# Who Uses Child Health Interventions in Kenya, and How Much Are They Willing to Pay?[1]

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**Abstract**

Respiratory infection and diarrhea are the leading causes of death of children in the developing world, but there are significant gaps in our knowledge of ways to improve child health through water, sanitation, hygiene, and nutrition. Uptake of interventions is often low, as is willingness to pay, and data collected from caregiver reports may be subject to bias. We conducted two separate but closely aligned cluster randomized trials of water, sanitation, hygiene, and nutrition interventions in rural western Kenya that enrolled 499 subjects in an attempt to investigate some of these issues. These interventions achieved high uptake, but the adoption decision appears to be idiosyncratic as distance outside the home to the point of water treatment is the only characteristic among those we test that predicts uptake. In particular, more educated households, those with more children, and those who have bednets hanging were no more likely to adopt the interventions. We use a discrete choice model to find that willingness to pay for clean water, and by extension health, in terms of travel cost, is quite low. We find a significant improvement in some caregiver-reported health measures, though borderline significant results in falsification tests give us concern when interpreting caregiver-reported health outcomes, underscoring the need for objective, as opposed to caregiver reported, outcomes.

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## I. Introduction

Respiratory infections and diarrheal episodes are the leading causes of death of children under 5 (Liu et al. 2012). Water, sanitation, and hygiene (WASH) interventions have been found to reduce diarrheal and respiratory diseases according to caregiver reports, yet uptake of interventions is often low (Makutsa et al. 2001), as is willingness to pay, whether measured in monetary terms using prices (Kremer and Miguel 2007; Bates et al. 2012; Null et al. 2012) or physical effort such as walking (Kremer et al. 2011), with an enormous decrease in uptake with any non-zero price. In this paper we investigate characteristics that predict uptake of WASH interventions, and estimate willingness to pay for a water quality improvement, using two small parallel randomized trials in rural western Kenya which enrolled 499 pregnant women and mothers of young children in 2011 and 2012. More details on the design of the trials and the basic uptake results have been published previously (Christensen et al. 2015). High uptake of the WASH interventions (up to 60 percentage point increase in water chlorination, up to 47 percentage point decrease in visible stool on latrine floors, up to 66 percentage point increase in handwashing soap availability) was achieved by developing innovative hardware technologies that could become part of habitual behavior by respondents.

In an exploration of characteristics that predict uptake, we find that household baseline characteristics can explain very little of uptake levels for interventions delivered directly to respondent compounds. While there is often observational evidence of correlation between household characteristics and good environmental health behavior, our results are similar to other experimental findings that household characteristics cannot explain differences in intervention uptake (Luby et al. 2008; Christen et al. 2011; Imanishi et al. 2014; Blum, Null, and Hoffmann 2014). We also find suggestive evidence that the addition of the nutrition intervention to the combined WASH package did not reduce take-up of the WASH interventions.

The main contribution of this paper is evidence that willingness to pay for the water intervention, and by extension, health, is quite low, based on the fact that longer distances to the only intervention provided outside the home (chlorine dispensers at water sources) strongly reduced uptake. Using a discrete choice model of travel cost we find that respondents have very low willingness to pay for health in the form of cleaner water. Using some strong assumptions, we estimate a willingness to pay between $152.62 and $1273.59 per diarrhea death averted, or between $4.70 and $39.21 per disability-adjusted life year (DALY), which is far below normal cutoffs of cost-effectiveness used by public health planners.

Though the study was not deliberately designed with power to detect health effects, we test for reductions in caregiver reported diarrhea and respiratory problems. We observe no significant reduction in diarrhea, but roughly a 20% reduction in coughing in all of the treated arms in the larger of our two study areas. Borderline significance of health effects in falsification tests gives us concern, and is more evidence of the need for objective health outcomes such as child height-for-age, especially when subjects cannot be blinded (Boisson et al. 2013).

The rest of the paper is as follows: Section II describes the trial, Section III shows results of our empirical analysis of uptake and willingness to pay, Section IV discusses health outcomes, and Section V concludes. A supplementary appendix includes alternative specifications of health results.

## II. Background and Design

The study described in this paper was a pilot for a larger project called WASH Benefits which is testing the independent versus combined effects of water, sanitation, hygiene, and nutrition interventions with an emphasis on objective health outcomes (height for age and clinical measures of compromised gut and immune function) in addition to caregiver-reported outcomes.

Previous evidence on combined effects of interventions is quite limited (Dangour et al. 2013). More detail on the larger project is available in the project protocol (Arnold et al. 2013), and more detail on the pilot study analyzed in this paper, and the interventions used in the study, are described in more detail elsewhere: we again refer the reader to (Christensen et al. 2015), and here provide a brief overview.

### A. Study Design

In November 2011 the study enrolled 72 villages and 499 subjects in two separate but closely aligned pilot randomized trials in rural western Kenya for a predetermined length of six months. The study enrolled caregivers of 4-16 month-old children in the first study area (all 38 villages in Shianda Location near the town of Kakamega), and pregnant women in their second or third trimester and caregivers of children under three months in the second study area (all 34 villages in Kibingei Location near the town of Bungoma). We attempted to enroll all eligible caregivers in the 72 study villages. The sample size of two locations (a Kenyan administrative unit) was chosen to allow training and piloting in both of our project offices (in the towns of Bungoma and Kakamega), as opposed to a more deliberate design based on power calculation and predicted effect sizes. Due to unobservable differences in region as well as age of child eligibility, outcomes compared across study areas should not be interpreted as causal effects of the intervention. Within study area, since interventions were randomized by village, causal interpretation is appropriate.

Each of the study areas had a separate trial, with four possible intervention assignments, as described in Table 1. The Kakamega villages were assigned to either (1) WASH: combined water, sanitation, and hygiene interventions, (2) WASH+: combined water, sanitation, hygiene, and nutrition interventions, (3) N: nutrition intervention, or (4) control. Bungoma villages were assigned to either (1) W: water intervention, (2) S: sanitation intervention, (3) H: hygiene intervention, or (4) control. Villages were randomized into one of the four interventions for their respective region after baseline data collection and enrollment, with no stratification or matching used for randomization.[2]

Starting in late January 2012, two months after enrollment, water, sanitation, and hygiene interventions were delivered to respondents according to the treatment status of their village. However, delivery of the nutrition interventions (both alone and in combination) was delayed until April 2012. The nutirition intervention consisted of lipid-based nutrient supplements (LNS) and was originally intended to be delivered at the same time as the water, sanitation, and hygiene interventions, but despite approval for all parts of the study from the appropriate IRBs, obtaining Kenyan government approval delayed LNS implementation. Due to this significant delay, some analysis of the Kakamega trial treats the nutrition-only arm (N) as the same as the control arm, and the water, sanitation, hygiene, and nutrition arm (WASH+) the same as water, sanitation and hygiene (WASH). Respondents were surveyed again in May 2012, four months after intervention delivery.

### B. Interventions

All interventions were randomized at the village level. All villages, including controls, received at least monthly visits from local health promoters, trained to promote behavior change specific to their treatment arm, facilitated by the interventions they received. In addition, promoters weighed mothers and children and measured child middle-upper arm circumference (MUAC).

[2] The split design between the two regions, although clearly suboptimal for comparison of combined and single intervention treatment arms, was necessitated by the simple on-the-ground reality that training staff to appropriately work with all seven different study arms in both areas was an impossible task in the given time horizon. Training of village promoters is done in groups by treatment type, and we were unable to hold all training types in each location. The difference in eligibility age groups was necessitated by the short duration of the study—child potties are not well suited for newborns, and LNS is only suitable for children over 6 months of age, so we enrolled 4-month olds in Kakamega (who would be 6 months old by the time of intervention delivery) to gauge use amongst age-appropriate children.

Weight and MUAC measurements were not collected as an outcome measure; they were measured in order to give the health promoters in control villages (where there were no interventions to promote) a concrete task that justified repeated household visits. This active nature of the control arm was designed because we were concerned that visits, in and of themselves, may lead mothers to change behavior that may affect child health (Zwane et al. 2011). We are primarily interested in the effects of water, sanitation, and hygiene, so having the active control include home visits allows us to difference out the effect of visits per se, and leaves us with estimates of the WASH effects we are interested in.

Health promoters, working to increase behavior change and demand for interventions, were selected from among each village's population, chosen by eligible respondents (who were themselves excluded from selection as health promoters) with some limited input by village elders, and were given a monthly monetary appreciation of 1500 Kenyan Shillings for their assistance (approximately $18.75). Health promoters also assisted in replacing broken or stolen hardware, and maintaining communal interventions. Control respondent visits contained no messaging concerning water, sanitation, or hygiene and pertained only to monitoring child growth. Thus comparisons of intervention and controls estimate a treatment effect that differences out the effect of visits by health promoters *per se* and can instead be attributed to intervention-related behavior change.

Dilute chlorine was selected for the water intervention on the basis of its low-cost, local availability, and the research group’s prior experience achieving high and sustained take-up in a nearby area during another research project (Ahuja, Kremer, and Zwane 2010). Dilute chlorine, branded as WaterGuard, was widely promoted and distributed by the manufacturer in Kenya (Population Services International) so was familiar to the study population. In water villages, the intervention consisted of installing chlorine dispensers at respondents' reported water sources within the village, usually a protected spring, well, or other source of ground water, with an average rate of 3.3 dispensers per water-treated village. One turn of the knob on the chlorine dispenser releases the appropriate amount (3ml) of 1.25% sodium hypochlorite solution to treat 20L of water. The chlorine dispensers used in the study cost 5,000 Kenyan shillings each (approximately $62.50).

For those households in water-treated villages who were unlikely to benefit from chlorine dispensers in their village, namely those who had piped water, or reported that their primary and secondary water sources were located in a different, non-water-treatment village, promoters regularly provided 150mL bottles of WaterGuard brand chlorine for point of use water treatment (each bottle cost 20 Kenyan shillings, or approximately $0.25). These conditions applied to 9% of households in the water-treated arms. Interventions in all other arms were delivered only to study households or compounds.

Sanitation compounds received a feces-disposal sani-scooper tool akin to a dustpan with a metal paddle (one for each household in the compound, which cost 180 Kenyan shillings each, approximately $2.25), plastic child potty (one for each household in the compound with a child under 3 years, which cost 85 Kenyan shillings each, approximately $1.07), and improvements to their existing latrine (consisting of a plastic latrine slab with a built-in drop-hole cover if the latrine floor was not concrete, and simple mud walls, roof, and door if not present) or construction of a new latrine if they had none (which cost 1,750 Kenyan shillings or approximately $21.88 for the slab and up to 19,000 Kenyan shillings or approximately $237.50 for a new latrine). Of the recipients in the sanitation villages who had latrines, 27% were scheduled to receive improvements to the latrine door, 25% to latrine floor (this is separate from the plastic slabs, and more structural in nature), 9% to latrine roof, and 32% to latrine walls.

Hygiene households received two locally manufactured dual tippy-tap handwashing stations, one for near their latrine and one for their cooking area, each costing 650 Kenyan shillings or approximately $8.13. (“Dual” meaning two separate pedal-level controlled jugs, one with soapy water, one with plain water.) A limited quantity of two small sachets of powdered detergent were provided for the initial soapy water, valued at 5 Kenyan shillings or approximately $0.06. Respondents in nutrition arms were provided with two 10g sachets of LNS per day for each of their children 6 to 24 months of age, though delivery had only begun a month prior to the follow-up survey (the LNS produced specifically for this study cost 3 Euro per kilo, or approximately $4.05, and was not sold commercially).

The engagement strategy for the behavior change component of the interventions firstly targeted the respondents (primary caregivers) of study children with monthly visits and secondarily their siblings and fathers. Each monthly visit took approximately 40--60 minutes. The behavior change material comprised of visit scripts that included activities such as songs, interactive games, and visual aids (calendars, cue cards and picture sheet).The behavior change messages delivered through these engagements and materials balanced the need to promote the targeted behavior regardless of the hardware provided and the hardware as a facilitator for the desired behavior.

Table 1: Design of Treatment Arms

| Region 1: Kakamega | Region 2: Bungoma |
|---|---|
| N=38 Villages (V), 367 Households (HH) | N=34 Villages, 132 Households |

| | |
|---|---|
| Eligibility: 4-16 month olds | Eligibility: 2nd & 3rd trimester pregnancies, under 3 months |
| WASH (9 V, 90 HH) | W (9 V, 38 HH) |
| WASH+ (10 V, 87 HH) | S (8 V, 31 HH) |
| N (9 V, 89 HH) | H (8 V, 33 HH) |
| Control (10 V, 101HH) | Control (9 V, 30 HH) |

## C. Data

Primary data were generated from household surveys conducted by trained enumerators in November 2011 (baseline) and May and June 2012 (follow-up). Effort was made to keep the survey visits unannounced, though enforcement was almost certainly imperfect. Our primary outcomes were adoption indicators of improved water, sanitation, and hygiene behavior and were all measured at the household level. The pilot study also collected information about child illness and growth from all study households.

Table 1 in (Christensen et al. 2015) shows baseline characteristics of the recipients, which are generally balanced across treatment arm, but many are not balanced across the two study sites. At baseline, in Kakamega, respondents reported that 20% of children 0 to 36 months old suffered from diarrhea the week before the survey. Of children under 3 years, 55% were reportedly being breastfed, so this may be an overstatement of the population prevalance of diarrhea if healthy breastfed children meet the standard definition of diarrhea. Of children over 18 months (only 4% of whom were being breastfed) 7% were reported to have had diarrhea in the previous week. Only 3% of households reported chlorinating the water currently stored in their home, while 12% reported ever treating their water with chlorine. No adults reported open defecation, while 55% reported appropriate disposal of child feces. The vast majority of households used a multipurposed basin for handwashing (94%), but only 12% of respondents had soap and water accessible for handwashing.

In Bungoma, only 8% of respondents' children under 3 years old were reported as having diarrhea in the week prior. Only 5% of households reported chlorinating the water currently stored, while 14% reported ever chlorinating water. Only 34% of respondents with children under 3 years reported appropriate disposal of child feces, and 29% of respondents had soap and water accessible for handwashing.

### D. Uptake

In previous work (Christensen et al. 2015) we compared uptake of interventions in treatment groups to control groups with ordinary least squares, according to the following simple Intention to Treat analysis equation:

$$Y_{ij} = \alpha + \sum_k (\beta_k \cdot T_{ik}) + X'_{ij}\delta + u_i + e_{ij} \qquad (1)$$

Where $Y_{ij}$ was the outcome of a given individual, $i$ referred to the village cluster and $j$ to the individual; $T_{ik}$ were village indicator variables for treatment arm assignment ($k \in$ W, S, H, N, WASH, WASH+) ; $X'_{ij}$ were baseline characteristics such as age (listed more completely below); $u_i$ was a village level error term; and $e_{ij}$ was an individual error term. Standard errors were clustered at the village level, the level of treatment, for all analyses.

In the combined treatment arms in Kakamega, intervention households saw increases in chlorination of household stored water by 36 percentage points, latrine drop holes were covered by 55 percentage points more, with stool visible on the floor of latrines 16 percentage points less, and soap was available for handwashing 49 percentage points more.

In the single treatment arms in Bungoma, detection of chlorination of household stored water increased by 60 percentage points in the water arm. Latrine drop holes were covered 75 percentage points more and stool was visible on the latrine floor 47 percentage points less in the sanitation arm. In the hygiene arm, 66 percentage points more of the households had soap for handwashing. [3]

# III. Uptake and Willingness to Pay

## A. Correlates of Uptake

Within the larger Kakamega trial, where respondents received combined WASH interventions, we have attempted to identify mechanisms that might explain why some individuals adopted our technology and others did not.[4] Table 2 shows results from regressions of uptake on combined treatment (WASH or WASH+) interacted with several baseline characteristics that could potentially modify uptake. The most straightforward and strongest result is the effect of distance to a chlorine dispenser on water chlorination. We find that every additional kilometer to the nearest chlorine dispenser results in a nearly 70 percentage point reduction in household water chlorination amongst treated group, explaining nearly the entire effect of treatment on uptake. (The average distance from the home to a dispenser in water-treated Kakamega villages is 0.18km (s.d. 0.15), while the average distance in Kakamega

[3] In addition to measures of uptake discussed here that do not directly depend on the provided hardware, we also measured use of the hardware itself in relevant intervention arms. See Table 3 in (Christensen et al. 2015) for a summary of these results. We see that self-reported use of all of the hardware is high (95--100% for sani-scoopers, up to 65% for using chlorine dispensers every time water is drawn) and that enumerator-observed indicators of use, although lower, are still high (72--85% for having both soap and water present at either tippy-tap). We also included analysis of respondents' attitudes regarding visits by the promoter. There were few significant differences between treatment and control arms. In control arms, where promoters had no hardware to promote, and no health messages other than monitoring of child growth, all but one caregiver reported visits were worth their time, and 92% knew the name of their promoter.

[4] These estimates are not shown for Bungoma, as small sample sizes in the arm relevant to any given uptake measure and large numbers of covariates preclude regression analysis.

villages without water treatment is 0.56km (s.d. 0.32).) Predictably, distance to the dispenser is unrelated to uptake of any other intervention.

We also test several characteristics inside the compound such as mother's education, mother's age, child's age, youngest child's gender, whether there is more than one household in the compound, whether there is more than one 0-3yo child in the compound, wealth indicators, and whether a mosquito bednet was observed hanging in the home. Most of these potential modifiers do not exhibit strong patterns, and some go in the opposite direction than what we would have assumed. For example, although tin roofing (a simple wealth indicator) is associated with an increased uptake of chlorination and handwashing, as is having older children, tin roofing is associated with less adoption of covering latrine drop holes. Having more children and more households was associated with smaller latrine drop hole coverage increases, and with increased presence of stool on the latrine floor, as one might expect, but with increased knowledge of handwashing critical times. One surprising result is the score on our reading comprehension test—those in the top quartile of our sample appear less likely to chlorinate their water and are less likely to have properly disposed of their youngest child's last feces. Observing a net hanging is correlated with cleaner hands and correct belief about health risks from poor sanitation, yet with reduced proper disposal of child feces. Given the large number of tests involved, we are circumspect with these results, and place strong confidence only in the estimates of distance to water source and chlorination, where theory and evidence seem to align: distance to an intervention explains using the dispenser, but since all other interventions are already within the compound and extremely close, we are unable to explain who is more likely to use them than others. In regressions shown in Appendix Table 1, we have also tested interactions with characteristics of the village promoter, (gender, number of children, secondary school completion, and distance from respondent home to promoter home) but there is less variation to work with since there is only one promoter per village, and no strong patterns emerge.

Comparing larger combinations of interventions to fewer interventions could be another potential way to predict uptake, as attention may be a limited resource, and respondents may be able to only understand and adopt a certain number of newly facilitated behaviors. As described above, the design of our two separate trials confound comparisons of single arms in Bungoma to combined arms in Kakamega, but within Kakamega, some comparisons are unconfounded. As described above, delivery of the nutrition intervention was delayed, but did reach respondents prior to the follow-up survey. As a test of any effects on uptake of adding the nutrition intervention to the package, Table 3 shows regressions for Kakamega with indicator variables for each of the three treatment arms (WASH, WASH+, LNS-only) compared to the control group. It also shows the p-values from F-tests of equality between the WASH and WASH+ treatment coefficients. The large majority of tests cannot be rejected, indicating that the addition of a fourth treatment (LNS) did not decrease uptake of the three interventions that were the same across the WASH and WASH+ arms. The exception is with one measure of sanitation uptake—the effect of treatment on cleaning feces from the compound was significantly larger in the WASH+ arm than the WASH arm. A simple comparison of the magnitude of coefficients show that there is an even 7-7 split between larger treatment coefficients in WASH and those in WASH+. At least in our trial, addition of a fourth intervention did not significantly reduce uptake of the previous three interventions. (Unfortunately we collected little data on the uptake of the nutrition intervention in the main pilot endline survey, but what little we were able to collect showed near universal consumption, indicating no significant difference between LNS consumption in the WASH+ arm compared to the LNS-only arm.)

## B. Discrete Choice Model

We further investigate the distance from the home to a chlorine dispenser using a discrete choice model like that in (McFadden 1974). All respondents were asked to name their primary water source, and a survey of all water sources in the village was conducted. Using the respondents in the three water-treated arms (W, WASH, WASH+), we model a respondent's utility over their choice of water source. We estimate two choice models, one with the four closest sources to a respondent, and one with all sources within a kilometer; results are very similar. Borrowing notation from (Train 2009), we model a respondent's utility as $U_{nj} = V_{nj} + \epsilon_{nj} \forall j$, where n indexes respondents and j their potential water sources. The $\epsilon_{nj}$ are assumed to be independent and identically extreme value distributed. The $V_{nj}$ are modeled linearly, $V_{nj} = \beta' x_{nj}$ where $x$ are observed characteristics of a source, primarily distance in kilometers, whether the source has a dispenser, and whether the source is a protected spring, which generally produces the least contaminated water of any source type commonly available in the region (alternatives are largely unprotected spring, dug wells, and boreholes. Piped water is extremely rare.) These characteristics are also interacted with a few characteristics of the respondents: age, gender of the youngest child, secondary schooling, and number of children 0-3yo. Given a set of characteristics $x_{ni}$, the probability a user selects a certain source is:

$$P_{ni} = \frac{e^{\beta' x_{ni}}}{\sum_j e^{\beta' x_{nj}}} \quad (2)$$

and the ratio of the coefficient estimate on a dispenser at the source (or protected spring) to the coefficient estimate of distance to the source represents the value of a dispenser (or protected spring) to a respondent in terms of (one-way) kilometers of walking required. These estimates are shown in Table 4. In addition we estimate a random coefficient mixed logit model that allows the coefficients to vary over individuals to model unexplained heterogeneity, as in (Train 1998). Here the probability that a user selects a particular source is given by:

$$P_{ni} = \int \frac{e^{\beta' x_{ni}}}{\sum_j e^{\beta' x_{nj}}} f(\beta) d\beta \qquad (3)$$

where *f*(β) is the mixing distribution, which we select as normal for the dispenser and protected spring sources, and log normal for the distance to the source, since it seems reasonable to assume that distance to water sources enters negatively in all respondents' utility functions. However, since the log normal distribution only takes on positive values, the estimate is actually for the negative of the kilometers to the source. To interpret the coefficient, one should first exponentiate the coefficient (which is done in the table), and then take the additive inverse.

It is important to note that this analysis is not entirely experimentally identified. By not randomly varying which sources were treated with dispensers, we face the possibility that unobserved characteristics of sources may bias our coefficients. For example, if the underlying fecal contamination of a source were correlated with users' source selection, and we had chosen to install dispensers at sources that were more contaminated, then the utility coefficient of dispensers would be biased.

We find that (one-way) distance to the source in kilometers yields large and significant negative results in the conditional logit (-8.3, standard error 1.16 in the all-sources-in-1km specification, -10.3, standard error 2.0 in the 4-closest-sources specification). A chlorine dispenser at a source returns a positive coefficient of 1.38 to 1.44, while source protection plays an insignificant role, as do all the user characteristics tested. When we use the mixed logit to allow the coefficients to vary over respondents, the coefficient on kilometers has a median of between -32 and -42, while the dispenser has an estimated mean of 4.2 to 5.4, and a protected spring as a source again plays an insignificant role. The flexibility of the mixed logit allows us to estimate the standard deviation of this coefficient: with estimated standard deviations of 2.97 and 4.39, an estimated 7.7% of respondents place negative utility value on the dispenser in the all-sources-in-1km specification, and 10.8% in the 4-closest specification.

The utility coefficients from above are only meaningful in a relative sense, but if we make assumptions regarding walking speed, earnings, frequency of water collection, and effectiveness of water chlorination in preventing disease, we can use these estimates to calculate a willingness to pay for health. We use wage and time valuation assumptions from(Kremer et al. 2011): The average 8-hour workday wage in Kenya is $1.26, but between 7% to 25% of the laborer wage are more appropriate for valuations of time ($0.088 to $0.32). Respondents in our study make an average 3.6 trips per day to their source, and we assume the average person can walk 5km/hour. Walking roundtrip 1 km to the source 3.6 times per day, 365 days per year at 5 km per hour would take 525.6 hours, or 65.7 eight-hour work days, in which one could earn between $5.78 and $21.02. The lowest and highest ratios of coefficients from the base specifications in Table 5, (0.127, 0.167) imply a willingness to pay for one year's access to a chlorine dispenser between $0.73 and $3.50.

We can combine this willingness to pay with health effects to estimate a willingness to pay for each disability adjusted life year (DALY) saved. Our pilot was not specifically designed with power to detect health outcomes (though we test them in the next section), so instead we use the established 20%-35% reduction from (Ahuja, Kremer, and Zwane 2010) and (Arnold, Colford Jr, and others 2007). We observed 20% diarrhea at baseline with one-week recall. With an average of 1.14 children under 3 year and 52 weeks per year, then the 20%-35% reduction would result in a reduction of 2.4 to 4.1 diarrhea cases per respondent per year (and a willingness to pay per case avoided of $0.68 to $5.65). If we assume that mortality is proportional to morbidity (as in (Kremer et al. 2011)) then 1.16 deaths from diarrhea would be averted for each 1,000 diarrhea cases eliminated, or between 1-in-208 and 1-in-364 deaths per dispenser-year per household. This translates to a willingness to pay of between $152.62 and $1273.59 per diarrhea death averted, or between $4.70 and $39.21 per DALY.

The estimates of willingness to pay are far below both the standard estimates of the value of a statistical life (though those are often based on wealthy countries and the estimates do not transfer well to the developing world) and the estimate of cost-effectiveness for health interventions by aid organizations such as the World Bank or World Health Organization, which range upwards from $100 per DALY (Shillcutt et al. 2009). This does not speak to the issue of the cost-benefit analysis of dispensers—there is some evidence that at scale they can cost as little as $0.50 per person per year[5], but in terms of willingness to pay for improved health, people in developing countries may have very low demand, necessitating that NGOs and policy makers design interventions with very low costs of adoption to achieve substantial uptake.

## IV. Health Outcomes

Although this pilot study was designed more out of a concern for uptake of interventions and a desire for a smaller scale practice of implementation rather than as a study powered for statistically detecting differences in health outcomes, we still investigate the question of the effect of our interventions on child health. Results are summarized in Table 5.

Using a one-week recall period, we find no significant reduction in diarrhea in any treatment arm, either by the colloquial definition (*kuhara* in Swahili) or by the case definition of 3 or more loose or watery stools in a 24-hour period. We do, however see a significant reduction

5 See http://www.poverty-action.org/safewater.

in coughing, a reduction of between 18 and 26 percentage points off a mean of 45 percent, with the highest reduction observed in the LNS-only arm. Interpretation of this result is complicated by a reported increase in fever in the WASH arm, and reduction in bruising and rash in the WASH+ arm. These outcomes were included for falsification or placebo purposes—there is no strong biological pathway for a reduction in bruising from our intervention. (An additional placebo test of toothaches, not shown, indicates no significant reduction.) This reduction of bruising, and the increase in reported fever give us pause concerning these self-reported outcomes, and self-reported outcomes in general. When treatment status cannot be blinded, as is the case in our study, self-reported outcomes must be evaluated carefully since the possibility of courtesy bias exists. A main purpose of the much larger main study that is currently under way is to have a sample size large enough to detect objective (i.e. observed, not self-reported) health outcomes, namely length-for-age.

Probit regressions and regressions using two-day recall instead of one week recall (not shown) also provide similar results. Our main regressions include all children less than 36 months belonging to the respondent, so there are up to 149 additional observations beyond the one from each of the 499 households. Standard errors are still clustered at the village level, which fully accounts for additional correlation within the household, since nested correlation is fully accounted for by clustering at the higher level (Cameron, Gelbach, and Miller 2011). We also surveyed up to two additional children each from up to two additional mothers residing in the same compound as the main respondent. These "secondary respondents" resulted in health data on an additional 38 children. Results including these children are included in Appendix Table 2.

We also considered using two-stage least squares to estimate the treatment on the treated

(TOT) effect of certain uptake behaviors. In these regressions we used treatment as an instrumental variable for uptake of our interventions. This requires the standard assumptions that treatment only (weakly) increases subjects' likelihood of uptake, and that there are no subjects who deliberately defy treatment status. Also important is the exclusion restriction, which in this case requires that an individual's treatment status only affects their health outcomes through the channel of their own hardware uptake. This is clearly violated if externalities are present, as treatment status affects an individual's health through their neighbors' uptake as well. We generally assume that there will be within-village externalities that violate the exclusion restriction at the individual level, which is part of the justification for clustering randomization at the village level, so these regressions were purely exploratory. First stages generally had quite low F statistics, leading to the additional problems of weak instruments, and noisy and insignificant results. Results are not shown, but are available upon request. In the main WASH Benefits study, we plan to test for the presence of cross-village externalities, and estimate TOT effects at the village level if externalities are not found.

Lastly, a note on attrition: of the 499 respondents at baseline, we were able to survey 436, or 87% of them at endline 6 months later. While a cause for concern, we tested for differential attrition and find only limited evidence, documented in Table 4 in (Christensen et al. 2015). For the forthcoming larger main study, we took the problem of attrition seriously and changed the exclusion criteria to eliminate those likely to move such as renters, and we are more strongly engaging our promoters to help us track respondents.

## V. Conclusion

The interventions described in this paper achieved high take-up, as discussed here and shown in Table 2 in (Christensen et al. 2015), but we find very little other than distance outside the home that predicts this high uptake. A 37 percentage point increase in detection of free chlorine in combined treatment arms compared to the control group is a significant improvement over many household water treatment efforts. Mothers in the combined arms also had observably cleaner hands and could report to us more of the critical times for handwashing, and the 17 percentage point reduction in visible stool in the latrine, coupled with the 55 percentage point increase in drop holes being covered shows that our hygiene and sanitation interventions were also successfully adopted, but no measured characteristics within the homely were strongly correlated with the level of uptake.  In particular, more educated households, those with more children, and those who have bednets hanging are no more likely to adopt the interventions. Considering that these interventions were provided for free to study participants, this finding suggests that education or indicators of other good environmental health behaviors may not always correlate with adoption of healthier behaviors, and households most in need of the interventions may require special facilitation to increase uptake. This complicates the goal of achieving high uptake of interventions, and adds to existing evidence that uptake is difficult to predict using respondent characteristics.

We also found that giving additional interventions (in our case, nutritional supplements) did not significantly alter uptake rates. Though we were unable to use the randomized design to distinguish between outcomes in combined arms versus single arms due to confounding, we were able to compare the addition of the nutrition intervention to the already combined water, sanitation, and hygiene interventions, and found no evidence that uptake was affected.

We found that uptake of interventions provided outside the home is significantly reduced by geographic distance. Respondents had a willingness to pay for a dispenser between $0.73 and $3.50, which corresponds to a willingness to pay to avert a diarrhea death of only $152.62 and

$1273.59, or $4.70 to $39.21 per DALY, which is consistent with recent evidence that charging for health interventions is likely to significantly reduce uptake, and continued subsidies may be necessary. A significant reduction in coughing was reported, but interpretation is complicated since outcomes are self-reported and falsification tests with no plausible biological mechanism for effect show borderline significant results. This is evidence that objective outcomes are useful in experiments where blinding subjects is not possible.

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**Table 2: Uptake of Interventions Interacted with Baseline Characteristics, Kakamega**

| VARIABLES | (1) Free Chlorine | (2) Total Chlorine | (3) VF filter use | (4) Believe feces poses risk | (5) Proper child feces disposal | (6) Latrine hole covered | (7) Stool visible on latrine floor | (8) Human Feces in compound | (9) Any Feces in compound | (10) HW critical Times | (11) Have HW Place | (12) Have HW Materials | (13) Mom's hands no dirt | (14) Kid's hands no dirt |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Combined Treatment | 0.032 | 0.092 | -0.016 | -0.082 | 0.556*** | 0.817*** | 0.115 | -0.175 | -0.007 | 0.157 | 0.951*** | 0.411* | 0.363* | 0.471* |
| | [0.242] | [0.244] | [0.133] | [0.260] | [0.192] | [0.149] | [0.217] | [0.120] | [0.195] | [0.500] | [0.121] | [0.218] | [0.210] | [0.242] |
| Kilometers to Dispenser | -0.698*** | -0.645*** | 0.014 | 0.182 | 0.026 | 0.218 | -0.450* | -0.02 | 0.266 | 0.959 | -0.092 | 0.376 | -0.219 | -0.325 |
| | [0.214] | [0.202] | [0.169] | [0.222] | [0.285] | [0.210] | [0.241] | [0.095] | [0.255] | [0.752] | [0.137] | [0.246] | [0.237] | [0.327] |
| Tin Roof | 0.200* | 0.218* | -0.057 | 0.124 | -0.117 | -0.263*** | -0.086 | 0.048 | 0.013 | 0.491* | -0.04 | 0.1 | -0.022 | 0.260** |
| | [0.117] | [0.119] | [0.083] | [0.110] | [0.096] | [0.071] | [0.114] | [0.054] | [0.098] | [0.267] | [0.065] | [0.106] | [0.101] | [0.106] |
| Resp. Age Quartile1 | 0.109 | 0.052 | -0.053 | 0.007 | -0.07 | -0.296*** | 0.058 | 0.075 | 0.006 | 0.042 | -0.089 | -0.151 | -0.21 | -0.013 |
| | [0.126] | [0.113] | [0.086] | [0.138] | [0.133] | [0.107] | [0.141] | [0.081] | [0.165] | [0.436] | [0.087] | [0.146] | [0.133] | [0.163] |
| Resp. Age Quartile2 | 0.103 | 0.115 | 0.014 | -0.031 | -0.155 | -0.312*** | 0.176 | 0.055 | 0.113 | -0.041 | -0.034 | -0.139 | -0.09 | 0.005 |
| | [0.108] | [0.107] | [0.092] | [0.119] | [0.171] | [0.098] | [0.153] | [0.064] | [0.142] | [0.394] | [0.082] | [0.105] | [0.116] | [0.156] |
| Resp. Age Quartile3 | 0.213 | 0.236* | 0.037 | -0.075 | -0.009 | 0.01 | 0.029 | 0.09 | 0.11 | -0.389 | 0.068 | 0.01 | -0.006 | -0.022 |
| | [0.140] | [0.123] | [0.127] | [0.145] | [0.122] | [0.088] | [0.181] | [0.095] | [0.182] | [0.342] | [0.067] | [0.110] | [0.125] | [0.166] |
| Literate | 0.035 | 0.01 | -0.008 | 0.118 | 0.177 | 0.118 | -0.308** | -0.08 | 0.076 | 0.127 | -0.008 | 0.126 | -0.162 | -0.047 |
| | [0.106] | [0.096] | [0.080] | [0.127] | [0.116] | [0.084] | [0.131] | [0.075] | [0.107] | [0.346] | [0.074] | [0.112] | [0.125] | [0.130] |
| Any Secondary Schooling | 0.26 | 0.277* | 0.094 | -0.08 | -0.026 | -0.012 | 0.231* | 0.082 | 0.126 | 0.173 | 0.002 | -0.068 | 0.218* | -0.097 |
| | [0.165] | [0.150] | [0.127] | [0.119] | [0.177] | [0.113] | [0.122] | [0.057] | [0.114] | [0.369] | [0.065] | [0.115] | [0.108] | [0.134] |
| Reading Comp. Top Quartile | -0.298** | -0.271** | 0.01 | -0.142 | -0.321** | 0.023 | 0.001 | 0.013 | -0.023 | -0.244 | 0.086 | 0.15 | -0.144 | -0.209 |
| | [0.114] | [0.116] | [0.094] | [0.104] | [0.124] | [0.117] | [0.160] | [0.060] | [0.134] | [0.327] | [0.081] | [0.115] | [0.093] | [0.138] |
| Num. Households >1 | 0.08 | 0.064 | 0.02 | -0.044 | 0.072 | -0.180* | -0.148 | 0.022 | -0.078 | -0.21 | 0.053 | 0.038 | -0.022 | -0.092 |
| | [0.091] | [0.102] | [0.079] | [0.112] | [0.124] | [0.093] | [0.117] | [0.059] | [0.102] | [0.344] | [0.064] | [0.104] | [0.082] | [0.140] |
| Num. Children >1 | -0.042 | -0.105 | -0.051 | -0.127 | 0.102 | -0.254** | 0.196* | -0.022 | -0.032 | 0.483** | -0.003 | 0.067 | 0.014 | -0.072 |
| | [0.080] | [0.089] | [0.048] | [0.103] | [0.120] | [0.095] | [0.108] | [0.054] | [0.098] | [0.210] | [0.066] | [0.102] | [0.094] | [0.117] |
| Youngest Child=Male | 0.016 | -0.065 | -0.007 | -0.074 | -0.105 | -0.075 | 0.163 | -0.007 | -0.108 | -0.186 | 0.002 | -0.118 | 0.092 | -0.066 |
| | [0.091] | [0.099] | [0.069] | [0.074] | [0.100] | [0.073] | [0.125] | [0.046] | [0.091] | [0.230] | [0.057] | [0.089] | [0.083] | [0.124] |
| Bednet observed hanging | -0.058 | 0.007 | -0.014 | 0.214** | -0.156* | -0.054 | -0.151 | -0.047 | -0.007 | -0.189 | -0.02 | 0.105 | 0.196** | 0.024 |
| | [0.063] | [0.073] | [0.068] | [0.090] | [0.082] | [0.063] | [0.094] | [0.061] | [0.069] | [0.303] | [0.060] | [0.096] | [0.085] | [0.106] |
| Child Age (months) | 0.021* | 0.024** | 0.001 | -0.002 | -0.002 | 0.021* | -0.007 | 0.008 | -0.019 | -0.003 | -0.008 | -0.013 | -0.022* | -0.016 |
| | [0.011] | [0.011] | [0.008] | [0.016] | [0.016] | [0.012] | [0.016] | [0.009] | [0.013] | [0.028] | [0.007] | [0.013] | [0.011] | [0.014] |
| Observations | 314 | 276 | 276 | 314 | 314 | 314 | 314 | 313 | 312 | 314 | 296 | 296 | 309 | 314 |
| R-squared | 0.049 | 0.293 | 0.357 | 0.124 | 0.713 | 0.271 | 0.133 | 0.065 | 0.087 | 0.285 | 0.485 | 0.1 | 0.065 | 0.083 |

Robust standard errors, clustered by village, in brackets. Coefficients shown are for the interaction of treatment (WASH or WASH+) with all the baseline variables (not standardized, since many are binary), with the outcome variables different measures of uptake. All the baseline variables themselves are included in the regression, as well as an indicator for treatment in the LNS-only arm, and fixed effects for survey enumerators.
*** p<0.01, ** p<0.05, * p<0.1
intupALLadj.txt

**Table 3: Analysis of Uptake of Water, Sanitation, and Hygiene Interventions, Kakamega Arms Separated**

| | Kakamega (Each Arm Separately) | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **Uptake Variable** | **(1)** | | | | **(2)** | | | |
| **Water Treatment Uptake** | **WASH** | **WASH+** | **LNS** | **(WASH=WASH+)** | **WASH** | **WASH+** | **LNS** | **(WASH=WASH+)** |
| Free Chlorine Detected, [se] | 0.382*** [0.083] | 0.347*** [0.063] | 0.002 [0.018] | 0.74 | 0.385*** [0.077] | 0.354*** [0.065] | -0.009 [0.029] | 0.75 |
| Control Mean, (N) | 0.012 (284) | | | | 0.012 (283) | | | |
| Total Chlorine Detected, [se] | 0.458*** [0.077] | 0.363*** [0.063] | 0.002 [0.018] | 0.34 | 0.462*** [0.069] | 0.355*** [0.063] | -0.013 [0.030] | 0.22 |
| Control Mean, (N) | 0.012 (284) | | | | 0.012 (283) | | | |
| VF Water Filter Use, [se] | -0.079* [0.056] | -0.079* [0.052] | -0.029 [0.058] | 0.99 | -0.077* [0.059] | -0.082* [0.054] | -0.027 [0.063] | 0.90 |
| Control Mean, (N) | 0.122 (304) | | | | 0.122 (303) | | | |
| **Sanitation Treatment Uptake** | | | | | | | | |
| Child Feces Risk Belief, [se] | 0.048 [0.050] | 0.039 [0.074] | -0.022 [0.063] | 0.90 | 0.054 [0.058] | 0.053 [0.080] | -0.023 [0.062] | 0.98 |
| Control Mean, (N) | 0.785 (321) | | | | 0.785 (320) | | | |
| Child Feces Properly Disposed Of, [se] | 0.460*** [0.061] | 0.508*** [0.070] | 0.027 [0.069] | 0.50 | 0.474*** [0.058] | 0.519*** [0.077] | 0.043 [0.076] | 0.55 |
| Control Mean, (N) | 0.181 (323) | | | | 0.181 (322) | | | |
| Drop Hole Covered, [se] | 0.604*** [0.046] | 0.477*** [0.058] | -0.023* [0.015] | 0.08 | 0.565*** [0.050] | 0.471*** [0.052] | -0.057** [0.027] | 0.15 |
| Control Mean, (N) | 0.023 (304) | | | | 0.023 (303) | | | |
| Stool Visible in Latrine, [se] | -0.247*** [0.085] | -0.153* [0.097] | -0.092 [0.095] | 0.28 | -0.231*** [0.089] | -0.167** [0.096] | -0.083 [0.102] | 0.44 |
| Control Mean, (N) | 0.420 (304) | | | | 0.420 (303) | | | |
| Human Feces in Compound, [se] | -0.079** [0.048] | -0.093** [0.042] | -0.027 [0.046] | 0.65 | -0.087** [0.047] | -0.102*** [0.043] | -0.034 [0.049] | 0.59 |
| Control Mean, (N) | 0.106 (317) | | | | 0.106 (316) | | | |
| Any Feces in Compound, [se] | -0.016 [0.043] | -0.145*** [0.058] | -0.057 [0.064] | 0.04 | -0.025 [0.051] | -0.207*** [0.065] | -0.057 [0.067] | 0.01 |
| Control Mean, (N) | 0.862 (323) | | | | 0.862 (322) | | | |
| **Hygiene Treatment Uptake** | | | | | | | | |
| HW Critical Times (of 5), [se] | 0.546*** [0.190] | 0.557*** [0.198] | 0.009 [0.171] | 0.96 | 0.652*** [0.162] | 0.560*** [0.168] | 0.098 [0.158] | 0.65 |
| Control Mean, (N) | 2.160 (323) | | | | 2.160 (322) | | | |
| Have Place for HW, [se] | 0.842*** [0.040] | 0.876*** [0.025] | 0.009 [0.026] | 0.42 | 0.835*** [0.045] | 0.859*** [0.034] | 0.022 [0.029] | 0.63 |
| Control Mean, (N) | 0.043 (323) | | | | 0.043 (322) | | | |
| Have Soap for HW, [se] | 0.526*** [0.092] | 0.484*** [0.072] | 0.029 [0.065] | 0.65 | 0.510*** [0.093] | 0.512*** [0.072] | 0.040 [0.065] | 0.99 |
| Control Mean, (N) | 0.191 (323) | | | | 0.191 (322) | | | |
| Mother Clean Hands, [se] | 0.046 [0.072] | 0.118** [0.058] | -0.112** [0.056] | 0.29 | 0.042 [0.069] | 0.109** [0.063] | -0.128** [0.056] | 0.35 |
| Control Mean, (N) | 0.787 (323) | | | | 0.787 (322) | | | |
| Child Clean Hands, [se] | 0.110* [0.077] | 0.052 [0.069] | 0.053 [0.065] | 0.49 | 0.126** [0.072] | 0.090* [0.070] | 0.063 [0.074] | 0.65 |
| Control Mean, (N) | 0.570 (322) | | | | 0.570 (321) | | | |
| **Health Promoter Uptake** | | | | | | | | |
| Respondent Knows Promoter's Name, [se] | -0.000 [0.038] | 0.065** [0.030] | -0.028 [0.039] | 0.01 | 0.004 [0.039] | 0.079*** [0.033] | -0.017 [0.039] | 0.01 |
| Control Mean, (N) | 0.935 (319) | | | | 0.935 (318) | | | |
| Promoter Booklet Available, [se] | -0.159** [0.089] | -0.184* [0.127] | -0.150* [0.096] | 0.87 | -0.151** [0.080] | -0.205* [0.134] | -0.162** [0.095] | 0.70 |
| Control Mean, (N) | 0.978 (307) | | | | 0.978 (307) | | | |
| Trusts Promoter Info Highly, [se] | -0.044* [0.033] | 0.006 [0.025] | -0.007 [0.031] | 0.14 | -0.035 [0.031] | 0.016 [0.025] | -0.006 [0.037] | 0.11 |
| Control Mean, (N) | 0.967 (319) | | | | 0.967 (319) | | | |
| Ranks Promoter Highly Committed, [se] | 0.008 [0.051] | 0.098** [0.043] | 0.043 [0.048] | 0.08 | 0.021 [0.053] | 0.114*** [0.044] | 0.061* [0.047] | 0.10 |
| Control Mean, (N) | 0.847 (307) | | | | 0.847 (307) | | | |
| Considers Promoter Visits Worth Time, [se] | -0.013 [0.013] | -0.000*** [0.000] | -0.013 [0.013] | 0.32 | -0.009 [0.010] | 0.003 [0.005] | -0.012 [0.013] | 0.40 |
| Control Mean, (N) | 1.000 (319) | | | | 1.000 (319) | | | |
| | | | | | | | | |
| Enumerator FE | NO | | | | YES | | | |
| Controls | NO | | | | YES | | | |

Notes: Table shows estimated OLS coefficient on treatment status, with standard errors adjusted for clustering at the village level. Regression in first three columns is from unadjusted regression, the latter three are adjusted. Each arm's uptake levels are compared to the omitted control group. The (WASH=WASH+) columns display p-values for F-tests of equality between the WASH and the WASH+ arm coefficients.

**Table 4: Fixed Coefficient Logit and Random Coefficient Mixed Logit Discrete Choice Models of Source Selection**

| | (1) | (2) | (3) | (4) | (5) | | (6) | (7) | (8) | (9) | (10) | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 4 Closest Sources | | | | | | All Sources within 1km | | | | | |
| | Fixed Coefficient Logit | | | | Mixed Logit | | Fixed Coefficient Logit | | | | Mixed Logit | |
| | | Dispenser | Distance | Both | | | | Dispenser | Distance | Both | | |
| VARIABLES | Basic | Interactions | Interactions | Interactions | Basic | | Basic | Interactions | Interactions | Interactions | Basic | |
| Kilometers to Source | -10.336*** | -10.558*** | 4.213 | 1.795 | | | -8.266*** | -8.100*** | -12.512*** | -12.570*** | | |
| | [2.019] | [2.120] | [8.544] | [9.057] | | | [1.156] | [1.181] | [4.392] | [4.389] | | |
| (-1)*Kilometers to Source | | | | | 3.748*** | Median | | | | | 3.466*** | Median |
| Mixed Logit-Mean, log normal | | | | | [0.540] | 42.436 | | | | | [0.488] | 32.008 |
| Mixed Logit-s.d., log normal | | | | | 1.633*** | Mean | | | | | 1.835*** | Mean |
| | | | | | [0.637] | 160.990 | | | | | [0.537] | 172.365 |
| Dispenser at Source | 1.440*** | 3.753** | 1.886*** | 4.680*** | 5.392** | | 1.377*** | 2.395* | 1.392*** | 2.417* | 4.244** | |
| Mixed Logit-Mean, normal | [0.376] | [1.662] | [0.509] | [1.766] | [2.540] | | [0.324] | [1.321] | [0.347] | [1.419] | [2.079] | |
| Mixed Logit-s.d., normal | | | | | 4.386** | | | | | | 2.965* | |
| | | | | | [2.184] | | | | | | [1.868] | |
| Protected Spring | -0.147 | 0.003 | -0.178 | -0.209 | -0.413 | | -0.027 | 0.065 | 0.071 | 0.056 | 0.097 | |
| Mixed Logit-Mean, normal | [0.299] | [0.280] | [0.317] | [0.320] | [0.643] | | [0.246] | [0.241] | [0.250] | [0.247] | [0.465] | |
| Mixed Logit-s.d., normal | | | | | 0.857 | | | | | | -0.047 | |
| | | | | | [1.560] | | | | | | [1.081] | |
| Dispenser*Youngest Child Male | | -0.416 | | 0.686 | | | | -0.242 | | -0.182 | | |
| | | [1.185] | | [0.955] | | | | [0.825] | | [0.767] | | |
| Dispenser*Number of Children 0-3 yo | | -0.626 | | -1.174* | | | | -0.467 | | -0.507 | | |
| | | [0.784] | | [0.650] | | | | [0.641] | | [0.571] | | |
| Dispenser*Respondent Age | | -0.053 | | -0.069 | | | | -0.017 | | -0.015 | | |
| | | [0.036] | | [0.043] | | | | [0.033] | | [0.036] | | |
| Dispenser*Any Secondary Schooling | | 0.316 | | 0.437 | | | | 0.504 | | 0.418 | | |
| | | [1.515] | | [1.165] | | | | [1.011] | | [0.847] | | |
| km*Youngest Child Male | | | -11.432* | -13.101 | | | | | -0.434 | -0.5 | | |
| | | | [6.210] | [8.120] | | | | | [2.348] | [2.356] | | |
| km*Number of Children 0-3 yo | | | 2.24 | 4.216 | | | | | 0.789 | 1.101 | | |
| | | | [2.804] | [2.725] | | | | | [1.537] | [1.477] | | |
| km*Respondent Age | | | -0.604* | -0.607* | | | | | 0.104 | 0.095 | | |
| | | | [0.312] | [0.322] | | | | | [0.105] | [0.111] | | |
| km*Any Secondary Schooling | | | 1.319 | 0.895 | | | | | 2.552 | 2.278 | | |
| | | | [3.278] | [3.653] | | | | | [2.320] | [2.214] | | |
| Observations | 484 | 440 | 440 | 440 | 484 | | 1,234 | 1,153 | 1,153 | 1,153 | 1,234 | |
| Log Likelihood | -90.72 | -81 | -73.1 | -70.56 | -78.37 | | -129.4 | -119.5 | -118.8 | -118.1 | -112.13 | |

Coefficients are from conditional and mixed logits where dependent variable is whether a respondent named a source as their primary source. Data are from 121-127 endline household in the W, WASH, or WASH+ arms with GPS location for both their compound and their reported primary source. Choice set in regressions (1)-(5) are the four sources closest to the respondent household. Choice in (6)-(10) is all sources within 1 km from respondent household via straight line distance. (1)-(4) and (6)-(9) show estimates from fixed coefficient logit, while (5) and (10) show coefficients from a mixed logit with lognormal and normally distributed coefficients. Since distance to source very likely negatively affects selection, we have restricted the distribution to log normal. Since log normals are only positive, distance is actually -1*distance in the mixed models. Since the coefficient is from a log normal, we also show the median and mean for easier interpretation. These are simply exp(b) and exp(b+s^2/2), respectively.

*** p<0.01, ** p<0.05, * p<0.1

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**Table 5: Health Outcomes Linear Regression**

| | (1) | | | (2) | | | (3) | | | (4) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **Kakamega (Treatments Separately v. Control)** | | | | | | **Bungoma (Treatments Separately v. Control)** | | | | | |
| **Variable** | **Unadjusted** | | | **Controls** | | | **Unadjusted** | | | **Controls** | | |
| **Treatment** | **WASH** | **WASH+** | **LNS** | **WASH** | **WASH+** | **LNS** | **Water** | **Sanitation** | **Hygiene** | **Water** | **Sanitation** | **Hygiene** |
| Fever | .139*** | -0.032 | -0.117* | .112** | -0.058 | -.128* | 0.044 | -0.063 | -0.149 | 0.071 | -0.03 | -0.117 |
| se | [.047] | [.049] | [.066] | [.051] | [.063] | [.072] | [.167] | [.141] | [.154] | [.157] | [.136] | [.153] |
| Control Mean, (N) | .361,(391) | | | | | | .405,(163) | | | | | |
| Diarrhea | -0.01 | 0.063 | 0.044 | 0.005 | 0.089 | 0.072 | -0.042 | -0.079 | -0.086 | -0.001 | -0.108 | 0.104 |
| se | [.062] | [.061] | [.058] | [.064] | [.058] | [.054] | [.122] | [.106] | [.101] | [.139] | [.119] | [.123] |
| Control Mean, (N) | .244,(391) | | | | | | .368,(164) | | | | | |
| Case Def'n | -0.038 | -0.013 | -0.052 | -0.042 | -0.008 | -0.056 | -0.001 | 0.111 | -0.024 | 0.039 | 0.126 | 0.055 |
| se | [.04] | [.045] | [.038] | [.044] | [.048] | [.041] | [.05] | [.067] | [.05] | [.058] | [.075] | [.068] |
| Control Mean, (N) | .138,(387) | | | | | | .105,(160) | | | | | |
| Blood in Stool | -0.007 | -0.017 | -.041** | -0.017 | -0.02 | -.052** | 0.042 | 0.027 | 0 | 0.052 | 0.031 | -0.005 |
| se | [.028] | [.025] | [.02] | [.026] | [.027] | [.022] | [.029] | [.028] | [0] | [.036] | [.032] | [.017] |
| Control Mean, (N) | .051,(389) | | | | | | 0,(161) | | | | | |
| Cough | -.176** | -.215*** | -.262*** | -.182** | -.233*** | -.261*** | -0.016 | -0.211 | -0.009 | -0.059 | -.196* | 0.047 |
| se | [.067] | [.075] | [.064] | [.072] | [.079] | [.07] | [.153] | [.133] | [.157] | [.113] | [.106] | [.154] |
| Control Mean, (N) | .454,(391) | | | | | | .342,(164) | | | | | |
| Congestion | -0.085 | -0.12 | -.154** | -0.082 | -0.124 | -.152** | 0.127 | -0.067 | 0.038 | .202* | 0.013 | 0.039 |
| se | [.062] | [.103] | [.062] | [.061] | [.103] | [.066] | [.123] | [.111] | [.153] | [.112] | [.124] | [.183] |
| Control Mean, (N) | .563,(390) | | | | | | .526,(163) | | | | | |
| Wheeze | -0.062 | -0.049 | -0.066 | -0.053 | -0.03 | -.073* | 0.099 | 0.132 | 0.023 | 0.05 | 0.145 | 0.034 |
| se | [.041] | [.045] | [.041] | [.044] | [.053] | [.043] | [.086] | [.104] | [.089] | [.081] | [.101] | [.117] |
| Control Mean, (N) | .151,(391) | | | | | | .105,(164) | | | | | |
| Rash | -0.016 | -.112** | -0.018 | -0.004 | -0.078 | -0.025 | -0.003 | 0.084 | 0.074 | -0.029 | 0.072 | 0.155 |
| se | [.063] | [.052] | [.061] | [.059] | [.052] | [.052] | [.057] | [.067] | [.086] | [.062] | [.082] | [.096] |
| Control Mean, (N) | .294,(391) | 0,() | 0,() | .294,(391) | 0,() | 0,() | .105,(163) | | | | | |
| Bruise | -0.049 | -.091** | 0 | -0.047 | -.09** | -0.027 | -0.024 | 0 | -0.003 | -0.063 | 0.019 | 0.023 |
| se | [.047] | [.038] | [.062] | [.051] | [.042] | [.058] | [.082] | [.093] | [.089] | [.107] | [.122] | [.117] |
| Control Mean, (N) | .16,(391) | | | | | | .105,(164) | | | | | |
| Enumerator FE | NO | | | YES | | | NO | | | YES | | |
| Controls | NO | | | YES | | | NO | | | YES | | |

Notes: Table shows OLS coefficients on treatment status, with standard errors clustered by village. Columns 1 and 2 show specifications with and without controls and enumerator fixed effects for a regression of each treatment type in Kakamega. (Coefficients are displayed horizontally, but are all from one regression.) Specification 3 and 4 are analagous for the single treatment arms in Bungoma.
outMasterSEP.txt

## A Supplementary Appendix

The appendix shows additional specifications for pilot results and more exploratory analysis than that conducted in the main section of the paper.

First, in Table A1 we test additional interaction terms on uptake, specifically, characteristics of the village promoter. The promoter characteristics we test (distance to respondent home, gender, secondary school completion, number of children) do not appear to explain differential uptake levels.

Second, in Table A2 we show estimates analogous to those from Table 5 in the main body of the paper, only this time using all children under 36 months in the compound, instead of only the subset of those children who belong to the respondent. The general results pattern still holds, with mildly stronger statistical significance.

**Table A1: Uptake of Interventions Interacted with Baseline and Promoter Characteristics, Kakamega**

| VARIABLES | (1) Free Chlorine | (2) Total Chlorine | (3) VF filter use | (4) Believe feces poses risk | (5) Proper child feces disposal | (6) Latrine hole covered | (7) Stool visible on latrine floor | (8) Human Feces in compound | (9) Any Feces in compound | (10) HW critical Times | (11) Have HW Place | (12) Have HW Materials | (13) Mom's hands no dirt | (14) Kid's hands no dirt |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Combined Treatment | -0.136 | 0.159 | 0.018 | -0.469* | 0.740*** | 0.678* | -0.357 | 0.153 | -0.329 | 0.876 | 0.768*** | 1.045*** | -0.127 | -0.35 |
| | [0.248] | [0.283] | [0.115] | [0.270] | [0.216] | [0.338] | [0.337] | [0.129] | [0.246] | [0.754] | [0.135] | [0.219] | [0.229] | [0.271] |
| INTERACTIONS | | | | | | | | | | | | | | |
| Kilometers to Promoter | 0.027 | -0.007 | -0.144 | 0.306* | 0.073 | -0.017 | 0.183 | 0.201* | 0.179 | 0.389 | 0.031 | -0.198 | 0.167 | -0.008 |
| | [0.162] | [0.163] | [0.114] | [0.175] | [0.129] | [0.124] | [0.193] | [0.109] | [0.143] | [0.438] | [0.090] | [0.153] | [0.142] | [0.178] |
| Female Promoter | 0.306** | 0.214 | -0.031 | 0.11 | 0.088 | -0.073 | 0.075 | -0.122* | 0.043 | -0.295 | 0.044 | -0.053 | -0.031 | 0.320** |
| | [0.114] | [0.127] | [0.072] | [0.099] | [0.094] | [0.095] | [0.137] | [0.064] | [0.103] | [0.426] | [0.075] | [0.116] | [0.115] | [0.127] |
| Promoter attended secondary school | 0.084 | 0.004 | 0.055 | -0.01 | -0.260** | -0.032 | 0.188 | -0.176** | 0.043 | -0.341 | -0.002 | -0.204 | -0.071 | 0.07 |
| | [0.117] | [0.132] | [0.078] | [0.135] | [0.128] | [0.172] | [0.183] | [0.067] | [0.133] | [0.355] | [0.062] | [0.125] | [0.119] | [0.139] |
| Promoter Num. Children | 0.055* | 0.025 | -0.01 | 0.058* | -0.063* | -0.019 | -0.004 | -0.041** | 0.021 | -0.05 | 0.01 | -0.062* | 0.024 | 0.041 |
| | [0.031] | [0.032] | [0.015] | [0.029] | [0.034] | [0.036] | [0.042] | [0.019] | [0.030] | [0.101] | [0.013] | [0.036] | [0.032] | [0.037] |
| Observations | 283 | 283 | 303 | 320 | 322 | 303 | 303 | 316 | 322 | 322 | 322 | 322 | 322 | 321 |
| R-squared | 0.273 | 0.287 | 0.048 | 0.039 | 0.263 | 0.385 | 0.083 | 0.064 | 0.02 | 0.078 | 0.737 | 0.286 | 0.076 | 0.033 |

Robust standard errors, clustered by village, in brackets. Coefficients shown are for the interaction of treatment (WASH or WASH+) with all the health promoter characterisitcs (not standardized, since many are binary), with the outcome variables different measures of uptake. All the promoter characteristics themselves are included in the regression, as well as an indicator for treatment in the LNS-only arm.
*** p<0.01, ** p<0.05, * p<0.1
intupIA.txt

**Table A2: Health Outcomes Linear Regression Including Secondary Respondents**

| | (1) | | | (2) | | | (3) | | | (4) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **Kakamega (Treatments Separately v. Control)** | | | | | | **Bungoma (Treatments Separately v. Control)** | | | | | |
| **Variable** | **Unadjusted** | | | **Controls** | | | **Unadjusted** | | | **Controls** | | |
| **Treatment** | **WASH** | **WASH+** | **LNS** | **WASH** | **WASH+** | **LNS** | **Water** | **Sanitation** | **Hygiene** | **Water** | **Sanitation** | **Hygiene** |
| Fever | .161** | -.005 | -.096 | .144** | -.04 | -.11 | .009 | -.06 | -.11 | .054 | -.039 | -.114 |
| se | [.049] | [.052] | [.072] | [.053] | [.059] | [.075] | [.16] | [.143] | [.162] | [.156] | [.136] | [.155] |
| Control Mean, (N) | .36,(427) | | | | | | .405,(145) | | | | | |
| Diarrhea | -.003 | .058 | .032 | .018 | .084 | .064 | -.021 | -.105 | .098 | -.012 | -.113 | .106 |
| se | [.065] | [.058] | [.06] | [.067] | [.054] | [.056] | [.114] | [.096] | [.11] | [.137] | [.12] | [.125] |
| Control Mean, (N) | .243,(427) | | | | | | .368,(146) | | | | | |
| Case Def'n | -.024 | .001 | -.049 | -.032 | .001 | -.058 | .023 | .114 | .081 | .037 | .124 | .055 |
| se | [.04] | [.039] | [.036] | [.043] | [.043] | [.039] | [.041] | [.063] | [.059] | [.056] | [.075] | [.068] |
| Control Mean, (N) | .128,(423) | | | | | | .105,(142) | | | | | |
| Cough | -.164** | -.198** | -.26*** | -.164** | -.202** | -.244*** | -.062 | -.23* | .052 | -.072 | -.198* | .05 |
| se | [.074] | [.079] | [.068] | [.076] | [.083] | [.077] | [.137] | [.118] | [.182] | [.113] | [.106] | [.154] |
| Control Mean, (N) | .456,(427) | | | | | | .342,(146) | | | | | |
| Congestion | -.094 | -.111 | -.148** | -.08 | -.103 | -.134* | .13 | -.014 | .069 | .173 | .002 | .044 |
| se | [.062] | [.102] | [.063] | [.058] | [.101] | [.066] | [.12] | [.119] | [.169] | [.114] | [.125] | [.184] |
| Control Mean, (N) | .574,(426) | | | | | | .526,(145) | | | | | |
| Wheeze | -.061 | -.058 | -.047 | -.049 | -.03 | -.052 | .065 | .105 | .049 | .035 | .144 | .039 |
| se | [.045] | [.049] | [.055] | [.04] | [.052] | [.05] | [.078] | [.113] | [.123] | [.079] | [.102] | [.117] |
| Control Mean, (N) | .154,(427) | | | | | | .105,(146) | | | | | |
| Rash | -.013 | -.111** | -.02 | -.006 | -.089* | -.035 | -.031 | .053 | .152 | -.034 | .071 | .156 |
| se | [.05] | [.046] | [.048] | [.05] | [.047] | [.044] | [.052] | [.069] | [.098] | [.061] | [.082] | [.096] |
| Control Mean, (N) | .294,(427) | | | | | | .105,(145) | | | | | |
| Bruise | -.04 | -.09** | .012 | -.037 | -.095** | -.033 | -.053 | .002 | .018 | -.066 | .019 | .024 |
| se | [.041] | [.036] | [.056] | [.046] | [.04] | [.049] | [.091] | [.102] | [.104] | [.106] | [.121] | [.117] |
| Control Mean, (N) | .154,(427) | | | | | | .105,(146) | | | | | |
| Analysis | Unadjusted | | | Adjusted | | | Unadjusted | | | Adjusted | | |
| Enumerator FE | NO | | | YES | | | NO | | | YES | | |
| Controls | NO | | | YES | | | NO | | | YES | | |

Notes: Table shows OLS coefficients on treatment status, with standard errors clustered by village. Columns 1 and 2 show specifications with and without controls and enumerator fixed effects for a regression of each treatment type in Kakamega. (Coefficients are displayed horizontally, but are all from one regression.) Specification 3 and 4 are analagous for the single treatment arms in Bungoma.