Impact of Integration of Hygiene Kit Distribution With Routine Immunizations on Infant Vaccine Coverage and Water Treatment and Handwashing Practices of Kenyan Mothers

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Integration of immunizations with hygiene interventions may improve use of both interventions. We interviewed 1361 intervention and 1139 comparison caregivers about hygiene practices and vaccination history, distributed water treatment and hygiene kits to caregivers during infant vaccination sessions in intervention clinics for 12 months, and conducted a followup survey of 2361 intervention and 1033 comparison caregivers. We observed significant increases in reported household water treatment (30% vs 44%, \( P < .0001 \)) and correct handwashing technique (25% vs 51%, \( P < .0001 \)) in intervention households and no changes in comparison households. Immunization coverage improved in both intervention and comparison infants (57% vs 66%, \( P = .04 \); 37% vs 53%, \( P < .0001 \), respectively). Hygiene kit distribution during routine immunizations positively impacted household water treatment and hygiene without a negative impact on vaccination coverage. Further study is needed to assess hygiene incentives, implement alternative water quality indicators, and evaluate the impact of this intervention in other settings.

Annually, 10 million children aged <5 years die from preventable causes. More than two-thirds of these deaths could be prevented through universal application of proven interventions [1]. However, because of inequitable distribution, these interventions often do not reach children at greatest risk of death [2]. For example, diarrheal diseases remain the second leading infectious cause of death in children aged <5 years in the developing world even though inexpensive and effective preventive interventions, such as household water treatment [3] and handwashing with soap [4], which have been shown to reduce diarrhea risk by 30%–40% [4, 5], are widely available. The barriers to scaling up these interventions are complex [3, 6] but may be diminished through programmatic innovations [7–9].

One promising solution is the integration of diarrhea prevention interventions with routine immunization services. The Expanded Programme on Immunization (EPI), which provides routine immunization to children, has the greatest and most equitable coverage of any preventive program in the developing world [10]. Because EPI involves multiple health contacts with mothers and children, extending the reach of other health interventions by integrating them with EPI is recommended by the Global Immunization Vision and Strategy to achieve Millennium Development Goal No. 4 of reduced child mortality [11]. Examples of successful integration programs include vitamin A supplementation and distribution of insecticide-treated bed nets with routine immunization services in Malawi [7, 12], distribution of
hygiene kits with antenatal clinic visits in Malawi [13], and human immunodeficiency virus services in Uganda [14]. However, no published studies to date have evaluated the integration of hygiene kit distribution with routine childhood immunizations.

In February 2009, a pilot program was initiated in western Kenya to provide hygiene kits (WaterGuard sodium hypochlorite solution for household water treatment, soap, and pictorial educational materials) and one-on-one or group counseling sessions to mothers attending routine immunization sessions during their infant’s first year of life. We conducted an evaluation to determine whether this incentive could increase vaccination coverage, household water treatment, and hygiene behavior.

**METHODS**

**Intervention**

The Ministry of Health selected Homa Bay and Suba districts as pilot program sites. Homa Bay was randomly selected as the intervention site and Suba as the comparison site. During routine immunization visits at health facilities in Homa Bay, caregivers with a child aged <12 months were offered free hygiene kits and education about water treatment and hand hygiene through group health talks (10–30 minutes) or one-on-one communication (5–15 minutes). In Kenya, pentavalent vaccine (diphtheria-tetanus-pertussis, *Haemophilus influenzae* type b, and hepatitis B) and oral polio vaccine are provided at 6, 10, and 14 weeks of age, and measles vaccine is provided at 9 months of age [15].

**Evaluation—Surveys**

**Population**

Interventions designed to improve vaccine coverage usually continue for a 2-year period, so that a 1-year cohort of infants aged 12–23 months will be fully exposed to the intervention. Due to resource limitations, this study was restricted to a 1-year period. To measure a 1-year age cohort of children for each of the immunizations recommended during the first year of life, we included infants aged 2–20 months. Vaccine coverage was determined for 2 overlapping groups of infants (Figure 1): (1) those aged 2–13 months who were age-eligible for the first 4 vaccinations only during the 12-month hygiene kit intervention period and (2) the complete cohort of infants aged 2–20 months, which included the group of infants aged 2–13 months noted above plus children aged 14–20 months who were eligible for some vaccines before the hygiene kit intervention began.

**Sample Size Calculations**

The sample size needed to measure an increase in WaterGuard use from 5% to 15% [8] was calculated as 320 households per district. Required sample size to detect a change in vaccination coverage from 38% to 48% [16] in the intervention group among the smaller age group was calculated as 808 children, based on an α = .05, power = 0.80, and a design effect of 2. However, because we included children aged 14–20 months for the expanded age group, we increased the sample by 50% to 1212 in each district to reflect the 50% larger cohort. In addition, because the follow-up
evaluation included a comparison of 2 different hygiene kit distribution strategies in Homa Bay [17], we doubled the intervention group sample size to 2424.

Sample Selection
A stratified cluster design was used for each survey. Each district was stratified by sublocation. To ensure that the sample in these largely rural districts included some urban enumeration areas (EA), EAs were stratified within each sublocation by urban and rural. Homa Bay had 9 sublocations with at least 1 urban EA, and Suba had 4 sublocations with at least 1 urban EA; the remaining sublocations were entirely rural. A total of 49 EAs in Homa Bay district (40 rural and 9 urban) and 49 EAs in Suba district (44 rural and 5 urban) were randomly selected. Using similar methodology, at follow-up we doubled the sample size in Homa Bay as described above and selected a new random sample of 98 EAs (80 rural, 18 urban) for Homa Bay district and 49 EAs (44 rural, 5 urban) for Suba district. Enumeration areas not accessible by car (none in Homa Bay and 4.3% in Suba) were excluded from sampling. All households within selected EAs were visited; those with children aged 2–20 months were eligible to participate. We interviewed the child’s caregiver or an alternative household member >18 years of age; only 1 person was interviewed per household but information was collected for all age-eligible children.

Surveys
The baseline survey was conducted February–April 2009, and the follow-up was conducted February–April 2010. Interviews were performed by bilingual enumerators using global positioning system (GPS)–enabled personal digital assistants (PDAs). For the entire evaluation population, we used a standard questionnaire to obtain demographic and socioeconomic characteristics, vaccination history for all children aged 2–20 months (using both maternal recall and immunization cards), and household water treatment and hygiene practices. Stored water was tested for residual chlorine using the \(N,N\)-diethyl-\(p\)-phenylenediamine method (LaMotte) as an objective measure of WaterGuard use. At each household and health facility in both districts, GPS mapping was attempted. For a random sample of one-third of the study population, additional detailed water treatment and hygiene questions were asked.

Health Facility Monitoring
Program monitoring data, including vaccine or hygiene kit stockouts, availability of functional refrigeration for vaccines, and information on concurrent water and hygiene activities implemented by other organizations, were collected monthly at all health facilities.

Human Subjects Protection
The evaluation protocol was exempted from review by the Centers for Disease Control and Prevention (CDC) Institutional Review Board (protocol 5571) because it examined proven public health practices with minimal risk, and it was approved by the Ethical Review Committee of the Kenya Medical Research Institute (protocol 1533). Written informed consent was obtained from all participants. Databases excluded personal identifiers.

Data Analysis
Data were entered into PDAs using Visual CE software. Data were analyzed using SAS software, version 9.2 (SAS Institute). All analyses accounted for stratification by baseline/follow-up, district, and rural/urban; EA as the primary sampling unit; probability of selection; and a finite population correction factor based on the total number of EAs per stratum. Univariate analysis produced weighted coverage estimates and 95% confidence intervals. Two-tailed \(\chi^2\) tests were used to assess differences between district-level estimates and change from baseline to follow-up within each district.

To assess changes in vaccine coverage within intervention and comparison groups, we defined 2 variables: implementation coverage and up-to-date coverage. Implementation coverage, measured for the entire cohort of children aged 2–20 months, was defined for the baseline survey as the percent of children who had received all vaccine doses due during the 12 months preceding the beginning of the hygiene kit intervention, and, for the follow-up survey, as the percent of children who received all vaccines due during the 12-month hygiene kit implementation period (Figure 1). Up-to-date coverage, measured for the cohort of children aged 2–13 months, was defined as the percent of children who received all age-appropriate vaccines (vaccines due based on child’s age) during the previous 12-month period (ie, before the intervention [for the baseline survey], or during the 12-month intervention period [for the follow-up survey]) (Figure 1).

We assessed water treatment and hygiene practices within the intervention and comparison groups at baseline and follow-up by comparing reported WaterGuard use, residual chlorine in stored water, soap observed in the home, and mothers’ ability to demonstrate proper handwashing technique.

RESULTS

Enrollment
We interviewed caregivers from 1361 households in Homa Bay (31% urban and 69% rural) and 1139 in Suba (9% urban and 91% rural) at baseline and from 2361 households in Homa Bay (46% urban and 54% rural) and 1033 in Suba (14% urban and 86% rural) at follow-up using the standard questionnaire. A random subsample of 447 (33%) respondents in Homa Bay and 368 (32%) in Suba at baseline and 800 (34%) respondents in Homa Bay and 314 (30%) in Suba at follow-up received the expanded questionnaire. In each survey, >99% of caregivers agreed to participate.
Demographic and Socioeconomic Characteristics
In both districts at baseline and follow-up, the median age of respondents was 23 years, >95% were female, and >90% were literate (Table 1). A higher percentage of respondents in Homa Bay than in Suba had completed primary school education at baseline (49% vs 39%, $P = .009$) and follow-up (57% vs 46%, $P = .003$).

Among the subsample completing the expanded questionnaire, a significantly higher percentage of Homa Bay respondents than Suba respondents (31% vs 31%, $P = .01$ at baseline; 64% vs 41%, $P = .0008$ at follow-up) reported using an improved water source. The majority of respondents in Homa Bay and Suba reported storing drinking water in a clay pot at baseline (64% vs 53%) and follow-up (60% vs 54%). Less than 31% of respondents reported using narrow-mouthed water storage containers in either district.

For households enrolled in either survey with GPS data available (71% of Homa Bay households and 41% of Suba households), the median distance from house to health facility in urban areas was 1.33 kilometers (interquartile range [IQR], 0.77–2.31 km) in Homa Bay and 0.56 km (IQR, 0.37–0.98 km) in Suba; in rural areas, the distance was 2.02 km (IQR, 1.38–2.82 km) in Homa Bay and 2.47 km (IQR, 1.37–3.91 km) in Suba.

Water Treatment
Awareness of WaterGuard exceeded 97% at baseline and follow-up in both districts. From baseline to follow-up, there was a statistically significant increase in the percentage of Homa Bay respondents who reported ever using WaterGuard (77% vs 95%, $P < .0001$), reported treating their current drinking water with WaterGuard (30% vs 44%, $P < .0001$), and had a WaterGuard bottle observed in the home (26% vs 62%, $P < .0001$) (Table 2). In contrast, the increases in Suba from baseline to follow-up of respondents who reported ever using WaterGuard (80% vs 85%) and treating their current drinking water with WaterGuard (37% vs 39%) were not statistically significant; however, there was a significant increase in observed WaterGuard in the home from baseline to follow-up (30% vs 44%, $P < .0001$). The percentage of stored water samples with detectable residual chlorine did not increase in either district (Table 2).

In the subsample of households completing the expanded questionnaire, a significant increase was observed among Homa Bay respondents from baseline to follow-up in knowledge of correct use of WaterGuard (52% vs 72%, $P < .0001$); no improvement was noted among Suba respondents (Table 2).

Hygiene
The percentage of households with soap increased from baseline to follow-up in Homa Bay (89% vs 92%, $P = .04$) but not in Suba. The percentage of respondents demonstrating correct handwashing technique increased in Homa Bay (25% vs 51%, $P < .0001$), but the observed improvement in Suba was not statistically significant (Table 2).

Immunization Coverage
The surveys included 1404 children aged 2–20 months in Homa Bay and 1175 in Suba at baseline, and 2419 in Homa Bay and 1082 in Suba at follow-up. At baseline and follow-up, 73%–80% of children in both districts had a vaccination card available (Table 3).

In Homa Bay, implementation coverage (children aged 2–20 months) increased significantly from baseline to follow-up among all children (61% vs 70%, $P = .007$) and among urban children (68% vs 84%, $P < .0001$) (Table 3); there was no change in implementation coverage among rural children. In Suba, implementation coverage increased significantly from baseline to follow-up among all children (47% vs 58%, $P = .005$) and among rural children (46% vs 57%, $P = .01$); the increase among urban children was not statistically significant.

In Homa Bay, up-to-date coverage (children aged 2–13 months) also increased significantly from baseline to follow-up among all children (57% vs 66%, $P = .04$) and among urban children (69% vs 82%, $P < .0001$) (Table 3); there was no change among rural children. In Suba, up-to-date coverage increased significantly from baseline to follow-up among all children (37% vs 53%, $P < .0001$) and among rural children (36% vs 52%, $P = .0003$); the change among urban children was not statistically significant.

Health Facility Monitoring
Figure 2 shows the percent of health facilities reporting problems with immunization infrastructure or vaccine stockouts by month. Of 3 urban facilities monitored in Suba, 1 or 2 had infrastructure problems or stockouts in 8 of 11 months for which data were available. Of 2 urban facilities monitored in Homa Bay, 1 or both had infrastructure problems or stockouts in all of the 12 monitoring months. Among rural health facilities in Homa Bay (n = 12), the median number with infrastructure problems or stockouts per month was 11 (range, 7–12). Among rural health facilities in Suba (n = 27), the median number with infrastructure problems or stockouts per month was 3 (range, 0–17). In the last 3 monitoring months, infrastructure problems or stockouts were rare in both urban and rural health facilities in Suba. Homa Bay saw a steady decline over time in the percentage of rural health facilities with infrastructure problems or stockouts. Concurrent interventions distributing WaterGuard were reported during 5% of Homa Bay and 9% of Suba monitoring months; none were integrated with vaccination programs. No incentives were offered for routine vaccination visits in either district.

DISCUSSION
This evaluation, the first to assess the integration of hygiene kit distribution with routine immunizations, suggests that the intervention may have had a positive impact on reported household water treatment, hygiene knowledge, and hygiene behavior.
Table 1. Demographic Characteristics and Water and Sanitation Coverage, at Baseline (February 2009) and Follow-up (April 2010) Surveys, Homa Bay and Suba Districts, Nyanza Province, Kenya

<table>
<thead>
<tr>
<th></th>
<th>Baseline</th>
<th></th>
<th>Suba (n = 1139)</th>
<th></th>
<th>Follow-up</th>
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<th>Suba (n = 1033)</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>Homa Bay (n = 1361)</td>
<td>Median (IQR)</td>
<td></td>
<td></td>
<td>Suba (n = 2361)</td>
<td>Median (IQR)</td>
<td></td>
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<tr>
<td>Head of household age</td>
<td>23.4 (19.9–28.0)</td>
<td>23.2 (19.5–28.5)</td>
<td>22.6 (19.5–27.1)</td>
<td>22.8 (19.6–28.4)</td>
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<tr>
<td>Household size</td>
<td>4.8 (3.6–6.1)</td>
<td>4.7 (3.5–6.3)</td>
<td>4.5 (3.4–6.0)</td>
<td>4.8 (3.6–6.3)</td>
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<tr>
<td>Literate</td>
<td>1360 93.8 (92.3–95.3)</td>
<td>1139 92.2 (90.5–93.9)</td>
<td>.20</td>
<td>2361 96.1 (95.2–97.1)</td>
<td>1033 94 (92.1–95.8)</td>
<td>.03</td>
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</tr>
<tr>
<td>Urban</td>
<td>230 94.6 (91.4–97.9)</td>
<td>119 94.8 (92.3–97.4)</td>
<td>.93</td>
<td>515 97.6 (96.2–98.9)</td>
<td>201 95.2 (93.1–97.3)</td>
<td>.02</td>
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<tr>
<td>Rural</td>
<td>1130 93.4 (91.8–95.0)</td>
<td>1020 92.0 (90.2–93.8)</td>
<td>.28</td>
<td>1846 94.9 (94.1–95.7)</td>
<td>832 93.8 (91.6–95.9)</td>
<td>.35</td>
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<tr>
<td>Education</td>
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<tr>
<td>Primary school or higher</td>
<td>1360 49.0 (42.5–55.4)</td>
<td>1090 38.8 (34.6–43.0)</td>
<td>.009</td>
<td>2361 57.3 (50.6–64.0)</td>
<td>1033 46.3 (42.1–50.5)</td>
<td>.003</td>
<td></td>
<td></td>
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<tr>
<td>Urban</td>
<td>230 63.3 (49.5–77.1)</td>
<td>119 55.4 (45.0–65.8)</td>
<td>.39</td>
<td>515 69.3 (60.4–78.2)</td>
<td>201 55.2 (48.6–61.7)</td>
<td>&lt; .0001</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rural</td>
<td>1130 42.5 (39.3–45.7)</td>
<td>1020 37.2 (32.7–41.7)</td>
<td>.09</td>
<td>1846 47 (44.6–49.3)</td>
<td>832 44.9 (40.1–49.7)</td>
<td>.49</td>
<td></td>
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</tr>
<tr>
<td>Toilet facilityd</td>
<td>1352 53.2 (40.1–66.4)</td>
<td>1132 38.0 (26.7–49.0)</td>
<td>.1</td>
<td>2353 68 (58.5–77.4)</td>
<td>1021 44 (36.2–51.8)</td>
<td>&lt; .0001</td>
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<td></td>
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<tr>
<td>Urban</td>
<td>229 80 (55.2–100)</td>
<td>119 89.9 (80.9–98.8)</td>
<td>.498</td>
<td>513 86.7 (77.8–95.7)</td>
<td>199 86.5 (80.8–92.2)</td>
<td>.96</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rural</td>
<td>1123 41.1 (34.9–47.3)</td>
<td>1013 32.9 (20.3–45.5)</td>
<td>.33</td>
<td>1840 51.7 (47.4–56.0)</td>
<td>822 37.3 (28.8–45.8)</td>
<td>.01</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Subsample of householdsf</td>
<td>444 51.2 (37.3–65.2)</td>
<td>363 31.2 (22.6–37.8)</td>
<td>.01</td>
<td>799 64.4 (53.0–75.8)</td>
<td>309 40.9 (31.2–50.6)</td>
<td>.0008</td>
<td></td>
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<tr>
<td>Improved water sourcef</td>
<td>64 85.3 (66.8–100)</td>
<td>39 74.2 (51.9–96.4)</td>
<td>.46</td>
<td>184 90.7 (81.9–99.4)</td>
<td>53 37.4 (12.2–62.5)</td>
<td>&lt; .0001</td>
<td></td>
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</tr>
<tr>
<td>Urban</td>
<td>380 35.7 (27.6–43.8)</td>
<td>324 27.3 (18.8–35.9)</td>
<td>.21</td>
<td>615 41.7 (36.0–47.4)</td>
<td>256 41.5 (31.0–52.0)</td>
<td>.97</td>
<td></td>
<td></td>
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</tbody>
</table>

Abbreviations: CI, confidence interval; IQR, interquartile range.

a The number changes based on missing values and “don’t know” (these values are <5% of the total data).

b χ² test evaluating a difference in the district-level proportions, overall and for urban- and rural-specific estimates.

c Education is a dichotomous variable; the second level is “Never attended school or completed less than primary school.”

d Pit or flush latrine.

e Subsample of households that answered the complete questionnaire (~1 in every 3 households was randomly selected to complete).

f Private or public tap, protected borehole, well, spring, or rain water.
## Table 2: Percentage of Respondents With Reported and Observed Water Treatment and Handwashing Practices, by Urban and Rural Residence, at Baseline (February 2009) and Follow-up (April 2010), Homa Bay and Suba Districts, Nyanza Province, Kenya

<table>
<thead>
<tr>
<th></th>
<th>Homa Bay</th>
<th>Suba</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Baseline (n = 1361)</td>
<td>Follow-up (n = 2361)</td>
</tr>
<tr>
<td></td>
<td>No. a % (95% CI)</td>
<td>No. a % (95% CI)</td>
</tr>
<tr>
<td>All households</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ever used WaterGuard</td>
<td>1361 77.1 (71.3–82.9)</td>
<td>2361 94.9 (93.8–96.0)</td>
</tr>
<tr>
<td>Urban</td>
<td>230 90.1 (82.7–97.5)</td>
<td>515 96.8 (95.3–98.3)</td>
</tr>
<tr>
<td>Rural</td>
<td>1131 71.2 (67.2–75.3)</td>
<td>1846 93.3 (91.9–94.6)</td>
</tr>
<tr>
<td>Current water treated with WaterGuard</td>
<td>1354 30.1 (25.4–34.8)</td>
<td>2353 44.3 (40.7–48.0)</td>
</tr>
<tr>
<td>Urban</td>
<td>230 39.1 (31.4–46.8)</td>
<td>514 48.9 (42.8–55.1)</td>
</tr>
<tr>
<td>Rural</td>
<td>1124 26.0 (21.1–31.0)</td>
<td>1839 40.4 (27.8–43.0)</td>
</tr>
<tr>
<td>Waterguard observed in home</td>
<td>1316 25.7 (19.9–31.5)</td>
<td>2358 62.4 (59.1–65.8)</td>
</tr>
<tr>
<td>Urban</td>
<td>230 31.3 (14.9–47.7)</td>
<td>514 59.8 (54.0–65.6)</td>
</tr>
<tr>
<td>Rural</td>
<td>1086 23.1 (18.4–27.9)</td>
<td>1844 64.7 (62.6–66.8)</td>
</tr>
<tr>
<td>Positive free residual chlorine</td>
<td>1316 7.2 (3.7–10.7)</td>
<td>2255 6.9 (5.6–8.3)</td>
</tr>
<tr>
<td>Urban</td>
<td>221 12.2 (2.7–21.7)</td>
<td>493 6.8 (4.6–9.0)</td>
</tr>
<tr>
<td>Rural</td>
<td>1095 4.9 (3.1–6.7)</td>
<td>1762 7.1 (91.3–94.6)</td>
</tr>
<tr>
<td>Soap observed in home</td>
<td>1361 88.6 (86.1–91.1)</td>
<td>2358 91.8 (90.6–92.9)</td>
</tr>
<tr>
<td>Urban</td>
<td>230 93.2 (89.1–97.3)</td>
<td>514 92.7 (90.5–94.8)</td>
</tr>
<tr>
<td>Rural</td>
<td>1131 86.5 (84.3–88.7)</td>
<td>1844 91.0 (89.9–92.1)</td>
</tr>
</tbody>
</table>

Subsample of households

| Correct knowledge of WaterGuard use | 447 51.9 (46.6–57.1) | 800 71.6 (68.1–75.0) | <.0001 | 368 59.3 (54.2–64.3) | 314 53.9 (39.1–53.2) | .27 |
| Urban | 64 56.8 (45.7–67.9) | 184 75.8 (69.4–82.1) | <.0001 | 42 82.1 (76.8–87.4) | 53 76.0 (53.9–98.0) | .62 |
| Rural | 383 48.8 (42.8–54.8) | 616 68.6 (64.8–72.5) | <.0001 | 326 57.1 (51.7–62.6) | 261 50.4 (44.1–56.6) | .14 |

| Correct handwashing demonstrated | 447 25.0 (19.7–30.3) | 800 50.7 (46.4–55.0) | <.0001 | 368 27.4 (22.3–32.5) | 314 34.0 (26.1–41.9) | .2 |
| Urban | 64 28.5 (17.0–40.1) | 184 52.4 (45.1–59.6) | <.0001 | 42 31.5 (18.3–44.7) | 53 35.6 (26.1–45.1) | .66 |
| Rural | 383 23.4 (17.9–28.9) | 616 49.2 (44.5–53.9) | <.0001 | 326 27.0 (21.6–32.4) | 261 33.7 (24.7–42.7) | .24 |

Abbreviation: CI, confidence interval.

- The number changes based on missing values and “don’t know” (these values are <5% of the total data).
- Chi-square test evaluating a difference in the district-level proportions, overall and for urban- and rural-specific estimates.
- Among households that had water available for testing.
- Subsample of households that answered the complete questionnaire (~1 in every 3 households was randomly selected to complete).
- Defined as knowing the correct number of capfuls and wait time.
- Defined as demonstrating all three steps: uses soap, lathers hands completely, and either air dries or uses a clean towel.
Measured indicators for all 3 increased significantly in Homa Bay but not in Suba. However, these results were not supported by a change in residual chlorine measured in stored water. The effect of the intervention on vaccination coverage is less clear. Although implementation and up-to-date vaccine coverage in urban areas of Homa Bay increased at follow-up, there was no change in rural vaccine coverage. Furthermore, vaccine coverage increased in rural areas of Suba in the absence of hygiene kit distribution.

**Water Treatment**

The fact that there were significantly increased rates of water treatment knowledge and reported practices in Homa Bay, without corresponding increases in Suba, suggests the hygiene kit distribution program had an effect. These findings were consistent with previous research [7, 13] and diffusion of innovations theory, which observes that incentives (ie, hygiene kits) can increase the rate of adoption of health innovations, such as vaccines or water treatment products [18]. The increase in observed WaterGuard in respondents’ homes in Suba from baseline to follow-up was likely a result of concurrent free WaterGuard distribution reported in Suba during program monitoring. The lack of increased WaterGuard knowledge or reported use in Suba, in contrast to the increases observed in Homa Bay, underscores the importance of the educational component of the intervention and is consistent with previous research in Kenya.
that found education delivered by trusted personnel is essential to successful execution of clinic-based hygiene programs [8].

The discrepancy between reported WaterGuard use and detection of residual chlorine in stored water in both districts could be explained by several factors. First, respondents may have exhibited courtesy bias, providing the answer they felt interviewers expected; however, we would expect this to occur equally at baseline and follow-up. Second, measurement of residual chlorine may have been inadequate for water sources with high chlorine demand. High chlorine demand, which occurs when organic materials in water combine with free available chlorine, may have reduced the percentage of water samples with detectable chlorine residuals in both districts [19, 20]. Third, water storage in clay pots or other wide-mouthed containers into which hands can be inserted may have increased chlorine demand [20]. Finally, the local practice of refilling clay pots with water every 2–4 days may have increased the likelihood that residual chlorine was not detectable at the time of testing due to chlorine residual decay [14, 20].

Hygiene
The ability of Homa Bay respondents to demonstrate proper handwashing procedure doubled from baseline to follow-up. It is likely that this improvement, which was consistent with other studies [8, 13], was attributable to this intervention because of the lack of other hygiene programs in the area. Although this indicator does not necessarily imply a change in behavior, acquisition of knowledge is an important first step in behavior change [21].

Vaccine Coverage
There are several possible explanations for the increase in implementation and up-to-date vaccination coverage in urban areas in Homa Bay. First, the hygiene kit may have attracted mothers to health facilities. No other programs in Homa Bay were offering incentives for routine vaccination visits. Second, compared with rural areas, urban areas had shorter distances to health facilities, lower transport costs, and better roads and access to public transportation, thus facilitating clinic access. It is unlikely that increases in urban vaccine coverage were an artifact of vaccine availability because program monitoring data suggested that vaccine stockouts or refrigeration problems were similar in rural and urban areas in Homa Bay.

The failure of hygiene kits to incentivize increased vaccine coverage in rural Homa Bay could have resulted from several factors, including high transportation costs and low perceived value of the kit. The median distance to health facilities in Homa Bay was approximately twice as far from rural EAs than urban EAs. Previous research suggests that vaccine coverage decreases with increasing distance from health facilities [22]. Transportation to rural health facilities in Homa Bay cost $0.50–$2.50 while WaterGuard and soap cost only $0.40, a value that may have been insufficient to motivate a trip to the clinic. In addition, WaterGuard has been marketed in Kenya for 7 years [23], is widely available, and has high product awareness, which may have reduced its appeal. In other programs, higher value and novel interventions (insecticide-treated bed nets, water storage containers with taps) motivated increased health service coverage rates in rural and urban sites [7, 13].

Increased vaccination coverage in rural areas of Suba from baseline to follow-up was unexpected. Baseline vaccination coverage rates in Suba were substantially lower than in Homa Bay, and follow-up coverage rates in Suba did not reach baseline levels observed in Homa Bay. It has been observed that lower baseline coverage rates increase more rapidly than higher rates (ie, improvements are easier to achieve at lower rates; M. Watkins, CDC, oral communication, April 2010), which may have played a role in Suba's immunization coverage improvement. Also, monitoring data revealed a sharp decrease in the percentage of health facilities in rural areas reporting problems with immunization infrastructure or vaccine supply in Suba during the year-long intervention period compared with Homa Bay, which may have contributed to increased vaccine availability and coverage, although this decrease was also seen in urban areas of Suba.

Limitations
Our evaluation had several limitations. First, to avoid the risk of mixing intervention and comparison populations, we used a quasi-experimental design. Because of time and resource constraints, we were only able to select a convenience sample of 1 intervention and 1 comparison district, limiting the generalizability of the findings. Although the districts were similar in many respects (eg, geography, demographics), the baseline survey revealed important differences, including immunization coverage. We were unable to ascertain detailed information about other interventions occurring during the intervention period that may have confounded project outcomes, and we did not have monitoring data from the year preceding the intervention for a year-to-year comparison of vaccine stockout rates. Second, the length of the intervention was not long enough to sample only children who would have been exposed to the intervention during the entire time that they should have received routine vaccinations. Finally, the discrepancy in reported water treatment and results of residual chlorine testing in stored water highlights the limitations of this test as an evaluation tool for populations that rely on water sources with high chlorine demand and points to the need for better low-cost water quality indicators.

CONCLUSIONS AND RECOMMENDATIONS
In conclusion, findings of this evaluation suggest that providing hygiene kits integrated with routine immunization services
increased water treatment knowledge and reported practices and demonstration of correct handwashing technique. The effect on vaccination coverage requires further evaluation. The lack of impact of the incentives in rural Homa Bay suggests that vaccine coverage may be related to more difficult clinic access and that different strategies may be needed in rural areas, such as higher-value incentives to overcome distance barriers. Future evaluations could benefit from random selection of more districts; pre-intervention assessment of stockout history; a longer intervention period to facilitate measurement of vaccination coverage and enable better ascertainment of behavior change and intervention sustainability; and improved methods for measuring water quality indicators.

Notes

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