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WATER, SANITATION, ENVIRONMENT and DEVELOPMENT
Chlorinating household water in The Gambia

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Abstract

This study investigated the feasibility of providing safe drinking and cooking water by in-home chlorination of household water jars (HWJ). Open well water quality was measured in the dry and rainy season and found acceptable for chlorination. Rural village women were taught to dose their HWJs with a diluted household bleach solution to give an organoleptically acceptable dose of 2.0 mg/L chlorine. This dose eliminated fecal coliforms within 30 minutes and protected stored water for 24 hours. A 22 village double blind randomized intervention trial was carried out over a rainy season. No effect of HWJ chlorination on the incidence of diarrhea was detected. A trend was revealed that for children 6-24 months, villages which chlorinated the HWJs did not suffer a significant decrease in the village mean weight-for-height Z-score as compared to control villages (p =.1170). In children 6-24 months and also 25-60 months, the control group suffered a significant increase in the proportion of malnourished children (p=.0002); whereas the intervention group did not experience a significant increase (p=.1000). The study concluded that women chlorinating their HWJs may be an appropriate avenue of providing safe drinking and cooking water in rural communities.

Introduction

It is common knowledge that when people must go outside of their homes to obtain water, they will store it in a household water jar. In general water supply programs have emphasized protecting the water source while neglecting the HWJ. An incorrect assumption has often been made by water providers that the quality of water from the source was the quality of water consumed, when in fact testing of stored water has consistently shown it to be fecally contaminated, even when collected from a safe source (Feachem et al, 1978; Ryder et al, 1985; Lindskog & Lindskog, 1988). Thus there is an urgent need to include the HWJ in water supply programs. Targeting the HWJ may include changes in design, changes in behaviour, or disinfection. The present paper is the first report on the provision of safe water in rural villages based on disinfecting household drinking and cooking water in the HWJ.

After preliminary studies on well and HWJ quality, an appropriate chlorine dose was determined, village women trained, and on intervention trial carried out. The trial assessed the efficacy of HWJ chlorination on diarrheal

morbidity and change in weight-for-height Z-score (WHZ) in children over a rainy season. The study sought to determine if household water chlorination could be recommended as a feasible, practical, cost effective means of providing safe water to rural residents of The Gambia. This work was carried out in 1990 and 1991.

Materials and methods

The study utilized small rural villages in one contiguous area of the Upper Baddibu District in the North Bank Division, The Gambia. All 22 communities in the study area whose primary source of drinking water came from open wells were included. In preliminary studies, the chemical, physical and microbiological quality of water from a sample of wells and HWJs was investigated, using standard testing procedures. The reaction of bleach (sodium hypochlorite) in the earthen HWJ was elucidated and organoleptic testing carried out to select an acceptable chlorine dose.

Village sensitization was performed in a series of meetings to explain the study objectives and methods; consent was given by each village. Next a sociodemographic census of all the compounds and households was performed. Each village was randomly assigned to either a control group or an intervention group. Comparability of the two groups of villages was assessed utilizing the sociodemographic census data. Each woman responsible for collecting water was given a 100 mL amber glass bottle, with childproof cap, and a plastic pasteur pipetree, clearly marked at the 1 mL point. Household bleach purchased locally was diluted to give a 2.5% (25,000 mg/L) chlorine solution. On collecting water, women were taught to put 2 mL into their standard 25 L plastic water collecting bucket, to give a chlorine dose of 2.0 mg/L. The water was then stirred and poured into their drinking and cooking HWJs. If the HWJ was more than half full on the following day, then an additional dose of 1 mL of the bleach solution was to be added. The training in all villages was the same. A placebo of sterile water was substituted in control villages.

The intervention study was carried out over a 20 week period, covering the 1991 rainy season. Fresh chlorine solution was delivered bi-weekly. Outcome indicators were the weight-for-height Z-score (WHZ) of children 6-24 months and 25-60 months, and their diarrhea incidence. Diarrhea was logged daily on a validated home-based recording form by the mothers, using their definition of diarrhea. Compliance was monitored by measuring

chlorine residuals daily in a subset of villages, and spot testing for hydrogen sulfide producing bacteria and fecal coliforms in randomly selected HWJs in all villages. The study was planned to meet the methodological requirements of Blum and Feacham (1983) and the internal validation criteria of Esrey et al (1985) and Esrey and Habicht (1986).

Results

Water quality from open wells was acceptable for chlorination. Open well water was slightly acidic (pH 6.0-6.5), had a low buffering capacity, and highly corrosive. Ammonia was negligible and mean nitrate only half the WHO guidelines. The true colour (16 TCU) was at the WHO limit and turbidity averaged 23NTU, about five times above the WHO limit (WHO, 1984). Temperature was in the range 27° to 30°C. All well samples were contaminated and showed a mean fecal coliform level of 1871/100 mL (n=94); the one hour chlorine demand was 0.67 mg/L. Change in seasons did not significantly affect open well water variables. After 24-48 hours, water stored in the typically used HWJ contained a mean fecal coliform level of 3358/100 mL (n=52) in the rainy season and 1014/100 mL (n=32) in the dry season; 95% of HWJ samples were fecally contaminated. After reacting with the immediate chlorine demand, a dose of 2.0 mg/L dissipated slowly and continuously in the HWJ over a 24 hour period to an unsafe residual level below 0.2 mg/L. Factors affecting the rate of disappearance included the source well water quality, HWJ volume (i.e. reaction with earthen side), and chlorine demand introduced during storage. Under typical village conditions, 2.0 mg/L chlorine dose was sufficient to eliminate fecal coliforms within 30 minutes and to maintain microbiologically safe drinking water for 24 hours, even when high turbidity was present.

In the intervention study, an analysis of data aggregated by village showed that for both age groups, the mean diarrhea days per child was not significantly different between the two groups of villages. Although not significant at the 5% level of confidence, village mean weight gain was 27% higher in the villages chlorinating their HWJs for both age groups. Pre- and post- rain WHZ was compared in each village by a Paired t-test. The proportion of villages having a significantly lower post-rain WHZ was then compared using Fisher's Exact Test. In the younger age group fewer intervention villages had a significant decrease in WHZ at the 88% confidence level (1-tailed p-value = 0.117).

To increase statistical power, an analysis was performed of disaggregated data using each child as the unit of measure. The subset of malnourished children (i.e., WHZ < -2.0 standard deviations) was identified in each village. The proportion of pre-rain and post-rain malnourished children was compared in a 2X2 contingency table. Within the control group there was a significantly greater proportion of malnourished children at the post-rainy season survey as compared to the pre-rain survey in both age groups: 6-

24 months p=.0002; 25-60 months p=.008. In contrast, there was not a significantly greater proportion of malnourished children in the post-rain survey for children drinking water from chlorinated HWJs. For both age groups the increase in the proportion of malnourished children in intervention villages was one-half that of control villages. Compliance monitoring revealed that on a daily basis, about 60% of intervention HWJs contained a chlorine residual or were microbiologically safe. The geometric mean fecal coliform level in 60 HWJs in 6 intervention villages was 178/100 mL, whereas in 30 HWJs in 6 control villages the level was 3020/100 mL.

Discussion

The study revealed that illiterate village women could properly dose their HWJs when given the proper training and supplies. Chlorinating HWJs at an organoleptically acceptable dose of 2.0mg/L provided safe drinking water for 24 hours. The evidence taken as a whole indicated that although a statistical association was not established between HWJ chlorination and improved village mean WHZ, a clear trend has been revealed in that direction. Chlorinating HWJs did prevent a significant proportion of children from becoming malnourished over the rainy season, particularly in younger children 6-24 months. The present study supports the thesis that water quality, not quantity, is more important to this younger age group.

There is evidence that chlorinating HWJs positively affected nutritional status, but no difference in diarrhea incidence was detected between study groups. This may be explained in two ways. First, the diarrhea surveillance instrument was not designed to reveal the intensity or severity of a diarrheal episode. For many enteric pathogens the severity of the diarrhea is related to the infecting dose. At the compliance level of the study, the dose of offending organisms may have been reduced such that diarrhea was present and thus recorded, but less severe. Or, the effect on nutritional status may have been independent of diarrhea (Stanton et al, 1988). Other factors which may have negatively affected the study results included:

1) other routes of transmission which masked the effect of HWJ chlorination,

2) a shorter than normal rainfall interval, in which over 90% of the rain fell in less than 12 weeks and a precipitation amount only two-thirds of the expected seasonal amount produced a lower than anticipated diarrhea incidence,

3) a lack of food availability, and

4) inadequate compliance level.

Although produced in Senegal and Mali, household bleach is generally imported from Europe and sold in town markets throughout The Gambia. To chlorinate one 50 L HWJ costs $0.002 per day, or $0.73 per year at current

retail prices. Bulk purchasing for a HWJ disinfection program would likely reduce this cost by half. Costs of a HWJ chlorination program would mainly consist of purchase/ distribution of disinfectant, educational programs on proper disinfection procedures, and related support and manpower requirements. Disinfectant could be distributed and sold using existing commercial outlets with a government-set price or within primary health care systems, utilizing the village health care worker. Multisectorial involvement with appropriate government departments, NGOs, and donor agencies could be encouraged and coordinated by the Department of Water Resources. Chlorination of HWJs is an appropriate strategy because household bleach is available and inexpensive, relies on existing open wells, involves the community as active participants (especially women), insures the ingestion of safe water by the entire household, and has a positive health impact on young children at risk of becoming malnourished over the rainy season. It is the hope of the author that agencies responsible for the provisions of safe water in developing countries will further explore HWJ disinfection.

Acknowledgements

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