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Water Treatment and Handwashing Behaviors among Non-Pregnant Friends and Relatives of Participants in an Antenatal Hygiene Promotion Program in Malawi

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Abstract. Access to safe drinking water and improved hygiene are essential for preventing diarrheal diseases. To integrate hygiene improvement with antenatal care, free hygiene kits (water storage containers, water treatment solution, soap) and educational messages were distributed to pregnant women at antenatal clinics in Malawi. We assessed water treatment and hygiene practices of 275 non-pregnant friends and relatives of the hygiene kit recipients at baseline and follow-up nine months later to measure program impact on non-participants in the same communities. At follow-up, friends and relatives who did not receive kits or education were more likely than at baseline to purchase and use water treatment solution (25% versus 1%; $P < 0.0001$) and demonstrate correct handwashing practices (60% versus 18%; $P < 0.0001$). This antenatal clinic–based program resulted in improved water treatment and hygiene behaviors among non-pregnant friends and relatives living in the same communities as hygiene kit recipients, suggesting that program benefits extended beyond direct beneficiaries.

INTRODUCTION

Diarrheal illness is a leading cause of mortality in children less than five years of age in the developing world.[1] In Malawi, where the child mortality rate is high at 122 deaths per 1,000 live births, a national survey found that nearly 24% of children less than five years of age had an episode of diarrhea in the preceding two weeks.[2] Among other things, three key practices have been shown to be effective in reducing the risk of diarrheal diseases: use of household water treatment, handwashing with soap, and improved sanitation.[3–5] To reduce the risk of diarrhea in Malawi, a household water treatment product (WaterGuard) was introduced in 2002 for national marketing and distribution by the nongovernmental organization Population Services International (Washington, DC). A 2005 survey in Malawi showed that although 65% of mothers had heard of WaterGuard, reported current use was 7%.[6]

In 68 countries where 97% of global maternal and child deaths occur, 88% of women reported at least one antenatal visit, suggesting that antenatal care could be a productive platform for integrating interventions to improve maternal and child health.[7] In Malawi, 93% of pregnant women receive some antenatal care from a skilled provider; however, only 57% deliver at a health facility and only 7% of mothers receive postnatal checks. These gaps in care contribute to high maternal mortality, 984 deaths per 100,000 live births.[2]

In an attempt to increase use of perinatal services and motivate pregnant women to treat their household water and improve handwashing practices, we implemented a pilot program to integrate promotion of water treatment and hand hygiene with antenatal care programs targeting 15,000 pregnant women in two districts of Malawi.[8] The intervention consisted of the free distribution of hygiene kits (a water storage container with a cover and a tap, a bottle of WaterGuard, a bar of soap, two sachets of oral rehydration salts, and educational material) at their first antenatal clinic visit, and refills of WaterGuard and soap at up to three additional antenatal, delivery, or postnatal visits. We evaluated the program by conducting a baseline survey of 400 program participants and a follow-up survey nine months later. The evaluation demonstrated an increase in confirmed household water treatment among hygiene kit recipients with WaterGuard from 2% at baseline to 61% at follow-up and an increase in the ability to demonstrate proper handwashing technique from 22% at baseline to 68% at follow-up.[8]

During this evaluation, we also assessed water treatment and handwashing behaviors among friends and relatives of hygiene kit recipients. Behavior change research suggests that a variety of factors can influence adoption of interventions, including interactions within social networks.[9,10] We hypothesized that social relationships would facilitate the transfer of knowledge and behaviors promoted by antenatal care program staff from hygiene kit recipients to non-pregnant women in the same communities. In this report, we describe the results of an assessment of the behaviors of hygiene kit recipients' friends and relatives.

METHODS

Evaluation design. Pregnant women participating in the antenatal clinic program (hereafter referred to as hygiene kit recipients) were asked at enrollment to identify friends or relatives who were not currently pregnant and were mothers of children less than five years of age. We conducted a baseline cross-sectional survey of one non-pregnant mother per hygiene kit recipient and performed a follow-up survey of the same women nine months later.

Sample selection. The assumptions for sample size calculations were for hygiene kit recipients and were based on the objectives of the antenatal clinic program. By assuming 7% overall use of WaterGuard at baseline based on a previous national survey, 100% increase in use among hygiene kit recipients based on prior experience with water treatment interventions, a discordant proportion of 20%, a type I error of 5%, power of 80%, and a loss to follow-up of approximately

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20%, we calculated a sample size of 400 pregnant women (PASS 2008 version 8.06).[6,11,12] We selected hygiene kit recipients by weighted sample proportional to the average monthly antenatal clinic attendance at each health facility, and asked each hygiene kit recipient to provide the names of three non-pregnant female friends or relatives in their community who had at least one child less than five years of age. For each hygiene kit recipient, we selected one friend or relative, often the closest neighbor with a separate supply of drinking water for her family.

Baseline survey. We visited the friends and relatives at home in May 2007 to collect data on demographic and socioeconomic characteristics, water sources, and water storage, treatment, and hygiene practices. During the home visit, we made observations regarding water storage, treatment, and hygiene practices, presence of soap, and demonstration of handwashing procedure. We tested stored drinking water for residual chlorine using the *N,N*-diethyl-*p*-phenylenediamine colorimetric method using Hach Free and Total Chlorine kits (Hach Co., Loveland, CO) as an objective measure of WaterGuard use.

Program implementation. Details of the implementation of the antenatal integration program are described elsewhere.[8] As standard procedure, community health workers visit families in their catchment areas at regular intervals to reinforce health messages conveyed at the health clinics. These health workers visited hygiene kit recipients several times throughout the program period and included visits to neighboring friends and relatives on an array of health topics. Friends and relatives had no direct involvement with the antenatal hygiene kit program unless they became pregnant and therefore eligible for enrollment. Friends or relatives who became pregnant during the nine months between baseline and follow-up visits were excluded from this evaluation. Population Services International, which helped train Ministry of Health staff at the antenatal clinics, also ensured throughout the program period that WaterGuard awareness reached target communities through increased radio advertisements, billboards, and promotional materials in shops, and that WaterGuard bottles were made continually available at local commercial sales outlets. These promotional activities were designed to generate demand for, and assure an adequate supply of, WaterGuard for the duration of the program.

Follow-up survey. In February–March 2008, field workers conducted follow-up interviews and observations of friends and relatives during surprise visits to assess whether their practices had changed compared with baseline. Follow-up questionnaires were identical to baseline forms except for additional questions regarding whether the friend or relative herself had become pregnant and received a hygiene kit during the program.

Human subjects protection. The Centers for Disease Control and Prevention Institutional Review Board determined that, because this activity consisted of an evaluation of a proven public health practice, it was exempt from human subjects research oversight. The Ministry of Health collaborated fully in the implementation and evaluation of this program as public health practice. Oral informed consent was obtained from all survey participants and personal identifiers were permanently removed from the database.

Data analysis. Data from baseline and follow-up surveys were entered into an Access 2003 database (Microsoft, Redmond, WA) and analyzed by using SAS software version 9.2 (SAS Institute, Cary, NC) and SUDAAN version 10.0.1 (Sudaan, Research Triangle Park, NC). The primary outcomes of interest included confirmed WaterGuard use (defined as presence of a WaterGuard bottle in the home and detectable residual chlorine in stored water) and lathering hands completely with soap during a handwashing demonstration. To classify respondents by socioeconomic status, we used principal component analysis methodology in which household assets were assigned values based on a scoring factor as described.[13] Asset indicators included ownership of consumer durables, observed characteristics of the household dwelling, and land ownership. Asset values were summed for each woman to create a household asset score. Respondents were placed in socioeconomic quintiles based on their asset score relative to their district's survey population.

Comparisons between the two districts on baseline demographics were performed by using the Wald F-test accounting for clustering by health facility by the Taylor series method of variance estimation (SUDAAN). Baseline and follow-up data were summarized and compared using McNemar's test for paired proportions adjusting for clustering by health facility.[14] For a few instances in which the adjustment to McNemar's test was not feasible, an exact test of a binomial proportion was used.

To assess factors associated with confirmed use of WaterGuard and correct handwashing demonstration at follow-up among the subset of friends and relatives who did not exhibit these behaviors at baseline, bivariate odds ratios (ORs) were estimated by a logistic regression adjusting for district. The Taylor series method of variance estimation was used to account for stratification by district and clustering by health facility (SUDAAN). This method was also used to assess concordance at follow-up among friend/relative-hygiene kit recipient pairs in the subset that did not exhibit the behavior at baseline.

RESULTS

Enrollment. At baseline, we enrolled 230 friends and relatives in the catchment areas of the eight health facilities in Blantyre District and 156 from the seven health facilities in Salima District. Six women were excluded from each district because of poor data quality. During the follow-up survey, 65 (28%) women in Blantyre District and 19 (12%) in Salima District were lost to follow-up; the reasons included moved away (88%), refused to participate (3%), died (1%), and other (8%). Ten women from Blantyre and 17 from Salima became pregnant and eligible to receive hygiene kits through the antenatal clinics during the program period and were therefore excluded from analysis. Data from the remaining 275 women who completed the follow-up survey, 155 from Blantyre and 120 from Salima, were included in the analysis. Of the 111 respondents lost to follow-up, a relatively higher proportion lived in urban areas (45 [41%] of 111 versus 90 [33%] of 275) and in Blantyre District (75 [68%] of 111 versus 155 [56%] of 275), and were in the wealthier two quintiles (45 [42%] of 108 versus 99 [37%] of 269). For this analysis, women lost to follow-up were omitted.

Demographic and socioeconomic characteristics. Respondents had a median age of 25 years (range = 16–42 years) and a median of one child less than five years of age (range = 1–4) at the time of enrollment (Table 1). A higher proportion of

TABLE 1

Demographic characteristics, water sources, and water storage and sanitation practices of friends and relatives of pregnant women in the integrated hygiene promotion-antenatal clinic program, Blantyre and Salima Districts, Malawi, May–June 2007*

Characteristic	Blantyre (n = 155)	Salima (n = 120)	Total (n = 275)
Median age in years at enrollment (range)†	25 (16–42)	25 (16–42)	25 (16–42)
Median household size at enrollment (range)†	5 (2–11)	5 (2–15)	5 (2–15)
Median no. children < 5 years of age at enrollment (range)†	1 (1–4)	2 (1–3)	1 (1–4)
Residence, no. (%)			
Rural	74 (48)	111 (92)	185 (67)
Urban	81 (52)	9 (8)	90 (33)
Education, no. (%)‡			
No education or some primary school	77 (50)	101 (84)	178 (65)
Completed primary school	78 (50)	19 (16)	97 (35)
Literate‡	120 (77)	62 (52)	182 (66)
Improved primary water source, no. (%)	141 (92)	100 (84)	241 (89)
Latrine observed inside or near home, no. (%)‡	145 (94)	89 (75)	234 (86)
Stores drinking water, no. (%)‡	155 (100)	113 (95)	268 (98)
Primary water storage container, no. (%)‡			
Bucket	115 (74)	25 (23)	140 (53)
Clay pot	30 (19)	84 (76)	114 (43)
Other (jerry can, bottle, tank, basin)	10 (6)	2 (2)	12 (5)
Storage container with lid, no. (%)‡	143 (93)	93 (85)	236 (89)

*For some items, n may vary by small numbers.
†Medians were not compared by a statistical test.
‡$P < 0.05$, by Wald F-test accounting for clustering by health facility.

respondents from Blantyre than Salima reported urban residence (52% versus 8%), completion of primary school (50% versus 16%), and ability to read (77% versus 52%). There were no significant differences in the distribution of demographic, water, sanitation, or hygiene characteristics between friends and relatives and the hygiene kit recipients.

Assessment of change in behaviors from baseline to follow-up among friends and relatives.

Water sources, storage, and treatment. At baseline, 89% of all respondents reported using an improved drinking water source, 92% in Blantyre and 84% in Salima. Ninety-eight percent of respondents reported storing their drinking water, and by observation, 89% used a lid on their container (Table 1). From baseline to follow-up, the proportion of respondents who reported having treated their drinking water increased from 62% to 92% ($P < 0.0001$) (Table 2). The most commonly reported treatment methods were boiling (34 to 24%; $P < 0.0001$); WaterGuard (33 to 69%; $P < 0.01$); and using the free chlorine stock solution distributed by the Ministry of Health (10 to 22%; $P < 0.001$). At baseline, 24% reported treating their water by any method in the past two days compared with 70% at follow-up ($P < 0.0001$).

TABLE 2

Comparison of knowledge and practices regarding water treatment and hand hygiene from baseline to follow-up among friends and relatives of antenatal clinic program participants, Blantyre and Salima Districts, Malawi, 2007–2008*

Characteristic	Blantyre (n = 155)			Salima (n = 120)			Total (n = 275)		
	Baseline	Follow-up	P†	Baseline	Follow-up	P†	Baseline	Follow-up	P†
Water treatment									
Treats drinking water with any method	88 (68)	116 (89)	< 0.0001	60 (55)	104 (95)	< 0.0001	148 (62)	220 (92)	< 0.0001
WaterGuard	57 (41)	91 (65)	< 0.0001	26 (23)	84 (75)	< 0.0001	83 (33)	175 (69)	< 0.0001
Boiling	53 (38)	41 (29)	0.02	32 (29)	19 (17)	0.01	85 (34)	60 (24)	< 0.01
Treat with chlorine stock solution	10 (7)	28 (20)	< 0.01	14 (13)	27 (24)	0.04	24 (10)	55 (22)	< 0.001
Other (filter, settle, floculant)	24 (21)	4 (3)	< 0.01	15 (18)	10 (12)	0.28	39 (19)	14 (7)	< 0.0001
Reported use of any method in past 2 days	30 (24)	79 (63)	< 0.0001	26 (25)	84 (79)	< 0.0001	56 (24)	163 (70)	< 0.0001
WaterGuard knowledge and use									
Heard of WaterGuard	146 (94)	153 (99)	−‡	93 (79)	117 (99)	< 0.0001	239 (88)	270 (99)	−§
Knows correct WaterGuard treatment procedure	45 (31)	68 (47)	< 0.01	16 (17)	49 (53)	< 0.0001	61 (26)	117 (50)	< 0.0001
Ever used WaterGuard	103 (66)	127 (82)	< 0.001	52 (44)	104 (88)	< 0.0001	155 (57)	231 (85)	< 0.0001
Reported use of WaterGuard in last 2 days	20 (13)	46 (31)	< 0.001	8 (7)	62 (53)	< 0.0001	28 (11)	108 (41)	< 0.0001
WaterGuard bottle observed in home	12 (8)	32 (21)	< 0.0001	4 (3)	44 (38)	< 0.0001	16 (6)	76 (28)	< 0.0001
Detectable residual chlorine in stored water	16 (11)	40 (28)	< 0.001	3 (3)	53 (52)	< 0.0001	19 (8)	93 (38)	< 0.0001
Detectable chlorine plus bottle observed (confirmed use)	3 (2)	26 (18)	< 0.0001	0	34 (34)	−§	3 (1)	60 (25)	< 0.0001
Hygiene practices									
Soap observed in home	112 (73)	120 (78)	0.34	72 (61)	85 (72)	< 0.05	184 (68)	205 (76)	0.07
Hand washing demonstration									
Uses soap	42 (27)	99 (64)	< 0.0001	17 (15)	75 (66)	< 0.0001	59 (22)	174 (65)	< 0.0001
Lathers hands completely with soap	34 (22)	88 (57)	< 0.0001	14 (12)	72 (64)	< 0.0001	48 (18)	160 (60)	< 0.0001

*Values are no. (%). For some items, n may vary by small numbers.
†P value is from McNemar's test adjusted for clustering by health facility.
‡P value could not be estimated using McNemar's test adjusting for clustering by health facility, but using an exact test of binomial proportion, $P < 0.05$.
§P value could not be estimated using McNemar's test adjusting for clustering by health facility, but using an exact test of binomial proportion, $P < 0.0001$.

WaterGuard awareness and use. From baseline to follow-up, the percentage of respondents having heard of WaterGuard increased from 94% to 99% ($P < 0.05$) in Blantyre and from 79% to 99% ($P < 0.0001$) in Salima (Table 2). Among women in both districts who had heard of WaterGuard, the percentage who were able to correctly indicate how to use the product (i.e., could identify correct dose and wait time) increased from 26% at baseline to 50% at follow-up ($P < 0.0001$). At follow-up, most (78%) respondents reported that someone had taught them how to use WaterGuard. Health care providers in the clinic (44%), community health workers visiting the home (38%), and friends, relatives, or neighbors (13%) gave them the most confidence to use WaterGuard; 59% reported having heard about WaterGuard from a hygiene kit recipient, and 3% reported hearing about WaterGuard from a hygiene kit recipient alone.

The percentage of friends and relatives who reported having used WaterGuard in the previous two days increased from 11% to 41% ($P < 0.0001$ (Table 2). WaterGuard bottles were observed in 6% of homes at baseline and 28% of homes at follow-up ($P < 0.0001$). Stored water samples from 8% of homes at baseline had positive chlorine residuals compared with 38% at follow-up ($P < 0.0001$). We confirmed WaterGuard use (i.e., an observation of a WaterGuard bottle in the home and detectable residual chlorine in stored drinking water) in 1% of friends and relatives' homes at baseline compared with 25% of homes at follow-up ($P < 0.0001$).

Hand hygiene. Soap was observed in 68% of friends and relatives homes at baseline and 76% at follow-up ($P = 0.07$) (Table 2). When friends and relatives were asked to demonstrate how they washed their hands, 18% lathered their hands completely with soap at baseline compared with 60% at follow-up ($P < 0.0001$).

Factors associated with improved water treatment and hand hygiene practices. Among respondents who did not have confirmed WaterGuard use at baseline, there was a significant association, controlling for district, at follow-up between confirmed WaterGuard use and being in the upper two wealth quintiles (Table 3). Among respondents who did not demonstrate correct handwashing procedures at baseline, respondents who were literate were significantly more likely to demonstrate correct handwashing procedures at follow-up. Neither behavior was significantly associated with urban residence or completion of primary school. Both behaviors among friends and relatives at follow-up were significantly associated with hygiene kit recipient follow-up behavior, but not baseline behavior.

Concordance of behavior change among friend/relative and hygiene kit recipient pairs. Although there was a significant change in friend and relative behavior from baseline to follow-up independent of hygiene kit recipient behavior (Table 2) and a change from baseline associated with hygiene kit recipient follow-up behavior but not baseline behavior (Table 3), the following analysis specifically focuses on whether behavior change in friends and relatives is associated with behavior change in hygiene kit recipients. Among the set restricted to the 222 friend/relative-hygiene kit recipient pairs without confirmed WaterGuard use at baseline and controlling for district, friends or relatives were more likely to exhibit confirmed WaterGuard use at follow-up if the corresponding hygiene kit recipient also had confirmed WaterGuard use (OR = 2.6, 95% confidence interval = 1.3–5.3). Similarly, among 169 friend/relative-hygiene kit recipient pairs that did not demonstrate proper handwashing at baseline, friends or relatives were more likely to demonstrate proper handwashing at follow-up if the corresponding participant also exhibited proper handwashing technique (OR = 2.2, 95% confidence interval = 1.4–3.5).

DISCUSSION

Results of this evaluation suggest that the beneficial impact of an antenatal hygiene kit program on water treatment and handwashing behaviors in expectant mothers extended beyond direct beneficiaries to include friends and relatives who were not part of the program. The magnitude of the increase in water treatment behavior among friends and relatives was noteworthy because it required the purchase of WaterGuard solution. Our hypothesis that hygiene kit recipients influenced water treatment and hygiene behaviors in their friends and relatives is strongly supported by the observation that friends or relatives were significantly more likely to change from non-use of WaterGuard at baseline to confirmed use at follow-up if the corresponding hygiene kit recipient also changed from non-use to confirmed WaterGuard use. A similar positive association between friend/relative-hygiene kit recipient pairs in the change from improper handwashing technique at baseline to proper handwashing technique at follow-up further supports our hypothesis.

There are several possible explanations for these striking results. First, social networks are known to have an influence on behavior.[15] Second, research into the diffusion of innovations suggests that the transfer of ideas takes place most commonly among persons who share common demographic and

TABLE 3

Socioeconomic characteristics associated with adoption of key water treatment and hand hygiene behaviors among friends and relatives of antenatal clinic program participants, controlling for district, Blantyre and Salima Districts, Malawi, 2007–2008

Characteristic	Confirmed WaterGuard use, OR (95% CI)	Correct handwashing demonstration, OR (95% CI)
Salima	2.33 (0.89–6.11)	1.33 (0.57–3.06)
Urban residence	1.35 (0.57–3.22)	1.27 (0.38–4.24)
Upper two wealth quintiles	1.93 (1.05–3.52)	1.39 (0.72–2.68)
Completed primary school	1.35 (0.66–2.76)	1.51 (0.61–3.73)
Literate	1.09 (0.39–3.05)	2.26 (1.15–4.45)
Improved water source	0.94 (0.45–1.97)	0.77 (0.35–1.68)
Association with hygiene kit recipient behavior		
At baseline	1.66 (0.16–17.62)	0.70 (0.38–1.31)
At follow-up	2.85 (1.36–6.00)	2.08 (1.31–3.29)

OR = odds ratio; CI = confidence interval.

socioeconomic characteristics, as exhibited by the hygiene kit recipients and friends and relatives enrolled in this evaluation.[9,10,15,16] Furthermore, four of the five characteristics that influence diffusion of innovations were present in this program: advantage of the innovation over alternatives (e.g., boiling, which is more expensive and time-consuming than WaterGuard), compatibility with existing needs, low complexity, and trialability (i.e., the possibility of observing hygiene kit recipients using WaterGuard or washing hands).[9,10,15,16] The influence of the fifth characteristic, observed impact (in this case diarrhea prevention), was not assessed in our evaluation, but cannot be excluded. Additionally, the program may have facilitated the behavior change process by employing behavior change strategies at multiple levels of influence, including mass media promotion, Ministry of Health engagement, clinic-based education, and interpersonal communication by community health workers and between individuals.[16–18] The friends and relatives in this evaluation identified a variety of information sources about WaterGuard that may have influenced their behavior, including their corresponding hygiene kit recipient (59%), health providers in the clinic (44%), community health workers visiting the home (38%), and friends, relatives, or neighbors (13%). Although the multiple information sources identified in this evaluation obscure which influences were most important, we believe the transfer of information from the hygiene kit recipients or health workers in the program were the leading factors. A qualitative evaluation performed among hygiene kit recipients and their friends and relatives following this evaluation corroborated this likely mechanism of influence.[19] We doubt that secular trends in water treatment explain much, if any, of these changes because national sales of WaterGuard from 2007 through 2008 changed by less than 2% (Population Services International, unpublished data). In addition, no programs offering free distribution of WaterGuard other than the one described in this paper were present in these districts during the period of the evaluation.

Among hygiene kit recipients who received up to four free bottles of WaterGuard, the significant increase in water treatment from baseline to follow-up was associated with lower wealth quintiles, suggesting that free WaterGuard distribution helped improve equity of access to the product.[8] In this evaluation, the increase in water treatment from baseline to follow-up among friends or relatives, who had to purchase WaterGuard, was associated with higher wealth quintiles. This finding suggests that although the price of WaterGuard (US $0.12) was low, cost was a barrier to engaging in water treatment behavior. This finding was consistent with other reports and suggests that improving equity of access to health products like WaterGuard may require price subsidies.[18] In fact, in this evaluation we found that friends and relatives were also more likely to treat their drinking water at follow-up than at baseline with free chlorine stock solution distributed by the Ministry of Health, a fully-subsidized alternative that enabled demand for water treatment products to be met for some persons.

This evaluation had several important limitations. First, participation in the evaluation may have influenced the respondents' behavior. We attempted to mitigate this effect in the evaluation design by making two surprise visits nine months apart and in the analysis, by assessing whether change in behavior among friends and relatives was associated with change in behavior among hygiene kit recipients. Second, the population lost to follow-up was wealthier and more likely to live in urban areas than the follow-up evaluation population. However, improvements in water treatment and hand hygiene practices among respondents with similar demographics who remained in the evaluation suggest that the loss to follow-up of these women did not significantly alter evaluation findings. Third, the baseline survey was conducted during the dry season, but the follow-up survey was conducted during the rainy season. Seasonal variation may have affected water treatment behaviors. We do not, however, believe that the behavior changes noted could have been caused by seasonal variation alone because seasonal changes in WaterGuard purchases in Malawi are minimal and do not approach the magnitude of change seen in water treatment behavior in this evaluation (Population Services International, unpublished data).

The significant improvements in water treatment behavior and demonstrations of handwashing technique among friends and relatives of hygiene kit recipients suggested that the integration of these interventions into antenatal services had impact beyond direct program beneficiaries. Further evaluation into the apparent diffusion of these behaviors to networks of friends and relatives is warranted to better understand how to use novel implementation approaches to disseminate public health interventions as widely as possible among vulnerable populations.

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REFERENCES

1. Parashar UD, Bresee JS, Glass RI, 2003. The global burden of diarrhoeal disease in children. *Bull World Health Organ 81:* 236.
2. National Statistical Office of Malawi and UNICEF, 2008. *Malawi Multiple Indicator Cluster Survey 2006, Final Report*. Lilongwe, Malawi: National Statistical Office and UNICEF. Available

at: http://www.childinfo.org/files/MICS3_Malawi_FinalReport_2006_eng.pdf. Accessed March 14, 2010.
3. Fewtrell L, Kaufmann RB, Kay D, Enanoria W, Haller L, Colfor JM Jr, 2005. Water, sanitation, and hygiene interventions to reduce diarrhoea in less developed countries: a systematic review and meta-analysis. *Lancet Infect Dis 5:* 42–53.
4. Clasen T, Schmidt WP, Rabie T, Roberts I, Cairncross S, 2007. Interventions to improve water quality for preventing diarrhoea: systemic review and meta-analysis. *BMJ 334:* 755–756.
5. Curtis V, Cairncross S, 2003. Effect of washing hands with soap on diarrhoea risk in the community: a systematic review. *Lancet Infect Dis 3:* 275–281.
6. Stockman LJ, Fischer TK, Deming M, Ngwira B, Quick RE, 2007. Point-of-use water treatment and use among mothers in Malawi. *Emerg Infect Dis 13:* 1077–1080.
7. Bryce J, Daelmans B, Dwivedi A, Fauveau V, Lawn JE, Mason E, Newby H, Shankar A, Starrs A, Wardlaw T, 2008. Countdown to 2015 for maternal, newborn, and child survival: the 2008 report on tracking coverage of interventions. *Lancet 371:* 1247–1258.
8. Sheth, AN, Russo E, Menon M, Wannemuehler K, Weinger M, Kudzala AC, Tauzie B, Masuku HD, Msowoya TE, Quick R, 2010. Impact of the integration of water treatment and hand washing incentives with antenatal services on hygiene practices of pregnant women in Malawi. *Am J Trop Med Hyg 83:* 1315–1321.
9. Greenhalgh T, Robert G, Macfarlane F, Bate P, Kyriakidou O, 2004. Diffusion of Innovations in Service Organization: Systematic Review and Recommendation. *Milbank Q 82:* 581–629.
10. Rogers EM, 1995. *Diffusion of Innovations, Fourth edition*. New York: The Free Press.
11. Parker AA, Stephenson R, Riley PL, Ombeki S, Komolleh C, Sibley L, Quick R, 2006. Sustained high levels of stored drinking water treatment and retention of hand-washing knowledge in rural Kenyan households following a clinic-based intervention. *Epidemiol Infect 134:* 1029–1036.
12. Blanton E, Ombeki S, Oluoch GO, Mwaki A, Wannemuehler K, Quick R, 2010. Evaluation of the role of school children in the promotion of point-of-use water treatment and handwashing in schools and households, Nyanza Province, western Kenya, 2007. *Am J Trop Med Hyg 82:* 664–671.
13. Filmer D, Pritchett LH, 2001. Estimating wealth effects without expenditure data–or tears: an application to educational enrollments in states of India. *Demography 38:* 115–132.
14. Eliasziw M, Donner A, 1991. Application of the McNemar test to non-independent matched pair data. *Stat Med 10:* 1981–1991.
15. Goldman N, Pebleyb AR, Beckett M, 2001. Diffusion of ideas about personal hygiene and contamination in poor countries: evidence from Guatemala. *Soc Sci Med 52:* 53–69.
16. Institute of Medicine, 2001. *Health and Behavior: The Interplay of Biological, Behavioral and Societal Influences*. Washington, DC: National Academy Press.
17. McLeroy KR, Bibeau D, Steckler A, Glanz K, 1988. An ecological perspective on health promotion programs. *Health Educ Q 15:* 351–377.
18. Freeman MC, Quick RE, Abbott DP, Ogutu P, Rheingans R, 2009. Increasing equity of access to point-of-use water treatment products through social marketing and entrepreneurship: a case study in western Kenya. *J Water Health 7:* 527–534.
19. Wood S, Foster J, Goodyear LE, 2011. Motivations for use and non-use of WaterGuard by mothers in an antenatal water treatment and hygiene program in Malawi. *Soc Sci Med 73:* 351–377.