, and are therefore subject to reporting bias whereby respondents could have provided us with responses favorable to safer WASH practices. Fourth, the results presented here do not account for potential confounders nor do they correct for multiple comparisons. Therefore, these results should be interpreted with caution as we did not adjust for factors that may influence WASH behaviors such as education or wealth, and we may have uncovered more associations than anticipated because of the number of comparisons that were made. Last, this study's findings are not generalizable to a broader setting; however, they provide insights into the WASH practices of HIV-negative and HIV-positive households in this region of Western Kenya.

In summary, we found that HIV-positive and HIV-negative households within this region had very similar WASH practices. However, we noted better WASH behaviors and characteristics among HIV-positive households who were tested for HIV $\geq$ 30 days before GEMS enrollment as compared with HIV-positive households who were tested for HIV < 30 days before enrollment or thereafter. This suggests that within this population, HIV-positive households are effectively educated about the importance of drinking treated water and practicing good hand hygiene, and adopt these positive WASH behaviors. Future research should consider time as an important factor when examining WASH behaviors among PLHIV, taking into consideration the time it takes for consistent messaging, education transfer, and sustained behavior change to occur. Future studies should be adequately designed and powered to address these questions, and should attempt to identify factors that promote positive WASH behaviors to optimize strategies to overcome the barriers to safe WASH practices faced by PLHIV.

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