RESULTS FROM COLLABORATIVE RESEARCH ON HOUSEHOLD WATER TREATMENT AND SAFE STORAGE TO REDUCE MORBIDITY AND MORTALITY DUE TO WATERBORNE DISEASES AMONG RURAL WOMEN AND CHILDREN IN TANZANIA

EXECUTIVE SUMMARY

BACKGROUND AND RATIONALE

Diarrhea is a leading cause of death in Tanzania contributing 5% to 16% reported deaths among children less than 5 years of age. The burden of diarrhea has remained steady over the last decade despite achievements in reducing child mortality from infectious diseases such as Malaria and other neonatal conditions. The high rates of morbidities and mortalities due to the disease continue to pose risks to child survival thereby challenging the national progress towards meeting Millennium Development Goal 4. Apart from direct morbidity and mortality due to disease consequences of diarrhea include impairment of nutritional absorption leading to malnutrition and growth retardation in children.

Control of diarrhea and other feacal oral diseases is hampered by prevailing low access to safe water, poor sanitation and hygiene, and high prevalence of feacal oral pathogens infestation. About 50% of rural and 30% urban population do not have access to improved sources of water. A recent survey done in Geita by Malebo and others (2013) revealed further that 83% of improved water sources are feacal contaminated. Given the high risk of fecal oral diseases transmission, there is compelling need to expand delivery of high impact primary preventive interventions complementary with advancing secondary preventive measures to control diarrhea such as fluid replacement and zinc treatment. Household water treatment and safe storage (HWTS) interventions has potential to reduce up to 50% of diarrhea episodes where access to water from safe sources is low. The intervention is therefore appropriate in rural Tanzania.

In 2009 the ministry of Health and Social Welfare committed to adoption of HWTS interventions in the control of diarrhea. However there was a gap in evidence base to demonstrate the potential for success of a country wide program in achieving intended impact on health. This study was therefore adopted to address fundamental questions regarding scaling up HWTS in Tanzania context.

The National Institute for Medical Research was commissioned to undertake field research in collaboration with the Ministry of Health and Social Welfare, Ministry of Water, Muhimbili University of Health and Allied Sciences and external advisors from London School of Hygiene and Tropical Medicine and University of California Barkley. The project was entirely funded by UNICEF country office, Tanzania.

OBJECTIVES

Overall goal:

To strengthen the government of Tanzania's knowledge and capacity in providing effective guidance on household water treatment and safe storage; through collaborative HWTS research to reduce morbidity and mortality due to waterborne diseases of poor rural women and children in Tanzania.

Sub-project objectives:

Sub-project 1 – Chlorination and turbidity

To inform authorities and the population about the latest evidence based research concerning applicability of chlorination at different turbidity levels.

Sub-project 2 – Effectiveness of promotion and delivery strategies for HWTS

To assess successful and unsuccessful delivery and promotion approaches, which have been rigorously evaluated in other settings for promoting HWTS locally and at scale and to assess their effectiveness, cost-effectiveness, and potential for scalability in the Tanzania context.

Sub-project 3 – User preferences for HWTS

To introduce household water treatment and safe storage methods, and selected hygiene practices, and assess a number of key variables, in order to recommend their suitability for use in rural communities in Tanzania. Main variables: User preference; willingness to pay; ability to pay / affordability; adoption, correct and consistent usage; gender and poverty influences on the variables; and adherence to hygienic practices (hand washing with soap, drawing and cleaning practices) whilst utilizing the HWTS approach.

METHODS

The study was conducted in two districts of Kisarawe in Pwani Region and Geita in Geita Region (Formally part of Mwanza region). The two districts represented a large cultural diversity between coastal and inland areas and variations in water sources. Four rural villages took part in the study two from each of the districts.

This was a prospective open label field trial involving delivery of HWTS package and hygiene education. Specific HWTS options were delivered through a cross-over arrangement in which each participating household tested 4 of 7 technologies one round of use each. One of the HWTS options were assigned for each of the four rounds of product evaluation in a randomly decided sequential order. The HWTS technologies studied were consumables (liquid chlorine (WaterGuard liquid), chlorine tablets (WaterGuard tablets, or Aquatabs), and PUR) and durables (boiling over cooks stoves, ceramic pot filter and ceramic siphon filter).

Figure 1: Community level mobilization and education session in Kisarawe

The project used educational techniques aimed at engaging the participants in information exchange, through which they received information about water borne diseases and prevention.

Households were given HWTS products free of charge at the start of the rounds with instructions on how to use them. Participants were then, asked to share their own experiences in HWTS products use water and waterborne diseases. Information on households' use of delivered options, their preferences, and Willingness to pay was collected by field enumerators employed by the project.

Figure 2: Interpersonal education session in Geita District

Analysis of relation between turbidity and chlorination was done by collecting raw water from sources and households. Water samples were treated with conventional chlorine sources by applying recommended doses. Free residual chlorine wasted after 30 minutes and 24 hours in accordance with standard requirements. Microbial efficacy of water treatment options was ascertained by collecting samples of untreated water at households and the water that was treated by the assigned methods in order to measure change in microbial load after treatment. Determination of human feacal coliform counts was done using membrane filtration techniques followed by incubation using Del Agua field testing Kit.

Literature review was conducted to describe some study components particularly in describing and development of behavior change strategy. We addressed study components requiring testing of physical and chemical through laboratory and field based experiments set up to address specific objectives.

RESULTS

Demographic characteristics

A total of 604 households were enrolled in the study of which 306 and 298 were from Kisarawe and Geita districts respectively. Participants were household heads or spouses with mean age of 36years for Kisarawe and 40 years Geita residing in rural areas. The median reported monthly income was $13 for Kisarawe and $19 in Geita.

Water quality and access

Water sources used in the two districts are summarized in Figure 3 indicating the level of access to clean water. Majority of households used public dug wells which were often unimproved.

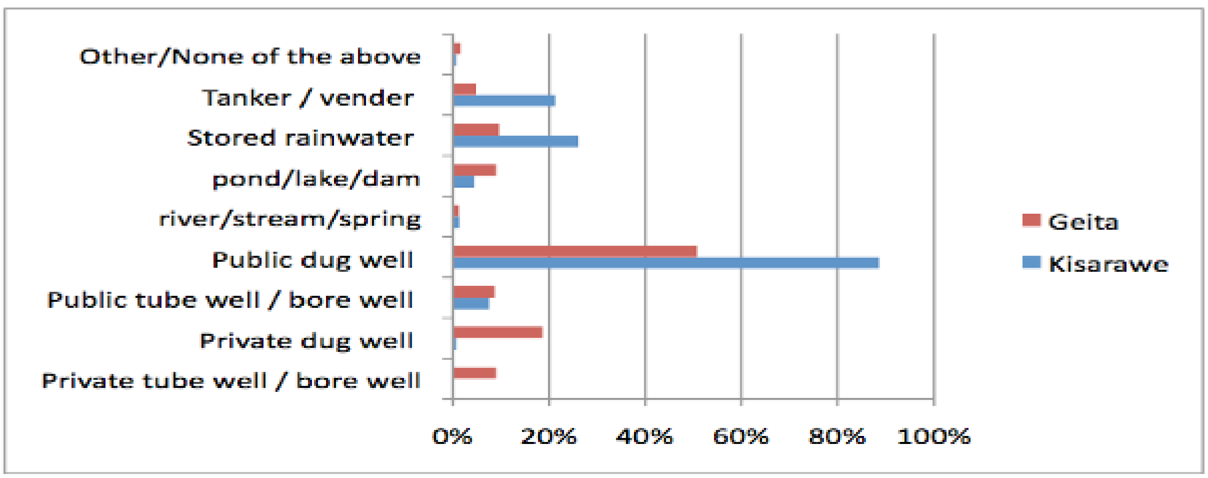

Figure 3: Access to water sources by study district

A large proportion of dug wells in Kisarawe were “milky” all year round; dug well usage increased during the dry season in both districts. Measured turbidity levels correspond well with the reported physical appearance of water. Water from source and households in Kisarawe had significantly higher turbidity than from sources and households in Geita (Figure 4). Mean concentration for Ammonia, Nitrate, Nitrite, and Iron were 0.477mg/L, 0.237mg/L, 0.006mg/L, and 0.697mg/L respectively, measured in Kisarawe sites only.

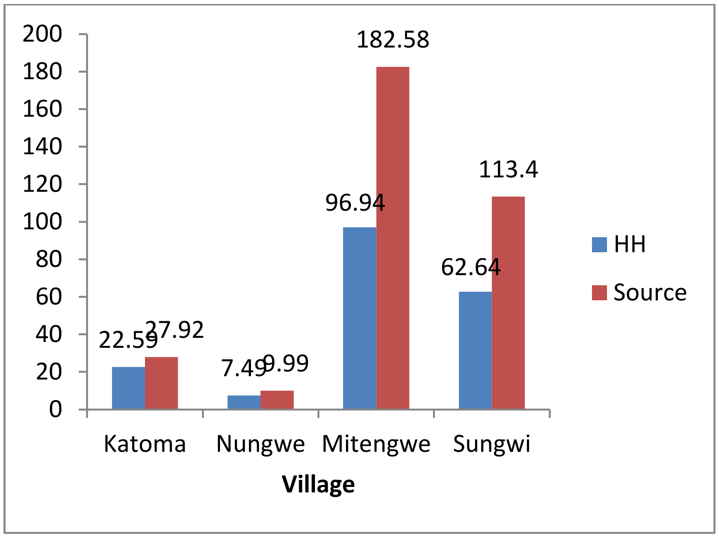

Figure 4: Measured turbidity of water at source and households by study villages

Relationship between chlorination and turbidity

Turbidity of water was measured 30minutes and 24hours after chlorination. When regular dose(1.875 mg/L)of chlorine was used for treatment of water target residual chlorine levels 0.5 – 2mg/L in 30minutes and at least 0.2mg/L in 24 hours were attained for low turbidity levels up to a maximum range of 10 to 20 NTU. When liquid water guard was used at a dose of (3.75 mg/L) target residual chlorine levels were attained for low turbidity levels up to a maximum range of 30 to 50 NTU. The use of single tablet aquatab (equal to 1.875 mg/L) yielded similar results to liquid chlorine achieving target chlorine levels for water up to turbidity range of 10 to 20 NTU. However double dose aquatab (two tablets) met the target chlorine residual for all ranges up to 100NTU.

User Preferences on HWTS methods

Less than 20% of household reported to treat water using any method at baseline. Usage of household water treatment methods rose to 80 – 97% in Kisarawe and 80 - 90% in Geita. During the final evaluation 93 -95% of households in Geita and up to 90 – 99% in Kisarawe reported to treat their drinking water using one of the promoted methods. There was strong preference for two HWTS options namely; boiling and the ceramic pot filter. PUR, WaterGuard Liquid, and

WaterGuard Tablets were deemed recommendable by 47%, 40% and 35% of households in Kisarawe, respectively. These rates were only slightly lower than those for boiling and the pot filter. There was marked contrast between commendation for HWTS in Geita, where lower proportions of households stated that they would recommend PUR, WaterGuard Liquid and WaterGuard Tablets; this was much lower than the for boiling and pot filter found in Geita. The siphon filter fared poorly in both districts; 21% recommending it in Geita and only 11% in Kisarawe.

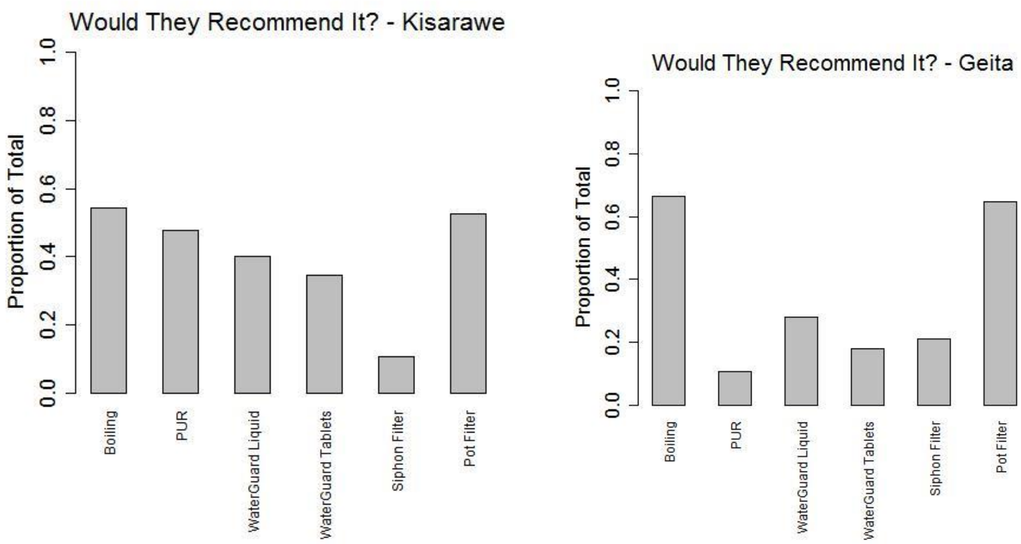

Figure 5: Expressed user preference through neighbor commendations

Seventy nine percent of all respondents ranked boiling as first or second best overall, in Geita: likewise 72% in Kisarawe. Of the households that used the pot filter (roughly half of the sampled houses overall), 59% of all households ranked it as first or second best overall, in Geita, and 58% in Kisarawe. PUR, WaterGuard Liquid and WaterGuard Tablets were all strongly disliked in Geita; WaterGuard Liquid and WaterGuard Tablets were less often rejected in Kisarawe but were still unpopular. PUR was strongly liked in Kisarawe, a much different outcome than in Geita, which may have been due to the much higher prevalence of “milky” water in Kisarawe than in Geita.

Willingness to Pay for HWTS options

WTP for the consumables HWTS (PUR, WaterGuard Liquid, WaterGuard Tablets) were, on average, half of the retail price. For PUR the median bid was half the retail price and for WaterGuard Liquid and WaterGuard Tablets it was roughly 1/3 of the retail price (the median representing what 50% of the participants are willing to pay). Since the filters were durable household products their bid prices were much higher, but the average and median bids represented a much smaller percentage of the retail price; the median bids for the siphon filter and the pot filter were 7% and 11% of their retail prices, respectively. This indicates that either more affordable versions of the HWTS will be necessary for scale up, or else subsidies will be needed if scale up is pursued. In the case of the pot filter, subsidies of 90% may be necessary for scale up.

Microbial efficacy of HWTS options

A total of 1,202 raw and treated water samples were analyzed for thermo-tolerant coliforms to test for microbial efficacy of treatment options at household level. Overall microbial reduction (in percent) ranged between 69% and 98% (See Figure 6). Efficacy levels attained in Geita District were higher than in Kisarawe.

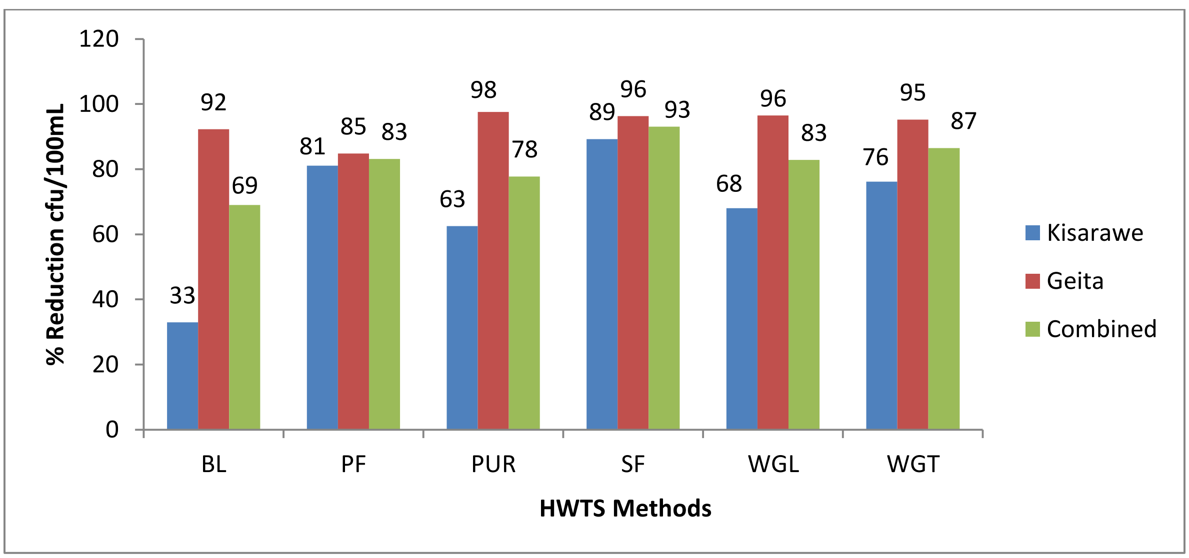

Figure 6: Microbial performance of HWTS options by districts (%)

Results from microbial efficacy studies show that the HWTS tested in this research have potential to achieve adequate microbial efficacy to for protection against waterborne diseases.

However microbial efficacy levels of even the well-known methods like boiling can be impaired by unsafe handling and storage of water after treatment. This signifies the need to combine HWTS options with adequate efficacy with safe storage devices along with appropriate hygiene education to members of the households.

OTHER OUTPUTS FROM PROJECT WORK

Further to compilation of direct research results the project has produced other outputs that emanated from implementation of research activities including;

Figure 7: A finished Takasa Maji product

Development of framework for HWTS promotion: This is a detailed description of model approach to promoting HWTS methods at community level that aims at achieving sustainable adoption, correct, and consistent use of HWTS options and drinking treated water by members of communities. The framework is made of two main parts describing the behavior change approach as well as equipment and product supply chain. The draft framework is recommended for adoption by the Government during scaling up of HWTS countrywide. The framework was developed through literature review and was adopted in HWTS promotion during field research where its relevance was tested.

IEC materials package: The materials were developed to facilitate communication at community as well as interpersonal level. IEC materials for promoting HWTS and hygiene practices were developed, field tested, and further revised by incorporating lessons learned during project implementation period. The materials can be used at diverse communities targeting multiple audiences including women and children.

Innovative HWTS products development:

Development of combined Chloro-floc product was done through series of testing and dose optimization experiments. This led to development of a treatment product named TAKASA MAJI. The new product use materials that are available in country including organic Chitosan extracted from marine crab shells. The product has a good potential for reducing overall cost of water treatment for rural households and address the challenge of treating turbid water through single step treatment process.

Safe Storage container: A storage vessel was developed to address water retention needs and compatibility with ceramic pot filter. The vessel ended up being a well preference water storage option in study villages. Scientists from NIMR Safe water project worked with members of the ceramic filter manufactures, UNICEF, and plastic factory to develop and produce the pot. The project also provided water drawing tap to buckets which were used as safe storage containers with other treatment options. Female participants reported that the water drawing mechanism works well in developing positive water protection behavior among children.

Capacity building through training: Safe water project supported four students 1 international and 3 local postgraduate student. Local students include 1 PhD candidate (Mr. Hussein Mohamed) who is doing his full PhD studies with publication. The PhD student is registered with Ardhi University to address varieties of water quality challenges, particularly treating turbid water at household level. Two Masters level students Ms. Aneth Sisya (University of Dar Es Salaam) and Dr. Rita Mutayoba (Muhimbili University of Health and Allied Sciences) were attached to Safe Water Project at NIMR Mabibo where they respectively conducted technical analysis related to water. Students work has made a substantial part of the this project output and in turn their involvement to this work has developed their technical capacity to address water safety challenges and cultivated interest to work in water safety promotion.

Figure 8: A Pot filter system with new container in Gaita District

CONCLUSION

1. Single dose chlorination of drinking water without pre-treatment leads to adequate chlorine residuals only in water with turbidity not exceeding 10NTU

2. When liquid Watergard is used as chlorine source, double chlorine dose leads to adequate residue chlorine for water with turbidity not exceeding 30NTU.

3. When tablet (Aquatab) is used as chlorine source, double chlorine dose can lead to adequate residue chlorine for water with turbidity up to 100NTU.

4. Turbidity of water sources varies significantly between communities and between seasons. The variability in turbidity is significant enough to affect operations of water treatment options. Water in Geita can be treated by various water treatment methods even without pre-treatment, while in Kisarawe, water should undergo pre-treatment such as settling or use of flocculent before being subjected to treatment

5. Storing water at the household (settling) lowers the turbidity of water.

6. Normal dosage of chlorine (1.875 mg/L) operates optimally within a limited range of turbidity (not exceeding 10NTU). Increasing the dose to double the regular dosage may help to attain minimum residual concentration but only within turbidity range not exceeding 30NTU. However increasing chlorine dose to double may lead to spiking levels of residual chlorine that may lead to objectionable dour thereby discouraging usage.

7. When correctly delivered with appropriate educational package HWTS methods deployed in this study have been readily accepted and used correctly by households in rural areas in Tanzania. Hence there is marked potential for sustainability if the methods will be scaled up accordingly.

8. Boiling and pot filters were the most widely preferred methods by members of households, however there has been considerable variation in preference for use of different HWTS options within community, so much that none of the technologies can be dismissed for deployment in community and that even the most preferred methods may not be as viable when delivered on alone.

9. Community members have demonstrated a high level of willingness to contribute towards purchasing HWTS products of their preference. However, the monetary value offered covered only half the prices for consumables and as low as 5 to 10% of high upfront cost durable equipment. The overall offers for purchases of consumables did not exceed Tsh. 500/-.

10. All the HWTS methods promoted in Geita and Kisarawe have maintained high efficacy against indicator microorganisms (Thermo-tolerant E. Coli) in field conditions. Each of them has achieving removal of at least 70% from initial microbial load.

11. Our results suggest that Siphon filter have had the highest overall microbial efficacy despite low preference accorded to it by users, followed by Water Guard and PUR. Users' preferences therefore are not guided by efficacy levels but other factors such as organoleptic properties of water and operational convenience.

12. Filtration methods have shown to be most stable in terms of maintaining microbial efficacy given the variations in physical chemical properties of water, microbial load, and hygiene practices between study sites.

13. Chlorine based products (Water Guard) have shown to have relatively high microbial efficacy despite the wide variation in physical chemical properties of raw water.

14. There is high risk of recontamination of water after treatment due to post treatment water handling; this is evident from the observed low microbial efficacy levels achieved by Boiling in Kisarawe.

15. Three main factors affecting microbial efficacy of water treatment options at household levels were identified as high water turbidity, unhygienic handling of water following treatment, and safe storage containers (including the type of container and the way it is linked to the treatment process).

RECOMMENDATIONS

1. The six HWTS options are recommendable for promotion in Tanzania communities based on their acceptability by communities and microbial performance. However, deployments of the methods must be done with technical advice that will take into account existing water quality situations.

2. HWTS options that must be regulated in order to maintain high level of microbial efficacy, this include methods imported as well as those that are produced in country in order to meet accepted health impact.

3. Assessment of physical chemical properties of water should be done in order to recommend the most suitable technologies for specific localities. Because microbial efficacy of water treatment technologies is affected by physical chemical properties of water, particularly turbidity. This must be accompanied by developing local capacity to perform at least physical chemical analysis of water at district level.

4. Hygiene education must include post treatment handling of water as it presents a major risk factor for recontamination of already treated water. Water treatment technologies must be provided together with safe storage containers in order to safeguard the already treated water. Safe storage containers should be linked as close as possible to water treatment processes in order to minimize human contact with water after contamination.

5. Chlorine based product particularly Water Guard should continue being promoted even where the water turbidity is relatively high but with additional information promoting

pre-treatment measures that will help to reduce turbidity. This is because chlorination methods have been shown to maintain relatively high level microbial efficacy even where water turbidity is high.

6. HWTS methods must be promoted using acceptable educational packages in order to attain reasonable uptake, correct, and consistency of use.