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Follow up study to assess the use and performance of household water filters in Zambia

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Effective household water treatment has the potential to improve drinking water quality and prevent diarrhoeal disease if used correctly and consistently over time. We previously conducted a randomized, controlled trial of water filters among households in Zambia with children under two years of HIV-positive mothers. One year after completion of the trial, we conducted a follow up study to assess use and performance the household filters. Ninety percent of participating households met the criteria for current users, and 75% had stored water with lower levels of faecal contamination than source water. Although this study provides some encouraging evidence about the potential to maintain HWTS use and performance, further research is necessary to assess whether these results can be achieved over longer periods and with larger populations.

Introduction

Unsafe drinking water, inadequate sanitation, and hygiene are major causes of diarrhoeal death and disease, especially for young children and people living with HIV/AIDS (PLHIV) (Mermin, Lule et al. 2004; Stark, Barratt et al. 2009). Our previous research in Zambia found that children <2 years born to HIV-positive mothers are particularly at risk of diarrhoeal disease (Peletz, Simuyandi et al. 2011).

Improving household drinking water quality through household water treatment and safe storage (HWTS) has been shown to have the potential to significantly reduce diarrhoeal disease (Fewtrell and Colford 2005; Clasen, Roberts et al. 2006; Waddington and Snilstveit 2009). However, there are questions about whether HWTS interventions are used correctly and consistently over an extended period of time (Arnold, Arana et al. 2009; Hunter 2009).

We previously undertook a 12-month randomized controlled trial (RCT) among 120 households with children <2 years (100 with HIV-positive mothers and 20 with HIV-negative mothers to reduce stigma of participation) in Chongwe District, Zambia to assess a HWTS intervention (Peletz, Simunyama et al. 2012). The HWTS intervention consisted of the filtration technology LifeStraw Family® filter combined with two 5 liter local jerry cans for safe storage (Peletz, Simunyama et al. 2012). Households were followed up monthly to evaluate intervention use, drinking water quality (measured by thermotolerant coliforms (TTC), a faecal contamination indicator), and reported diarrhoea (using a 7-day recall) among children <2 years and all household members.

In the RCT, we found that filter use was high, with 96% of household visits meeting the criteria for users. The filters were also microbiologically effective, reducing faecal contamination by 99.4% and providing intervention households with significantly improved water quality compared to control households (geometric mean of 3 vs. 181 TTC/100 mL, respectively, $p < 0.001$). The intervention was association with 53% reductions among children <2 years and 54% reductions among all household members. At the end of the RCT in August 2011, the control group received the intervention (filters and storage containers and the manufacturer's instructions for use and maintenance) and the intervention had the option of having their filter replaced with a new one.

We undertook this follow up study to assess filter use and microbiological performance one year after completion of the RCT study.

Methods

Study population and recruitment

All 101 households that completed the RCT were eligible to participate in the follow-up study. Participants that completed the RCT were recruited though unannounced household visits where they were informed about the follow up study and asked for written consent. If they consented, we proceeded by conducting a household questionnaire, observations and collecting water samples, as described below. The follow-up study consisted of one unannounced visit during October-November 2012, just over one year following completion of the RCT.

Filter use

Filter use and acceptability were assessed using household questionnaires and observations similar to those employed in the RCT. Households were classified as "reported users" if all three of the following conditions were met: i) the filter was observed in the household at the time of visit, ii) the storage vessel contained water reported to be treated at the time of visit, and iii) the respondent reported using the filter on the day of or day prior to the day of visit.

Households were classified as "confirmed users" if, in addition to these three criteria, there was at least a 1 $\log_{10}$ (90%) improvement in TTC in their stored household water over their unfiltered water, or stored water quality was < 10 TTC/100 mL. Householders were classified as "exclusive users" if they did not drink any unfiltered water the day of and day prior to the visit, as reported by the mother.

Microbiological performance

Filter performance was evaluated through bacteriological water testing, using the same sampling and analytical methods employed in the RCT. For each household, up to three samples were collected: i) unfiltered water stored in the home (influent water), ii) filtered water immediately after filtration (effluent water), and iii) stored water that the household reported to be filtered, if available.

Samples (125-mL) were collected in sterile Whirl-PakTM Bags (Nasco International, Fort Atikinson, WI, USA) containing a tablet of sodium thiosulfate to neutralize any disinfectant, placed on ice, and processed within 4 hours of collection to assess levels of TTC/100 mL at the University Teaching Hospital, Zambia. We assessed TTC levels using membrane filtration with membrane lauryl sulphate medium using a DelAgua field incubator (Robens Institute, University of Surrey, Guildford, Surry, UK).

Ethics

Ethical approval for this follow up study was obtained from the Ethics Committee of University of Zambia. Ethical approval from London School of Hygiene and Tropical Medicine was covered under our RCT ethical approval. Informed, written consent was obtained from all participants.

Results

Study population

Of the 101 possible households that completed the RCT, 93 (92%) households participated in the follow up study. Of the eight households that did not participate, six former participants had moved, one mother had died, and one mother refused to participate. The 93 households that participated in the follow up included 76 households with HIV-positive mothers; the remainder were HIV-negative mothers. Further details on demographics are reported with the RCT results (Peletz, Simunyama et al. 2012).

New filters had been received by 97.8% (91/93) households in August 2011 at the end of the RCT. Two households in the intervention group elected to keep the filter they used during the trial rather than have it replaced.

Filter use

Most households were using the filters. Overall, 90.3% (84/93) of households were classified as reported users and 72.0% (67/93) of households were classified as confirmed users as determined by microbiological water quality results. Exclusive use was reported by 87.1% (81/93) of mothers and 86.2% (75/87) of children. Use did not vary significantly between the original RCT intervention and control groups (p=0.23).

Five households did not have the filter set up for use at the time of visit. Storage containers that were provided during the RCT were used in 70.5% (65/93) of households; the primary reasons for not using the storage containers provided were that they were stolen (12 households) or that the container was broken (8 households).

Water quality

Unfiltered water samples were collected in all households. Filtered samples and stored filtered samples were each collected in 93.5% (87/93) of households. Stored water samples were of better quality compared to unfiltered water samples in 75.3% of households. However, stored water samples were significantly more contaminated compared to samples taken just after filtration ($p<0.0001$), indicating household contamination of stored water. The geometric mean removal from influent (unfiltered) to effluent (filtered) was 2.0 $\log_{10}$ TTC/100 mL, corresponding to a 99.0% reduction.

Conclusion

In a follow up study among households that received water filters more than one year before following participation in a RCT, the majority of households were using the filters and benefited from improved drinking quality. Microbiologically, the filters continued to perform well, removing an average of 99% of faecal indicator bacteria. Results on filter use and microbiological results are encouraging in terms of project sustainability.

Evidence suggests that the potential health benefits offered by effective HWTS are not possible in the absence of correct, consistent and sustained use of HWTS. This follow up study provides some encouraging evidence about the potential to maintain high uptake and filter performance even in the absence of regular household contact by researchers or implementers. This study is particularly relevant for Kenya, where LifeStraw Family filters were distributed as part of an integrated HIV testing campaign (Lugada, Millar et al. 2010). Further research is necessary to assess whether these results can be achieved over longer periods and with larger populations.

Disclosure of interests

This research was funded in part by Vestergaard-Frandsen SA, the manufacturer of the LifeStraw Family Filter used in the intervention. Rachel Peletz and Thomas Clasen have performed research and consulting services for Vestergaard-Frandsen. Vestergaard-Frandsen had no role in study design, data collection and analysis, or writing up results.

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