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Integrating Household Water Treatment, Hand Washing, and Insecticide-Treated Bed Nets Into Pediatric HIV Care in Mombasa, Kenya: Impact on Diarrhea and Malaria Risk

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Introduction: In developing countries, HIV-infected children are at higher risk of morbidity and mortality from opportunistic infections than HIV-uninfected children. To address this problem, the Healthy Living Initiative (HLI) in Mombasa, Kenya distributed basic care packages (BCPs) containing improved water storage vessels, water treatment solution, soap, and insecticide-treated bed nets to prevent diarrhea and malaria in children, and had community health workers (CHWs) make bimonthly home visits to encourage adherence to HLI interventions and antiretroviral (ARV) medicine use.

Methods: To evaluate HLI, we enrolled 500 HIV-infected children from Bomu Hospital. In the implementation phase, from February to August 2011, we conducted surveys of caregivers, then provided free BCPs. In the evaluation phase, from September 2011 to August 2012, CHWs recorded observations of BCP use during home visits. We abstracted hospital data to compare diarrhea and malaria episodes, and pharmacy data on ARVs dispensed, between the 12-month preimplementation baseline phase (February 2010–January 2011) and the evaluation phase.

Results: The retention rate of children in HLI was 78.4%. In a multivariable logistic regression model adjusting for demographic characteristics, number of CHW home visits, distance to clinic, orphan status, and number of ARVs dispensed, children in HLI had 71% lower risk of diarrhea (relative risk 0.29, $P < 0.001$) and 87% lower risk of malaria (relative risk 0.13, $P = 0.001$) during the evaluation phase than the baseline phase; there was no independent association between ARV use and illness.

Conclusions: HIV-infected children in HLI were less likely to experience diarrhea and malaria during the evaluation phase than the baseline phase.

Key Words: pediatric HIV, diarrhea, malaria, WASH, Kenya

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INTRODUCTION

Diarrheal disease and malaria are major causes of morbidity and mortality among HIV-infected children in Sub-Saharan Africa.[1] Despite increases in the use of antiretroviral (ARV) drugs and cotrimoxazole prophylaxis, not all HIV-infected children are effectively treated with ARVs, and even when they are treated with ARVs, they are still at a higher risk of opportunistic infections than immunocompetent persons. Primary reasons include poor access and adherence to treatment, inadequate retention in care, incomplete immune reconstitution, and residence in regions with frequent exposures to infectious diseases and fecally contaminated environments.[2]

Diarrheal diseases affect 90% of HIV-infected persons, and the disease is 2–6 times more prevalent among HIV-infected persons than in immunocompetent populations.[3] In Africa, diarrhea is 4 times more prevalent among HIV-infected children than their HIV-negative household members.[4] Episodes of acute, persistent, and recurrent diarrhea are more likely in HIV-infected children, who are at a greater risk of death from an episode of diarrhea than their immunocompetent peers.[5] Inexpensive interventions, such as household-based water, sanitation, and hygiene (WASH) programs, have been reported to reduce diarrhea and improve overall health in HIV-infected individuals[6,7] and at least 1 study of household water treatment documented decreased diarrhea in HIV-infected children less than 2 years old.[8]

HIV infection is a risk factor for the development of malaria, and co-infection may be as high as 30%.[9] In co-infected individuals, HIV infection impairs the body's ability to produce

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antibodies and respond effectively to malaria treatment.[10] Repeat malaria episodes are common, and in data from Tanzania, Uganda, and Kenya, children co-infected with HIV had a 28%–127% higher risk of developing a second malaria episode and had more severe illness than their HIV-negative peers.[9] Insecticide-treated bed nets (ITNs) are a proven, cost-effective measure to prevent malaria, reducing malaria risk by 50% and all-cause mortality by 18% among children.[11]

In Kenya, where only 71% of the population has access to improved drinking water sources,[12] WASH-related diseases are the number 1 cause of hospitalizations for children younger than 5 years,[13] and approximately 27,400 children die annually from diarrheal diseases.[14] Malaria is a leading cause of morbidity and mortality in Kenya,[12] and only 56% of Kenyan households have one or more ITNs.[15]

To help reduce morbidity and mortality related to diarrhea and malaria, some HIV care and treatment programs have provided basic care packages (BCPs) with interventions proven to decrease the risk of opportunistic infections.[2,16] Evaluations of BCPs suggest that they improve access to and use of health interventions, such as ITNs and household water treatment and storage products,[17] reduce malaria, diarrhea, and hospitalizations among people living with HIV,[2] and reduce risk of illness from any cause.[7]

In 2011, Project Sunshine (www.projectsunshine.org), a nonprofit organization that provides free educational, recreational, and social service programming to children and families living with medical challenges, developed a BCP to prevent diarrhea and malaria in HIV-infected children in a program called the Healthy Living Initiative (HLI) at Bomu Hospital in Mombasa, Kenya. Modeled after the US Centers for Disease Control and Prevention (CDC)'s BCP,[2] this initiative aimed to reduce the risk of opportunistic infections among a subset of Bomu Hospital's pediatric HIV cohort. We conducted a retrospective evaluation of the association between the HLI program and the risk of diarrhea and malaria among HIV-infected children in Mombasa, Kenya.

METHODS

HLI Program Overview

Project Sunshine's HLI program included distribution of a free BCP consisting of a 20 L safe water storage vessel, hypochlorite water treatment solution, soap, ITNs, and an educational guide to program participants; bimonthly home visits by community health workers (CHWs) to deliver health messages, hospital appointment reminders, periodic hypochlorite and soap refills; and the establishment of a pediatric play and education area in the hospital waiting room. Although the HLI was not designed as a research study, Project Sunshine requested assistance from the CDC to use existing data to measure the impact of the HLI on the risk of diarrhea and malaria among HIV-infected children.

Location

The HLI program took place at Bomu Hospital, a private social enterprise supported by the US President's Emergency Plan for AIDS Relief (PEPFAR) and located in peri-urban Mombasa, Kenya. Mombasa's estimated population is 1 million and, at the time of this evaluation, HIV prevalence was 11.1% and pediatric access to ARVs was low in Mombasa, with 31.5% of eligible HIV-infected children on treatment.[18]

Population

We selected a convenience sample of 550 HIV-infected children initially eligible for PEPFAR's Mwangalizi Project (PMP) at Bomu Hospital. To be enrolled in PMP, children were required to be on ARVs and cotrimoxazole prophylaxis (Alavi Z. PEPFAR Muangalizi Project–Bomu Medical Centre, Mombasa, Kenya). PMP took effect from November 2007 to October 2008, and its primary goal was to support clinic retention and treatment adherence among HIV-infected children by providing adult support persons for continuity of care between the health care facility and household. PMP provided health education to caregivers and children, psychosocial support, ARV therapy and hospital attendance support, and consultation between hospital appointments.[19]

Eligibility

Eligibility criteria for HLI included HIV-infected children 0–18 years of age on cotrimoxazole prophylaxis whose caretakers were agreeable to CHW home visits. Of 550 HIV-infected children, we excluded 30 who did not consent to CHW home visits, and 20 who lived in households beyond the program's geographic boundaries. All children (n = 500) in the HLI had regular appointments (every 30–90 days according to the needs and limitations of families) at Bomu Hospital (their sole source of care) to receive medical check-ups, ARVs and/or cotrimoxazole, and care for illnesses.

Baseline Phase

For this evaluation, the baseline phase (which preceded initiation of the HLI intervention) was defined as taking place from February, 2010 to January, 2011. To obtain baseline data, we conducted hospital chart reviews to ascertain incidence of diarrhea and malaria, and distribution of ARVs and cotrimoxazole to the HLI cohort.

Implementation Phase

The 6-month implementation phase, which included program enrollment and BCP distribution, took place from February 2011 through August 2011. During this phase, we surveyed participants about basic demographic and socioeconomic characteristics, water handling practices, ITN use, and hand washing behavior. The survey instrument was written in English and verbally translated into Kiswahili at each home visit by trained CHWs. Twelve CHWs administered the questionnaire and made household observations. Immediately after the baseline survey, free BCPs were distributed to HLI participants.

Evaluation Phase

During the 12-month HLI evaluation phase, which took place from September 2011 through August 2012, CHWs conducted bimonthly home visits to encourage program participation; monitor use of hypochlorite solution, soap, and ITNs; replace broken water vessels or torn ITNs; and replenish BCP components. CHWs monitored BCP use by observing whether water was in the storage vessel, stored water had the odor of chlorine (the program did not have chlorine residual test kits), hand washing stations had water and soap present, and ITNs were placed appropriately above children's beds. To help facilitate program evaluation, beginning in January 2011, Project Sunshine developed standardized questionnaires with 35 questions to capture information on adherence to water treatment, ITN use, and hand washing. At each home visit, CHWs also provided child-friendly education sessions using an illustrated book in Kiswahili that promoted proper water treatment, hand washing, use of ITNs, and the importance of seeking care from a health care provider when symptoms of malaria or diarrhea occurred.

Chart Review

We reviewed medical records from Bomu Hospital for physician-diagnosed episodes of diarrhea and malaria, and pharmacy records for distribution of ARVs and cotrimoxazole tablets to children as a proxy measure for drug adherence, during the evaluation phase and, as a basis for comparison, during the baseline phase.

Data Analysis

To account for the irregular and variable number of clinic visits among HLI participants, we created monthly binary variables for 12 months for diarrhea and malaria, with a value of 1 applied to children reporting one or more diarrhea or malaria episodes during their monthly clinic visits and a value of 0 applied to children with no reported illness episodes. For children who made no clinic visits during a given month, the variable was set as missing for that month. Thus, the final data format was unbalanced and longitudinal (ie, different and repeated numbers of observations per child). To recognize that children who missed a clinic visit may also have not been ill (ie, no diarrhea or malaria), we conducted a sensitivity analysis by applying a value of 0 to children with missing monthly clinic visits to assess the impact of missing values on the results.

To examine the association between the HLI program and diarrhea or malaria, multivariable logistic regression models were used, treating diarrhea or malaria as a binary outcome variable and HLI program exposure (baseline vs evaluation phase) as a primary independent variable. We compared the risk of diarrhea or malaria during the baseline phase to the risk at the evaluation phase.

Demographic covariates included sex, age group in years (0–7, 8–11, and 12–18), caregiver's education (primary or less, secondary or higher), and monthly household income [≤5000 Kenya shillings (KSH) ($49/USD), >5000 KSH]. Because this project extended over 2 and a half years, the children aged into different age groups, so we broadened each age category to have similar number of children in each category. This procedure resulted in atypical age categories of 0–7 years (instead of <5 years), 8–11 years (instead of 5–9 years), and 12–18 years (instead of 10–14 years).

To account for the potential influence of CHWs in promoting adherence to the HLI program, and thereby reducing the risk of diarrhea and malaria, we adjusted for the number of CHW home visits (≤7 vs >7 visits) in the model. We also adjusted for the distance from children's homes to Bomu Hospital (≤20 km vs >20 km) as a potential barrier to care that could impact outcomes. Because orphans and vulnerable children often experience worse health than children with parents,[20] we included orphan status (yes or no) as a covariate. Finally, we considered impact of drug adherence on malaria or diarrhea as a potential confounder by including the number of ARV pills dispensed through the year (≤300 vs >300) as a covariate. We also considered cotrimoxazole tablets for the same reason but because of multicollinearity, only ARV pills dispensed was included as a covariate in the modeling. Potential correlation between repeated measurements per child over multiple months was treated using the generalized estimating equation approach with compound symmetry correlation structure. All data analyses were performed using SAS 9.3.

Ethical Considerations

Ethical approval for the evaluation was obtained from the University of Nairobi College of Health Sciences and Kenyatta National Hospital Ethical Review Committee (Protocol P237/09/2006). Because the participation of CDC was limited to technical assistance with data analysis, involved no human subjects contact, and consisted of an evaluation of public health practice, the CDC Institutional Review Board representative ruled that IRB review was not required. Caregivers of all HLI children consented to participation in the evaluation; children >7 years old provided their assent.

RESULTS

We were able to analyze data for 392 (78.4%) of the 500 children enrolled in HLI. We excluded 70 who were lost to follow-up [32 (6.4%) moved away, 23 (4.6%) were lost for unknown reasons, and 15 (3.0%) died], and 38 (7.6%) who did not make any clinic visits before or during the HLI program.

Demographic Variables

The 392 children included in the evaluation had a median age of 10 years (range 2–18) and 215 (54.8%) were male (Table 1). Among 392 caregivers, 207 (52.8%) attained primary or lower level of education and 273 (69.6%) reported a household income of ≤5000 KSH ($49) per month. Most (81.6%) children lived within 20 km from Bomu Hospital and 108 (27.6%) were orphans. There were no statistically significant differences in demographic and socioeconomic characteristics between children included and excluded in the evaluation.

TABLE 1. Demographic and Socioeconomic Characteristics of Included and Excluded Enrollees in the Healthy Living Initiative Evaluation

Characteristic	N (%) Included	N (%) Excluded	*P**
Total	392	108	
Sex			0.22
Boys	215 (54.8)	52 (48.2)	
Girls	177 (45.2)	56 (51.9)	
Age, yr			
All, median (range)	10.0 (2–18)	9.0 (2.0–17.0)	0.14
0–7	135 (34.4)	36 (33.3)	
8–11	129 (32.9)	49 (45.4)	
12–18	128 (32.7)	23 (21.3)	
Caregiver's education			0.31
Primary or less	207 (52.8)	52 (48.2)	
Secondary or higher	180 (45.9)	56 (51.9)	
Missing	5 (1.3)	0 (0.0)	
HH income/mo			0.67
≤5000 KSH	273 (69.6)	77 (71.3)	
>5000 KSH	83 (21.2)	24 (22.2)	
Missing	36 (9.2)	7 (6.5)	
Distance to clinic			0.64
≤20 km	320 (81.6)	86 (79.6)	
>20 km	72 (18.4)	22 (20.4)	
Orphan status			0.24
Yes	108 (27.6)	36 (33.3)	
No	284 (72.5)	72 (66.7)	

*Chi-square for categorical variables or T test for continuous variable.

CHW Home Visits, BCP Use

During the evaluation phase, CHWs made a total of 3033 home visits for 392 children. The median number of home visits was 8 (range 4–12), with 4–7 visits to the homes of 168 (42.9%) children and 8–12 visits to 224 (57.1%) homes. Of 3033 total visits, 1350 (45%) visits from January to August 2012 were recorded on the standardized questionnaire. Of these 1350 questionnaires, CHWs recorded observing water in the safe storage vessel during 1322 (97.9%) visits, and being able to smell chlorine during 1314 (97.4%) visits. CHWs reported observing proper ITN placement over the child's bed on 1320 (97.8%) visits.

ARVs Received and Retention in Care

There was a statistically significant and nearly identical increase from the baseline phase to the evaluation phase in the percentage of children documented to have received >300 ARV (59.4% vs 75.5%, $P < 0.001$) and >300 cotrimoxazole (59.7% vs 75.8%, $P < 0.001$) tablets (Table 2). During the baseline phase, the percentage of children who received ARVs or cotrimoxazole did not vary by more than 2% during any month throughout the 12-month period. Over 78% of program participants were retained in the HLI program throughout the implementation and evaluation phases.

Clinical Outcomes

Among 392 children, there were a total of 2786 hospital visits in the baseline phase and 2799 hospital visits during the evaluation phase. During the baseline phase, 106 diarrhea episodes were reported in 90 (23%) participants compared with 33 episodes among 27 (7%) participants during the evaluation phase. A total of 33 malaria episodes were reported in 33 (8.4%) participants during the baseline phase compared with 4 episodes in 3 (0.8%) participants during the evaluation phase. Compared with the baseline phase, monthly rates of diarrhea and malaria tended to be lower and of consistent magnitude during the evaluation phase (Fig. 1). During the baseline phase, there was a reduction in both diarrhea (6%–2%) and malaria rates (4%–0%) over the 12-month period.

Diarrhea and Malaria Morbidity Models

In a multivariable logistic regression model adjusting for sex, age, caregiver's education, monthly household income, number of CHW home visits, distance to clinic, orphan status, and number of ARV pills dispensed, children in the HLI program were estimated to have 71% lower risk of diarrhea [relative risk (RR) 0.29, $P \leq 0.001$] and 87% lower risk of malaria (RR 0.13, $P = 0.001$) during the evaluation phase compared with the baseline phase (Table 3). Children whose caregivers had a primary school or lower education had 53% higher risk of developing diarrhea than those with more educated caregivers (RR 1.53, $P = 0.04$). Children in the group who received 8–12 CHW home visits had 70% lower risk of developing malaria (RR 0.30, $P = 0.005$) than children receiving 4–7 home visits. Orphan status was not associated with an increased risk of either diarrhea or malaria. Among the 392 children, the proportion of children who did not make a clinic visit during any given month was similar, at less than 2%, during both baseline (0.3%–1.8%) and evaluation phases (0.3%). Consequently, when missing values were set at 0 during each month of each evaluation phase, the impact on data analysis was negligible (data not shown).

TABLE 2. Distribution of Healthy Living Initiative Participants by Category of Total Number of ARV and Cotrimoxazole Tablets Dispensed (0–300, >300) During the 12-Month Baseline and Evaluation Phases

No. of Pills Dispensed	Baseline,* N (%)	Evaluation,† N (%)	*P*‡
ARV			
0–300	159 (40.6)	96 (24.5)	<0.001
>300	233 (59.4)	296 (75.5)	
Cotrimoxazole			
0–300	158 (40.3)	95 (24.2)	<0.001
>300	234 (59.7)	297 (75.8)	

*February/2010 ~ January/2011.
†September/2011 ~ August/2012.
‡McNemar test.

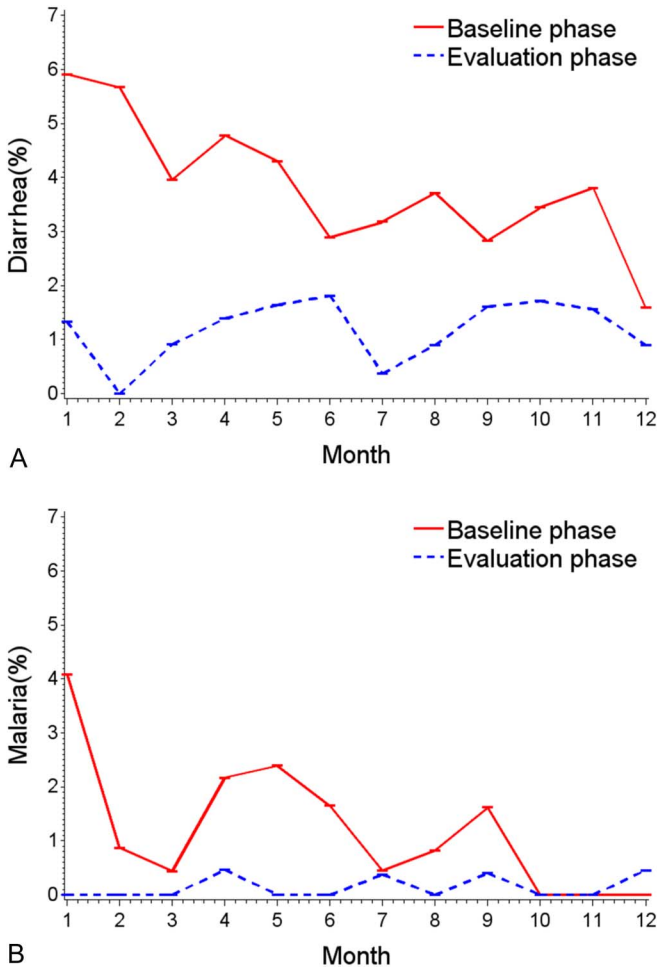

FIGURE 1. Proportion (%) of children diagnosed with diarrhea (A) or malaria (B) during clinic visits, by month, in the baseline and the evaluation phase.

DISCUSSION

To our knowledge, this evaluation is the first to attempt to evaluate the impact of a BCP on the health of HIV-infected children. Findings of this evaluation suggest that a combined intervention that included BCPs and home and clinic-based interventions was associated with a reduced risk of diarrhea and malaria in HIV-infected children. As is the case with any evaluation of a combined intervention, it is difficult to ascertain which elements were responsible for the observed decreases in disease outcomes. We attempted to address this difficulty by controlling for several variables in the modeling, despite the inherent limitations of that approach.

Adherence to the BCP by participant households was both reported and observed to be high, which was consistent with outcomes of other evaluations that suggested an impact of BCPs on prevention of opportunistic infections[8,16]; improvement of overall health[7]; improvement of effective HIV care[2]; and increases in the effectiveness of and retention in HIV care and treatment among HIV-infected persons.[21] Individual interventions included in the BCP used in HLI have been shown to reduce the risk of diarrhea[8,16] and malaria.[11,22] Bimonthly home visits by CHWs for health promotion and refills of hypochlorite solution and soap may have also contributed to high observed levels of use of the interventions; there was also an independent association between malaria risk and children receiving more CHW visits. Other studies have documented an association between frequent CHW visits and adherence to water quality interventions[23] and have demonstrated that distribution of preventive interventions such as ITNs and other malaria prophylactic measures improves child health outcomes and decreases mortality.[24,25] Trust in CHWs associated with a health facility has been shown in other studies to be effective at promoting increased use of water quality interventions.[23]

We cannot exclude the possibility that adherence to use of ARVs and cotrimoxazole, which appeared to increase significantly from the baseline to the evaluation phase, may have contributed to decreased risk of diarrhea and malaria, as has been shown in other studies.[2,4,16,26] Although it is not possible to discern whether the 17% increase from the baseline to evaluation phase in the population receiving >300 ARVs or cotrimoxazole tablets would have been sufficient to fully explain the decrease in estimated disease risk, it is unlikely that such a modest increase could account for very large reductions in diarrhea or malaria risk. Furthermore, the number of ARVs and cotrimoxazole tablets dispensed may not have precisely reflected actual drug adherence because some children could have had prescriptions filled but not taken the drug, which would have resulted in overestimation of drug adherence. Most importantly, in our analysis the number of ARVs dispensed was not independently associated with diarrhea or malaria reduction.

The decreases in monthly diarrhea and malaria rates during the baseline phase, which could have represented a trend that began before the initiation of the BCP program, are also difficult to explain with existing data. It is unlikely that ARV adherence could explain this trend because pharmacy records showed that the month-to-month variation in the percentage of children receiving ARVs and cotrimoxazole did not vary by more than 2%, and remained stable throughout the 12-month baseline phase.

Another important finding of this evaluation was high retention in care, which was over 78%. Although there is no standardized definition of retention in care,[27] systematic reviews documented 24-month retention at 70% for adults[28] and 72% for children[29] in HIV treatment programs. Several factors in HLI could have contributed to relatively high retention in care. Regular home visits by CHWs with intensive one-on-one instruction on water treatment, use of ITNs, and the importance of adherence to ARV treatment and keeping clinic appointments were designed to elicit the participation of caregivers. CHWs also created a play and education area at the hospital, which made the environment more child friendly and supportive,[30] effectively improving the quality of ongoing hospital-based HIV support for children and caregivers. High quality of care delivered by Bomu Hospital providers and the continuity of care through clinic and home visits may have contributed to adherence to care.[31] BCPs included in the HLI may have served as incentives for caregivers to participate in the program, as has been observed elsewhere.[7,17,20]

TABLE 3. RR of Diarrhea and Malaria From Multivariable Logistic Regression Model

		Diarrhea			Malaria		
Characteristics	**Categories**	**RR**	**SE§**	***P***	**RR**	**SE§**	***P***
HLI program	Baseline phase	Ref			Ref		
	Evaluation phase	0.29	0.07	<0.001	0.13	0.08	0.001
Sex	Boys	0.68	0.14	0.06	1.01	0.37	0.98
	Girls	Ref			Ref		
Age, yr	0–7	1.03	0.26	0.92	0.64	0.34	0.40
	8–11	0.76	0.19	0.27	0.83	0.37	0.68
	12–18	Ref			Ref		
Caregiver's	Primary or less	1.53	0.33	0.04	1.41	0.46	0.29
Education*	Secondary or higher	Ref			Ref		
HH income/mo†	≤5000 KSH	0.99	0.29	0.99	0.76	0.28	0.46
	>5000 KSH	Ref			Ref		
No. of ARV‡ pills dispensed	0–300	1.07	0.21	0.72	0.60	0.26	0.25
	>300	Ref			Ref		
No. of home visits	4–7	Ref			Ref		
	8–12	1.32	0.29	0.22	0.30	0.13	0.005
Distance to clinic	≤20 km	Ref			Ref		
	>20 km	1.46	0.21	0.12	1.73	0.70	0.17
Orphan status	Yes	1.15	0.24	0.51	0.95	0.44	0.90
	No	Ref			Ref		

*Five kids with missing value were excluded.
†Thirty-six kids with missing value were excluded.
‡ARV, antiretroviral.
§SE, standard error.

Limitations

This evaluation was subject to several limitations. First, courtesy bias could explain reported BCP use by participant households because home visits were announced by CHWs, which could have positively influenced use of the ITNs and water treatment and storage interventions. Furthermore, CHWs served as both implementers and evaluation data collectors for HLI and would have had an incentive to exaggerate program success. Independent data collectors and surprise visits would have helped reduce these possible biases. The strength of association between program phase and physician-diagnosed diarrhea and malaria suggests that the influence of interventions, which could have also included home visits and use of ARVs and cotrimoxazole, was not misrepresented. Second, the use of chlorine odor, rather than residual chlorine, to assess water treatment was subjective and a likely source of error. Third, the standardized questionnaire was only used during the second half of the evaluation, which reduced the number of observations on the use of interventions. Fourth, because the HLI population was limited to a convenience sample of 500 participants at Bomu Hospital, we are unable to make inferences to the greater community of HIV-infected children throughout Kenya. Finally, the before and after observational evaluation design was not as strong methodologically as a randomized controlled trial would have been, but it would not have been ethical to withhold proven interventions from an HIV-infected control group.

CONCLUSIONS

In conclusion, findings from this evaluation suggest high uptake of HLI interventions among HIV-infected children. Participation in the HLI was accompanied by high retention in care and reduced rates of diarrhea and malaria when compared with the baseline period. Although it was difficult to ascertain which of the combined interventions were responsible for health outcomes, the HLI serves as an effective approach to HIV care for children. This evaluation also provides an example of how nongovernmental organizations can efficiently measure health impact using existing data sources.

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