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2009

Randomized controlled trials of the plastic housing biosand filter in Cambodia, Ghana and Honduras.

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Recommended Citation

CE Stauber, AM Fabiszewski, EL Printy, BC Kominek, AR Walters, KR Liang, MD Sobsey. 2009. Randomized controlled trials of the plastic housing biosand filter in Cambodia, Ghana and Honduras. *Am J Trop Med Hyg* November 2009 vol. 81 no. 5 Suppl 1301-356; Abstract 1063.

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sold at a retail price of \$0.30 per month, despite several years of a vigorous social marketing campaign. We explore the role of persuasion, peers, price, promoters, and the product's delivery system in boosting chlorine use through a series of randomized evaluations. More intense persuasion efforts had little impact and we do not find strong evidence of peer effects. Price seems to be the single most important factor, with more than half of people using chlorine when it is delivered free to the house. Locally-elected chlorine promoters can boost chlorination rates, and are effective even when compensated at a flat rate alone rather than via bonuses for good performance. Based on the evidence, we developed a chlorine dispenser technology which drastically reduces the cost of chlorination and leads to the highest rates of use. Because the cost of the packaging is high relative to the cost of the chemical, supplying a community with bulk chlorine through a dispenser is vastly cheaper than subsidizing individually-packaged bottles. In addition, the dispenser provides a physical reminder to treat water at the moment when it is most salient (as water is collected), is more convenient to use than bottled chlorine, and maximizes the potential for peer effects by making each household's decision of whether or not to treat their water public, allowing community members to help one another learn to use the technology and set an example for others to follow. Chlorine dispensers are a promising new technology for providing access to safe water where piped infrastructure is not available. We estimate that the cost per DALY saved by a chlorine dispenser could be less than \$20, extremely cost-effective relative to other public health interventions in less-developed countries.

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INTERIM ASSESSMENT OF A SANITATION, HYGIENE EDUCATION AND WATER SUPPLY INTERVENTION IN RURAL BANGLADESH, 2008

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The Sanitation, Hygiene Education and Water Supply in Bangladesh Programme (SHEWA-B) is a large intensive program focusing mainly on social mobilization for awareness building, targeting 30 million rural population. The programme aims to improve standards of hygiene practices and behavior, whilst ensuring adequate sanitation and safe water supply. To measure early effects of the intervention in the programme areas, we conducted an interim assessment, at least 6 months after implementation, using 5-hour structured observations of hand washing behavior and spot-checks of water sources, latrines, and waste disposal. These data were compared to those collected at baseline from the same 500 households, selected randomly. At interim assessment, the proportion of people washing both hands with soap or ash after defecation increased to 30% compared with 17% at baseline, and after cleaning a child's anus the proportion rose to 34% compared to 22% at baseline. There were no changes in hand washing practices for food related events. Improved latrine coverage defined by WHO/UNICEF Joint Monitoring Programme increased to 91% in comparison to 88% during baseline. Open defecation declined from 10% to 8%. Child's feces were disposed of properly in 11% of households, a slight increase over 9% at baseline. Availability of appropriate household solid and liquid waste disposal was low, less than 3%, both at interim assessment and at baseline. About 99% households use protected source of drinking water both at interim assessment and at baseline. In conclusion, from the findings of the interim assessment we can conclude that additional time is required to observe further behavior change for some indicators linked to the study. While there have been improvements for some indicators, this assessment only collected information from the intervention households. Nevertheless, these data are useful interim indicators of the study progress and are helpful in identifying areas for improvement in the project implementation cycle.

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A COMPARISON OF WATER TREATMENT PRACTICES AMONG PEOPLE LIVING WITH HIV/AIDS AND COMMUNITY MEMBERS IN ETHIOPIA, DECEMBER, 2008

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Diarrhea is a leading cause of illness and death in people living with HIV/AIDS in sub-Saharan Africa. Chlorinating household drinking water reduces the risk of diarrhea in this population by at least 25%. In Ethiopia, some HIV programs promote and distribute WuhaAgar, a socially marketed water chlorination product. We assessed these programs by comparing WuhaAgar use among HIV-infected antiretroviral treatment (ART) clinic clients and community members. We surveyed 795 clients from 20 ART clinics and 795 community members (matched by age, sex, and neighborhood) about water-handling practices and WuhaAgar use. We tested stored household drinking water for residual chlorine. Clinic clients were more likely than community members to report chlorinating household water (30% vs. 8%, matched odds ratio [mOR] = 5.5; 95% confidence interval [CI]: 3.9-7.9), have a WuhaAgar bottle at home (21% vs. 3%, mOR = 8.7; 95% CI: 5.3-15.1), and have chlorine residuals in stored water (7% vs. 1%, mOR = 13.3; 95% CI: 4.9-50.4). In a subset analysis, clients from five clinics that promoted WuhaAgar were more likely than clients of clinics that did not promote WuhaAgar to report water chlorination (52% vs. 13%, adjusted odds ratio [aOR] = 7.1; 95% CI: 2.7-18.9) have WuhaAgar at home (36% vs. 9%, aOR = 6.1; 95% CI: 2.5-14.9), and had a greater tendency to have chlorine residuals in stored water (11% vs. 4%, aOR = 3.3; 95% CI: 0.9-11.9). In conclusion, ART clinic clients were more likely than community members to use a socially marketed water chlorination product. Promoting and distributing water chlorination products in ART clinics may increase water treatment and prevent diarrhea among people with HIV/AIDS.

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RANDOMIZED CONTROLLED TRIALS OF A PLASTIC HOUSING BIOSAND FILTER IN CAMBODIA, GHANA AND HONDURAS

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Point of use (POU) drinking water treatment allows people without access to safe water sources to improve the quality of their water by treating it in the home. One of the most promising emerging POU technologies is the biosand filter (BSF). Field studies of the concrete-housing BSF in Cambodia and the Dominican Republic have documented significant reductions in diarrheal disease and continued use over time. As a result of these and numerous other studies, there is growing interest in scaling up POU technologies. An alternative to the typically cumbersome concrete BSF is a plastic-housing one, one of which is a plastic BSF of the NGO International Aid. The purpose of this research was to document the ability of this BSF to reduce diarrheal disease in user households compared to non-user households. In 2008, three randomized controlled trials (RCTs) of plastic BSFs were performed in Cambodia, Ghana and Honduras. Approximately 150-250 households were recruited from rural villages in each location. Households were randomized to the plastic BSF intervention or no intervention at the village level in Cambodia and Ghana and at the household level in Honduras. Households were observed during the intervention period for four to six months. Initial results indicate significant reductions of diarrheal disease in Cambodia and Ghana with households reporting approximately 60% fewer cases of diarrheal disease. In Honduras, plastic BSF households also experienced considerably decreased

rates of diarrheal disease compared with non-filter households but initial analysis suggests this reduction not to be statistically significant. The observed reduction in diarrheal disease associated with plastic BSFs in all locations was within the range reported for other POU technologies such as the concrete BSF, chlorine disinfection or ceramic filtration. Hence, a plastic housing BSF appears to be an effective household POU water treatment technology that is physically easier to implement than the comparable concrete versions.

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A RETROFIT TO UPGRADE LOW-COST CERAMIC WATER FILTER DEVICES TO PURIFIER STATUS

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Ceramic candles have earned a place in household drinking water treatment in many countries, lending themselves readily to gravity-feed applications, and improving the safety and appearance of the filtered water. Steady improvements in ceramic technology have led to advances in performance that, at the high end, include effective removal of cysts and bacteria. At the low end, lesser efficacies are the rule, with variable and inconsistent removal of cysts and bacteria, depending on porosity and local manufacturing standards. We have developed a simple retrofit device aimed at upgrading the decontamination efficacy of existing ceramic-based filters to include disinfection of water borne viruses, at the high end, and enabling lower quality products to achieve superior bacterial removal. Customized cartridges containing variable amounts of brominated hydantoinylated polystyrene beads (EPA Reg#. 72083-3) were prototyped with a view to incorporating a quick-fit housing containing the medium directly into the water treatment train. Water exiting the ceramic element passes through the bead bed, and is decontaminated largely by contact, with the added benefit that suitably prepared beads could also impart a valuable but imperceptible halogen residual to the stored product water. Microbial challenges of the filters with polio, MS-2, *E.coli* and *K.terrigena*, and determination of the efficacy of the residual, showed that retrofitted devices of a variety of brands in India were able to provide long-lasting purification levels with attractive cost-benefit features. Results of Indian consumer reactions to the retrofit approach will be presented, as well as data on a lower- capacity, 2 gal. plastic device designed for service as an emergency relief purifier.

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HOUSEHOLD PREDICTORS OF ABUNDANCE OF THE LASSA VIRUS RESERVOIR, *MASTOMYS NATALENSIS*, IN THE EASTERN PROVINCE OF SIERRA LEONE

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Lassa fever is a severe hemorrhagic illness caused by Lassa virus, which is transmitted to humans primarily by contact with the excreta or blood of *Mastomys* rodents. Current recommendations to reduce *Mastomys* abundance in homes include improved food storage and removal of rodents by trapping or poison. It is unknown if house construction influences *Mastomys* infestation or if improved house construction is an effective control. For this study, two villages (<100 houses) and two towns (>200 houses) were sampled during the dry season in the Eastern Province of Sierra Leone, an area of high Lassa fever incidence. Household features including construction type and refuse location were documented, and knowledge of Lassa fever was assessed in one resident per household. To date, 142 houses have been sampled 102 in villages, where all homes were included, and 40 in towns, where homes were sampled in

two transects along the town perimeter. Three of the study sites had a laboratory-confirmed case of Lassa fever within two weeks prior to site visit, and rodent tissue was collected for further studies. A total of 224 small mammals were trapped in 2,909 trap nights (overall trap success [TS]=7.7%), including 162 *M. natalensis* (*M. natalensis* TS=5.6%), 55 *Rattus*, 6 *Crocidura*, and 1 *Mus*. Absolute number and TS of *M. natalensis* was similar between villages and towns. In a linear regression model, *Mastomys*-specific TS was correlated with the number of rodent burrows observed in homes ($t=2.62$, $p=0.01$). Wall and roof type were not associated with *M. natalensis* TS, however, type of floor construction did approach significance ($t=-1.84$, $p=0.068$). This relationship may be elucidated as we accrue a larger sample size in this ongoing study. *Mastomys* are burrowing rodents and the number of burrows observed may serve as a rapid indicator of *Mastomys* abundance and Lassa fever risk, as suggested by previous investigators. The ability of *Mastomys* to burrow in dirt floors may determine their capacity to infest houses, and promotion of cement floors may be a valuable control measure.

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ANTIMALARIAL ANTIBODIES ARE GOOD MARKERS OF PRIOR EXPOSURE BUT NOT PROTECTION AGAINST SUBSEQUENT MALARIA IN CHILDREN IN KAMPALA, UGANDA

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Individuals in malaria-endemic regions develop antibodies against multiple parasite antigens, but associations between antibody levels and protection against subsequent malaria remain uncertain. We enrolled a cohort of 438 children aged 1-10 from a region of Kampala where malaria incidence was previously found to be heterogeneous, with those living near a swamp having 4 times the incidence of those living 200 meters away. Children were treated for all episodes of malaria and monitored every 30 days for asymptomatic parasitemia. Plasma samples were collected at least 180 days after enrollment. For children with at least 1 year of follow-up after sample collection, IgG responses were assayed via ELISA to *P. falciparum* circumsporozoite protein (CSP), liver-stage antigen 1 (LSA1), merozoite surface protein 3 (MSP3), 3 variants of merozoite surface protein 1 (MSP1), and 2 variants of apical membrane antigen 1 (AMA1). Responses to different antigens were analyzed for associations with antecedent environmental and host factors, and for associations with subsequent malaria incidence. Overall antibody prevalence ranged from 12% (CSP) to 29% (AMA1). Increasing age, residence within 25 meters of the swamp and a shorter interval between last documented parasitemia and the time of plasma collection were all significantly associated with higher levels of antibodies to all 5 antigens in multivariate analysis. Higher antibody levels significantly predicted higher incidence of subsequent malaria after adjustment only for age (incidence 6%-16% higher per doubling of antibody level), but not after adjustment for age, prior malaria incidence, and distance from the swamp. In summary, IgG levels to 3 blood-stage and 2 pre-erythrocytic antigens were all markers of prior parasite exposure, but they did not predict protection against subsequent malaria. The relationship between antimalarial antibodies and subsequent malaria incidence may be confounded by heterogeneous exposure to parasites.