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Impact of a Hygiene Curriculum and the Installation of Simple Handwashing and Drinking Water Stations in Rural Kenyan Primary Schools on Student Health and Hygiene Practices

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Abstract. School-based hygiene and water treatment programs increase student knowledge, improve hygiene, and decrease absenteeism, however health impact studies of these programs are lacking. We collected baseline information from students in 42 schools in Kenya. We then instituted a curriculum on safe water and hand hygiene and installed water stations in half ("intervention schools"). One year later, we implemented the intervention in remaining schools. Through biweekly student household visits and two annual surveys, we compared the effect of the intervention on hygiene practices and reported student illness. We saw improvement in proper handwashing techniques after the school program was introduced. We observed a decrease in the median percentage of students with acute respiratory illness among those exposed to the program; no decrease in acute diarrhea was seen. Students in this school program exhibited sustained improvement in hygiene knowledge and a decreased risk of respiratory infections after the intervention.

INTRODUCTION

Acute respiratory illnesses (ARIs) and diarrheal diseases are the two most common causes of death among children < 5 years of age in developing countries.[1] Handwashing with soap has been shown to reduce the risk of both diseases, and household water treatment reduces diarrhea risk.[2,3] However, efforts to achieve widespread community penetration of both interventions have proven challenging.[4–7] Attempts to increase use of handwashing with soap and household water treatment through integration with other services such as maternal and child health programs have shown some promise.[8,9] Primary school programs aimed at preventing diarrhea by installing drinking water and handwashing stations in schools, teaching students about hygiene and water treatment, and instructing them to share these messages with their families have increased hygiene knowledge among students and changed practices of parents.[10–12] However, although some studies of these school-based programs have found reduced absenteeism among students,[13–17] limited data exist on the direct health impact of these programs.

From 2007 to 2009, the Nyando Integrated Child Health and Education (NICHE) Project attempted to increase access to water treatment products (WaterGuard, PuR, and Aquatabs), soap, micronutrient supplements, and insecticide-treated bed nets in rural households in western Kenya through a combination of approaches: 1) social marketing; 2) installation of drinking water and handwashing stations in schools, clinics, and churches; 3) health promotion by teachers, health workers, and religious leaders; and 4) local health education and product sales by human immunodeficiency virus (HIV) self-help groups organized by the Safe Water and AIDS Project (SWAP), a Kenyan non-governmental organization (www.swapkenya.org).[18] We evaluated the school-based handwashing and water treatment component of the NICHE Project to determine its impact on students' knowledge of handwashing, hygiene, and water treatment practices in students' homes, and students' health.

METHODS

Setting/study population. This study took place in Nyando division, in Nyanza province, Kenya; Nyanza province has the highest rates of mortality among infants (95 deaths/1,000 live births) and children < 5 years of age (149 deaths/1,000 live births) in the country. In a recent survey, the 2-week period prevalence of diarrhea and ARIs was 16.2% and 7.9%, respectively, for children < 5 years of age.[19]

Sampling/selection. This was a sub-study of the larger NICHE study, which was powered to detect a 10% change in anemia among children 6–35 months of age from 60% to 50% with a confidence level of 95%, a power of 80%, a design effect of 1.5, and a non-response rate of 20%. The sample size determined for this outcome was 729, 6–35-month-old children per study arm. For the school study, we used a convenience sample of school-age children in the households of the selected children. A separate sample size for school-age children was not calculated *a priori*.

A two-stage cluster-sampling strategy was used to select 60 villages from 17 sublocations (sub-counties) in Nyando Division (county).[20] In the first stage of sampling, 30 intervention and 30 comparison villages were randomly selected, with probability of selection proportional to size, using the 1999 Nyando Division census. Intervention and comparison villages were chosen from separate political jurisdictions (sublocations) to reduce the likelihood that interventions implemented in intervention villages would bleed into comparison villages. Villages in and near the urban centers (N = 38) and villages with pre-existing SWAP groups (N = 4) were excluded from selection. A census of the 60 villages was conducted, and from this, 25 children 6–35 months of age in each village were chosen. The student evaluation in the NICHE project was an observational evaluation in the context of the larger NICHE study; all students in grades 4–8 living in the households of the selected children was eligible for enrollment. The goal was to follow the selected students for the entire 2 years of this study.

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Schools in intervention villages were classified as intervention schools, and schools in comparison villages were classified as comparison schools. Community interventions occurred in intervention villages and targeted parents of young children, whereas separate interventions that targeted school children occurred in intervention schools. Not every village had a school, but the geographical separation of intervention and comparison villages reduced the likelihood of intervention students attending comparison schools, and vice versa.

Baseline surveys. In March 2007, students in grades 4 through 8 were interviewed about their water treatment knowledge and behaviors and asked to demonstrate their handwashing technique. Correct handwashing procedure was defined as using soap, lathering all hand surfaces, and air drying.

Students' caregivers were also interviewed about household demographic and socioeconomic characteristics; water handling, hygiene, and sanitation practices; and use of point-of-use water treatment products. Household water, hygiene, and sanitary infrastructure were observed. Stored water was tested for residual chlorine using the *N*, *N*-diethylphenylenediamine (DPD) method (La Motte, Chestertown, MD), and the caregiver handwashing technique was observed.

Implementation: intervention group. Starting in April 2007, teachers in intervention schools were trained about handwashing and water treatment and provided instructional materials for their students. In intervention schools, water stations were installed near latrines for handwashing and classrooms for drinking. The water stations consisted of 60-L plastic buckets with a lid and tap placed on a metal stand produced by local artisans (Figure 1), and schools were given a 3-month "starter" supply of soap and WaterGuard water treatment solution (a locally available product). Schools were expected to provide their own commodities after exhausting free supplies.

FIGURE 1. An example of a drinking water station in a school. Handwashing stations were identical but were located near latrines, Nyando Integrated Child Health and Education (NICHE) safe water and hygiene program, Nyando Division, Kenya, 2007–2009.

Active surveillance. Between June 2007 and February 2008, field workers made unscheduled biweekly home visits to enrolled households in both intervention and comparison communities to ask about use of water treatment products and episodes of any illness, diarrhea, or ARI among the selected students in the preceding 24 hours, and to test stored drinking water for residual chlorine. Participants were not informed of the chlorine status of their drinking water. We defined "any illness" as diarrhea, cough/difficulty breathing, rhinorrhea/coryza, or fever in the last 24 hours. We defined diarrhea as three or more loose stools in the 24 hours preceding the visit, and ARI as reported fever and cough or difficulty breathing in the preceding 24 hours.

First follow-up survey. In March–April 2008, we interviewed students from the baseline cohort who were still in school and their caregivers, using questionnaires similar to baseline.

Implementation: comparison group. In April 2008, the safe water and handwashing program was implemented in comparison schools using the approach described previously for intervention schools. Both intervention and comparison schools received a free 3-month "starter" supply of soap and WaterGuard.

Active surveillance. Between May 2008 and February 2009 we resumed biweekly home visits to assess use of health products and illnesses over the preceding 24 hours as described previously.

Second follow-up survey. In March–April 2009, we interviewed students from the baseline cohort who had remained in school and their caregivers, as described previously.

Data management/analysis. All data were collected using personal digital assistant devices. Data were analyzed with SAS 9.2 (SAS Institute Inc., Cary, NC). Students and/or households who were unavailable during the cross-sectional survey but continued to be part of active surveillance were included in the final data analysis. Households of graduated students were excluded from active surveillance in Year 2. In Year 1, we compared children exposed to the intervention to unexposed children in comparison schools to measure the effect of the intervention. In Year 2, after both groups had been exposed to the intervention, we compared the two groups to see if the difference found in Year 1 between the two groups had diminished or disappeared. We calculated the percentage of positive responses for a given question among students and their caregivers and grouped them by school. Because the randomization was at the village level and the intervention was implemented at schools within villages, all analyses are presented for data summarized at the school level. Summary measures included percentages and medians; in this work, data presented as school-level aggregates are referred to as median percent, and 25th–75th interquartile ranges (IQR) are shown. Interval estimates of the difference in median school proportions, referred to as the estimated difference in medians (EDM), between comparison and intervention groups was calculated for each of the time points and represents an estimated effect size. The estimates are simple percentile bootstrap intervals based on independent sampling of the school percentages. Because of the small number of schools representing the two arms, we report 90% confidence intervals (CIs); differences between intervention and comparison arms are considered significant if the EDM

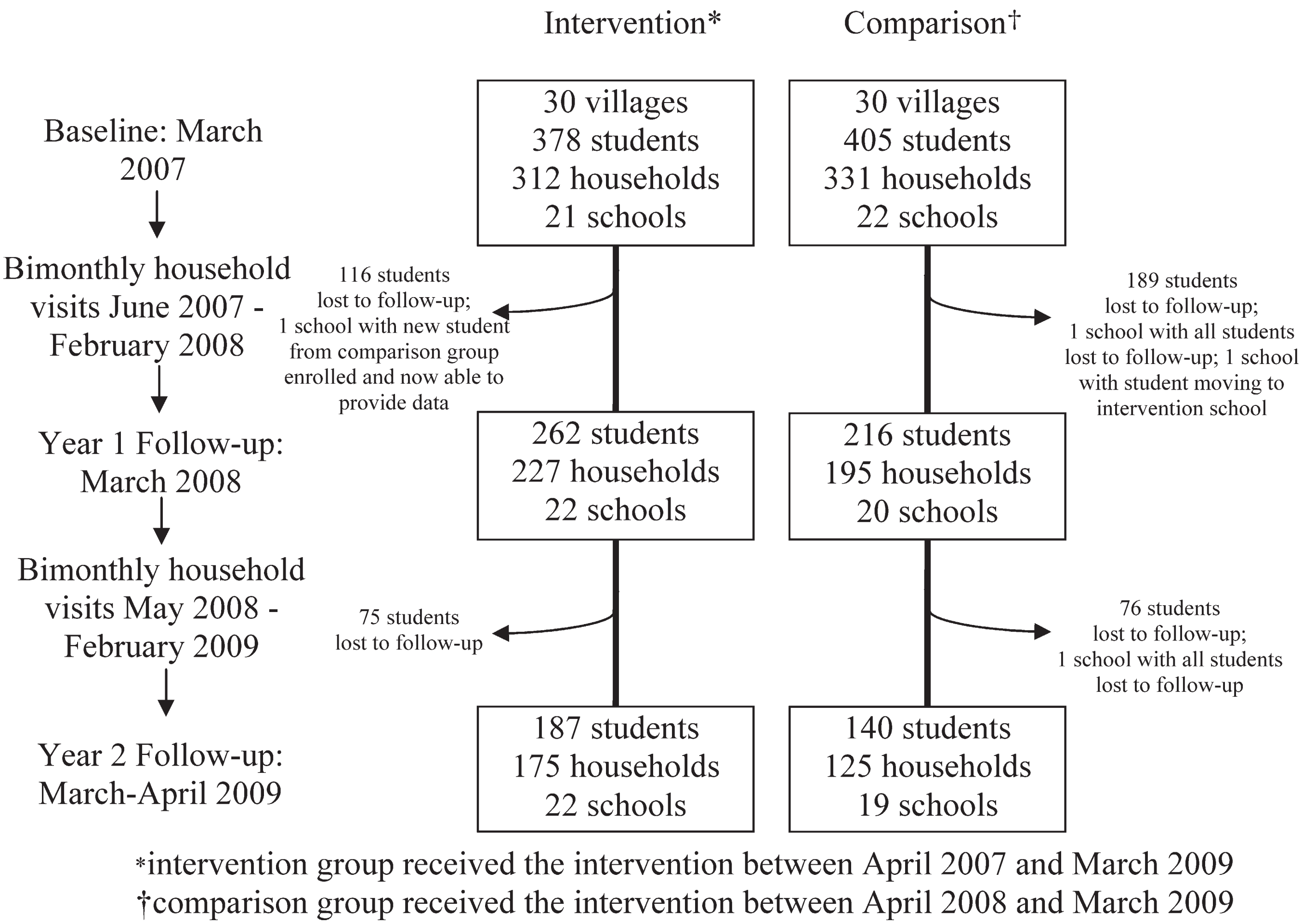

FIGURE 2. Nyando Integrated Child Health and Education (NICHE) study design and enrollment, NICHE safe water and hygiene program, Nyando Division, Kenya, 2007–2009.

90% CI does not cross zero. This nonparametric method and 90% confidence level were chosen after evaluating the data. Bootstrapping was restricted to schools with more than one student interview to reduce the influence of schools with small amounts of data in the bootstrap samples. For each year, active surveillance data were aggregated for each surveillance round at the school level, resulting in a water treatment and illness percentage for each school. Intervention school surveillance data were then compared with comparison school data using a similar method as described for the cross-sectional data.

Ethics. The protocol was approved by institutional review boards at the Kenya Medical Research Institute (protocol 1176) and the Centers for Disease Control and Prevention (CDC) (protocol 5039). We obtained written informed consent from all participants.

RESULTS

Demographic and socioeconomic characteristics. At baseline, 783 students from grades 4 to 8 were enrolled from 43 schools (range 1–48 students per school). In the first follow-up survey, 478 (61%) students of the original 783 participated from 42 schools (range 1–35 students per school), and in the second follow-up, 327 students (42%) from 41 schools (range 1–23 students per school) participated; in the cross-sectional study, loss to follow-up occurred because of graduation, dropping out, or absence from school (Figure 2). Students lost to follow-up were not different from students who remained in the study with regards to age, gender, or socioeconomic status. One school that was enrolled in the intervention group had no students involved in the intervention; however, one child moved into the intervention school and was included in the analysis, accounting for the increase in schools from 21 to 22 at the time of the first follow-up. Two small rural schools were excluded because of loss to follow-up of all their students. At baseline, the intervention group had a median of 42% (IQR 38–57%) female students participating in the study; the comparison group had a median of 43% (IQR 36–53%).

We interviewed caregivers of 643 (82%) of 783 students at baseline, 422 (89%) of 478 caregivers at first follow-up, and 300 (92%) of 327 caregivers at second follow-up. At baseline, caregivers' median age was 37 years in the intervention group and 39 years in the comparison group. Nearly all caregivers were female. A median of 0% of households (aggregated by school at which the child was enrolled) in both groups had electricity and over 94% lived in homes with mud or dung walls (Table 1). At baseline, a similar median percentage of households in intervention and comparison communities used

Table 1

Demographic and socioeconomic characteristics of students' households as reported by their caregivers, Nyando Integrated Child Health and Education (NICHE) safe water and hygiene program, Nyando Division, Kenya, 2007–2009*

Characteristics of students, caregivers, and their households	Baseline 2007		Follow-up year 1 2008		Follow-up year 2 2009	
	I (*N* = 21 schools/ 312 households)	C (*N* = 22 schools/ 331 households)	I (*N* = 22 schools/ 227 households)	C (*N* = 20 schools/ 195 households)	I (*N* = 22 schools/ 175 households)	C (*N* = 19 schools/ 125 households)
Median % of female household caregivers	100 (94–100)	100 (88–100)	100 (92–100)	100 (89–100)	100 (100–100)	100 (89–100)
Caregivers' median age	37 (30–45)	39 (31–49)	39 (31–49)	39 (32–49)	40 (33–49)	41 (35–48)
Median % households with electricity	0 (0–6)	0 (0–3)	0 (0–0)	0 (0–6)	0 (0–0)	0 (0–0)
Median % with homes with thatch roof	13 (6–25)	21 (15–33)	6 (0–20)	15 (6–32)	5 (0–17)	11 (0–25)

*Reported are observed median percentages, with the 25–75th percentiles in parentheses.
I = Intervention; C = Comparison.

improved water sources (40% versus 43%, respectively); this percentage increased in both groups at first (88% versus 93%) and second follow-up (both 100%), largely because of rain water harvesting caused by increased rainfall in the second year of the study.

Students' knowledge and practices. The median percentages of students (aggregated by schools) in intervention and comparison schools that reported washing their hands at school was higher in the intervention group at baseline (76% versus 56%, EDM 23%, 90% CI 3–39%), significantly higher in intervention than comparison schools at first follow-up (100% versus 40%, EDM 60%, 90% CI 53–73%), and 100% in both groups at second follow-up (EDM 0%, 90% CI 0–0%). The median percentage of students in intervention schools that could demonstrate proper handwashing technique was similar to comparison schools at baseline (31% versus 32%, EDM 4%, 90% CI –11–19%), was significantly higher in intervention schools at first follow-up (46% versus 14%, EDM 32%, 90% CI 10–46%), and was similar in both groups at second follow-up (54% versus 50%, EDM 0%, 90% CI –17–11%, Table 2).

At baseline, the median percentage of students who were aware of WaterGuard was 100% in intervention and comparison schools. The median percentage of students in intervention and comparison schools who reported hearing about WaterGuard at school was higher in the intervention group at baseline (20% versus 13%, EDM 9%, 90% CI 1–14%), significantly higher in the intervention schools at first follow-up (63% versus 12%, EDM 53% 90% CI 44–61%), and similar between the two groups at second follow-up (87% versus 82%, EDM –2%, 90% CI –2–11%, Table 2). During the first follow-up survey, a higher median percentage of students from intervention schools than comparison schools said that they told family (41% versus 13%, EDM 27%, 90% CI 7–36%) and friends/neighbors (31% versus 17%, EDM 14%, 90% CI 7–25%) about WaterGuard; no differences were seen between the two groups at second follow-up (Table 2).

The median percentage of students in intervention and comparison schools reporting that water at their school was treated with WaterGuard was similar at baseline (13% versus 7%, EDM 7%, 90% CI –12–24%); significantly higher in students in intervention schools at first follow-up (100% versus 14%, EDM 82%, 90% CI 75–86%); and similar in both groups at second follow-up (Table 2).

Students', caregivers' knowledge and practices. Proper handwashing among caregivers showed little differences between the intervention and comparison groups at any of the cross-sectional studies (Table 3). At baseline, a median of 100% of caregivers in both groups had heard of WaterGuard. The median percentage of caregivers who reported receiving teaching on WaterGuard from their child was higher in the intervention than the comparison group at first follow-up (23% versus 8%, EDM 16%, 90% CI 6–26%) but similar at second follow-up (41% versus 50%, EDM –7%, 90% CI –17–13%). The median percentage of caregivers in intervention and comparison communities that reported treating their water currently with WaterGuard was similar at baseline (24% versus 27%, EDM 3%, 90% CI –8–15%), higher in intervention communities at first follow-up (50% versus 33%, EDM 22%, 90% CI 8–34%), and similar in intervention and comparison communities at second follow-up (50% versus 50%, EDM 7%, 90% CI –5–25%). The median percentage of caregivers that had a bottle of WaterGuard present in the home was similar in intervention and comparison communities at baseline (29% versus 33%, EDM –9%, 90% CI –19–5%), higher in the intervention group at first follow-up (43% versus 34%, EDM 8%, 90% CI 1–21%), and similar at second follow-up (67% versus 60%, EDM 7%, 90% CI –3–31% [Table 3]).

Active surveillance data. During rounds 1 through 17 of surveillance (Year 1), a median of 43% of caregivers in intervention communities and 40% in comparison communities reported treating their water with WaterGuard (EDM 3%, 90% CI –7–12%) within the preceding 36 hours. During rounds 18–36 (Year 2), a median of 58% of caregivers in intervention communities and 51% in comparison communities reported treating their water in the preceding 36 hours (EDM 7%, 90% CI 2–15%, [Table 4]). The median percentages of households with detectable free chlorine residuals in stored water during surveillance rounds 1–17 was 10% in intervention communities and 11% in comparison communities (EDM –1%, 90% CI –6–3%), and during rounds 18–36, was 9% in intervention and comparison communities (EDM 0% 90% CI –5–4%, [Table 4]).

During the first 17 rounds of surveillance, a lower median percentage of students in intervention schools than comparison schools reported being ill with any illness (5% versus 7%, EDM –3%, 90% CI –4% to –1%) and having an ARI (2% versus 3%, EDM –2%, 90% CI –3% to –1%) in the preceding 24 hours (Table 5). During rounds 18 through 36 of surveillance, a similar median percentage of students in intervention and comparison schools reported being ill (3% versus 2%, EDM 1%, 90% CI –1–1%) and having an ARI (0.8% versus 0.7%, EDM 0%, 90% CI –1–1%) in the preceding 24 hours. There were no differences in the median percentages of students in intervention schools and comparison schools that reported diarrheal illness during either year of surveillance (Year 1: 0% versus 0.3%, EDM 0%, 90% CI 0–0%,

TABLE 2

Safe water treatment and hygiene knowledge and practices among students and their schools, Nyando Integrated Child Health and Education (NICHE) safe water and hygiene program, Nyando Division, Kenya, 2007–2009*

	Baseline 2007			Follow-up year 1 2008			Follow-up year 2 2009		
Characteristics of students	Intervention (N = 21 schools/ 378 students)	Comparison (N = 22 schools/ 405 students)	EDM (90% CI)	Intervention (N = 22 schools/ 262 students)	Comparison (N = 20 schools/ 216 students)	EDM (90% CI)	Intervention (N = 22 schools/ 187 students)	Comparison (N = 19 schools/ 140 students)	EDM (90% CI)
Reported washing their hands while at school	76 (42–88)	56 (38–72)	**23 (3–39)**	100 (93–100)	40 (25–54)	**60 (53–73)**	100 (100–100)	100 (100–100)	0 (0–0)
If yes, location of HW is facility/tap in school	25 (0–57)	0 (0–35)	25 (–12–46)	100 (86–100)	12 (0–50)	**95 (70–100)**	100 (88–100)	100 (88–100)	0 (–9–8)
Demonstrated proper HW skills	31 (25–48)	32 (14–42)	4 (–11–19)	46 (30–75)	14 (0–33)	**32 (10–46)**	54 (33–100)	50 (31–75)	0 (–17–11)
Heard of WG from media	50 (38–70)	52 (33–64)	–2 (–17–13)	33 (20–50)	39 (23–54)	–5 (–17–10)	26 (13–50)	40 (20–50)	–11 (–25–10)
Heard of WG from school	20 (12–29)	13 (5–22)	**9 (1–14)**	63 (43–75)	12 (3–24)	**53 (44–61)**	87 (63–100)	82 (67–100)	–2 (–18–11)
Heard of WG from family/friends/ community	70 (63–76)	73 (67–84)	–5 (–14–2)	64 (55–71)	69 (45–82)	–3 (–15–18)	48 (35–71)	50 (44–75)	–5 (–23–5)
Heard of WG from NGOs/HCWs	22 (13–27)	11 (5–24)	10 (–1–14)	14 (0–33)	13 (0–24)	0 (–9–18)	0 (0–29)	9 (0–25)	–9 (–18–13)
Know amount of WG to use in clear water	50 (37–74)	50 (20–67)	0 (–17–25)	66 (45–78)	55 (40–75)	11 (–7–25)	61 (50–71)	50 (40–78)	10 (–15–20)
Know amount of WG to use in turbid water	38 (21–52)	38 (19–50)	–2 (–15–17)	50 (35–60)	42 (26–52)	8 (–4–23)	48 (17–57)	45 (0–56)	1 (–13–30)
Told someone about WG				69 (50–83)	40 (30–50)	**20 (6–38)**	57 (43–83)	50 (40–75)	2 (–14–25)
Told family about WG				41 (15–54)	13 (3–28)	**27 (7–36)**	47 (14–64)	38 (22–50)	12 (–7–20)
Told other students about WG				21 (10–29)	14 (0–23)	6 (–1–21)	17 (0–39)	25 (15–33)	–8 (–19–5)
Told friends/neighbors about WG				31 (21–50)	17 (3–21)	**14 (7–23)**	31 (20–38)	27 (18–38)	6 (–6–11)
Told family amount of WG to use				11 (0–30)	0 (0–7)	17 (0–23)	13 (0–33)	0 (0–30)	4 (–11–17)
Told family about importance of WG				26 (8–50)	12 (3–18)	**13 (4–30)**	27 (13–50)	33 (11–50)	–5 (–16–15)
Reported that water at school was treated	29 (11–46)	16 (5–29)	7 (–12–24)	100 (93–100)	18 (7–28)	**82 (75–86)**	100 (100–100)	100 (88–100)	0 (0–0)
Reported that WG specifically is used to make water safe	13 (6–29)	7 (0–22)	5 (–9–17)	100 (89–100)	14 (0–21)	**86 (77–87)**	98 (88–100)	100 (82–100)	–4 (–13–13)
Obtained drinking water from storage container in school	45 (21–60)	23 (7–89)	26 (–13–43)	100 (86–100)	21 (10–71)	**80 (50–86)**	96 (86–100)	92 (82–100)	–1 (–13–10)

*Reported are observed median percentages, with the 25–75th percentiles in parentheses and estimated differences in medians (EDM) with 90% confidence intervals (CI) in parentheses. Significant (where the 90% CI does not cross zero) differences are bolded. WG = WaterGuard; HW = handwashing; NGO = non-governmental organization; HCW = health care workers.

TABLE 3

Safe water treatment and hygiene knowledge and practices among students' caregivers at home, Nyando Integrated Child Health and Education (NICHE) safe water and hygiene program, Nyando Division, Kenya, 2007–2009*

Characteristics of students' caregivers and their households	Baseline 2007			Follow-up year 1 2008			Follow-up year 2 2009		
	Intervention (N = 21 schools/ 312 households)	Comparison (N = 22 schools/ 331 households)	EDM (90% CI)	Intervention (N = 22 schools/ 227 households)	Comparison (N = 20 schools/ 195 households)	EDM (90% CI)	Intervention (N = 22 schools/ 175 households)	Comparison (N = 19 schools/ 125 households)	EDM (90% CI)
Demonstrated proper HW skills	35 (27–43)	37 (28–50)	1 (−13–11)	56 (42–71)	48 (39–67)	8 (−6–20)	50 (33–77)	80 (33–100)	−30 (−40–6)
Reported making water at home safe to drink	78 (67–85)	66 (55–78)	**11 (1–21)**	85 (75–100)	65 (48–82)	**22 (8–38)**	91 (83–100)	100 (83–100)	−13 (−14–5)
Reported making water safe with WG	44 (30–55)	41 (29–52)	3 (−8–15)	75 (63–86)	52 (41–68)	**23 (8–34)**	82 (67–100)	70 (63–90)	7 (−5–25)
Taught about WG by child				23 (14–41)	8 (0–18)	**16 (6–26)**	41 (20–67)	50 (33–63)	−7 (−17–13)
Learned from student that WG prevents diarrhea				15 (9–25)	7 (0–14)	**9 (4–17)**	29 (0–50)	25 (10–50)	−2 (−17–22)
WG present in home at time of interview	29 (20–40)	33 (21–45)	−9 (−19–5)	43 (38–61)	34 (25–43)	**8 (1–21)**	67 (50–100)	60 (33–67)	7 (−3–31)

*Reported are observed median percentages, with the 25–75th percentiles in parentheses, and estimated differences in medians (EDM) with 90% confidence intervals (CI) in parentheses. Significant (where the 90% CI does not cross zero) differences are bolded.
WG = WaterGuard; HW = handwashing.

Year 2: 0% versus 0%, EDM 0%, 90% CI 0–0%). No seasonal differences were observed for ARI or diarrhea.

DISCUSSION

Findings of this longitudinal study suggest that the installation of handwashing stations in schools and provision of hygiene training may have improved knowledge about proper handwashing techniques and reduced the risk of ARIs among students after they were exposed to the intervention. The decrease in burden of ARI found in this study was consistent with other studies on the health impact of handwashing,[21] though few studies have shown the impact of handwashing among children in international settings and most of these have focused on children < 5 years of age. This study provides additional evidence to support the global effort to expand hygiene interventions, including hardware, in schools.[22–24]

Although knowledge of water treatment and access to safe water at school increased among intervention students in Year 1, we did not observe differences in diarrheal diseases between the two groups during this period. There are several potential explanations for this observation. First, diarrhea rates among the students were low (< 1%). Second, at baseline, a high percentage of students and their caregivers had heard of WaterGuard, which likely was the result of a social marketing program that began in 2003.[25] Furthermore, similar percentages of caregivers in the intervention and comparison groups both reported and were confirmed to be treating their water during surveillance visits in both years of the study, a finding that was also likely influenced by exposure to social marketing and easy access to WaterGuard. Third, although only the water at intervention schools was reported to have been treated during the first year of the study, the students in both groups were exposed to multiple drinking water sources outside of school that may have resulted in a similar risk of diarrhea.

Although the school program appeared to meet some of its objectives, as demonstrated by the higher percentage of intervention than comparison students that exhibited increased knowledge of water treatment and transmitted this information to their caregivers, it did not appear to lead to a change in caregivers' practices. No differences between intervention and comparison groups were observed in reported household water treatment, presence of WaterGuard bottles in the home, or detectable chlorine residual in stored water. Other studies have also reported that, although transfer of information from students to caregivers has occurred, caregiver practices can lag behind.[15,26] In this case, the integration of other interventions at multiple levels of influence (individual; organizations such as schools, clinics, and churches; mass media; and government) may have also had an impact on caregiver knowledge and behavior.[18] Further research into determinants of behavior change could help elucidate reasons for the lack of effect in this and other studies as compared with studies that have shown an impact on caregiver water treatment behavior.[12,13,27]

TABLE 4

Home drinking water treatment at students' households as reported during bimonthly active surveillance by caregivers, Nyando Integrated Child Health and Education (NICHE) safe water and hygiene program, Nyando Division, Kenya, 2007–2009*

	Year 1 (17 visits maximum per household)			Year 2 (19 visits maximum per household)		
	Intervention (N = 21 schools/ 4,497 households)	Comparison (N = 22 schools/ 4,825 households)	EDM (90% CI)	Intervention (N = 21 schools/ 4,391 households)	Comparison (N = 22 schools/ 4,947 households)	EDM (90% CI)
Treated water in the 36 hours before study visit	43 (33–53)	40 (35–44)	3 (−7–12)	58 (47–65)	51 (42–57)	**7 (2–15)**
Chlorine present in water	10 (3–14)	11 (7–17)	−1 (−6–3)	9 (6–14)	9 (6–18)	0 (−5–4)

*Reported are median percentages, with the 25–75th percentiles in parentheses and estimated differences in medians (EDM) with 90% confidence intervals (CI) in parentheses. Significant (where the 90% CI does not cross zero) differences are bolded.

Table 5

Illness reported among students during bimonthly active surveillance by caregivers, Nyando Integrated Child Health and Education (NICHE) safe water and hygiene program, Nyando Division, Kenya, 2007–2009*

	Year 1 (17 visits maximum per household)			Year 2 (19 visits maximum per household)		
	Intervention (N = 21 schools/ 5071 students)	Comparison (N = 22 schools/ 5428 students)	EDM (90% CI)	Intervention (N = 21 schools/ 4996 students)	Comparison (N = 22 schools/ 5601 students)	EDM (90% CI)
Any illness (diarrhea, cough/difficulty breathing, rhinorrhea/coryza, or fever)	5 (4–7)	7 (6–9)	**–3 (–4–1)**	3 (2–3)	2 (1–3)	1 (–1–1)
Diarrhea	0 (0–0.3)	0.3 (0–0.6)	0 (0–0)	0 (0–0)	0 (0–0)	0 (0–0)
Acute respiratory illness (fever and cough)	2 (1–4)	3 (3–6)	**–2 (–3–1)**	0.8 (0–1.5)	0.7 (0.3–1.5)	1 (–1–1)

*Reported are median percentages, with the 25–75th percentiles in parentheses, and estimated differences in medians (EDM) with 90% confidence intervals (CI) in parentheses. Significant (where the 90% CI does not cross zero) differences are bolded.

Despite mixed results, the school intervention did appear to have a sustained impact. Over the course of the 2-year study, students in the intervention schools sustained improvements in knowledge (e.g., knew purpose of WaterGuard) and positive changes in behavior (washed hands at school and maintained the ability to demonstrate proper handwashing skills). Additionally, although schools were only given a 3-month free supply of WaterGuard, students at the intervention school reported that their school treated the water a year after the intervention. This held true during Year 2 among both groups. A similar instance of sustained implementation of a school-based intervention has been shown previously where a school-based safe water pilot was found to persist 10 months after the end of the pilot.[13]

This study had several important limitations. First, because the school program was implemented concurrently with a number of other village-level interventions and implementation strategies in the NICHE project, particularly at the household level, it was not possible to determine whether results derived primarily from the school or the community intervention. However, the community interventions were meant to target adults, whereas the school intervention was targeted at students. Although no differences were found in mothers' ability to demonstrate proper handwashing between the intervention and comparison groups throughout the study, we did observe a significant difference between intervention and comparison school students at Year 1, and comparison students "caught up" to intervention children at Year 2. These differences in knowledge among students in the two groups were paralleled by the differences in respiratory illness. It is not unreasonable to infer that the installation of school handwashing stations and instruction in a learning environment may have led to these outcomes among students. Furthermore, the increase in knowledge observed in this study was similar to other school-based hygiene programs from the same region,[13,15] and the impact on respiratory illness is biologically plausible. A second limitation is that illness outcomes were reported and not clinically confirmed raising the possibility of illness misclassification. Additionally, students were not asked about their illness directly, and if they failed to inform their caregivers of their illness, then illness episodes would not have been captured. It is likely that illness reported by children to caregivers would more likely be severe in nature; this potential reporting bias could have resulted in an underestimation of the impact of the intervention. Third, biweekly home visits could have resulted in respondent fatigue and lowered rates of reported illness. Fourth, repeated home visits with observations of household practices may have influenced the behavior of students and caregivers through the Hawthorne effect. Fifth, many students were lost to follow-up in this study through graduation and dropping out. Although students lost to follow-up were not different from the overall population surveyed at baseline, it would be difficult to impute the impact the lost children would have on the data. For this reason, we did not compare illness rates between the first and second years of the study. This study had a small sample size, which restricted our analysis to a 90% confidence limit rather than a 95% confidence limit as is the standard. Thus, the findings are limited when compared with other more robust studies. Finally, courtesy bias could have contributed to over-reporting of use of water treatment products and handwashing by participants.

In conclusion, the installation of handwashing stations and hygiene education may have contributed to decreased rates of overall illness and ARIs in primary school students. Although we observed gains in knowledge among students about water treatment and increased access to safe drinking water in schools, these changes did not translate to reduced diarrhea rates, perhaps because of the influence of additional concurrent water interventions in project communities. Despite the mixed findings, simple, inexpensive programs such as the one described in this work, along with curricular materials to enhance learning about water treatment, hygiene, and sanitation, merit expansion and further evaluation until universal coverage by piped, treated water and sanitary infrastructure in schools is achieved.

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