The Impact of Sodium Dichloroisocyanurate Treatment on Household Drinking Water Quality and Health in Peri-urban Ghana: a Randomized, Double-blind, Placebo-controlled Trial

Osman K. Sahanoon, Seema Jain, Elizabeth Blanton, Ann Schmitz, Thomas Sayibu Imoro, Michael Hoekstra, and Robert E. Quick
Global Burden of Unsafe Water

- Diarrhea causes 1.8 million deaths per year
- Over 1 billion people lack access to safe water
- Fecally contaminated drinking water is a major contributor to diarrheal diseases
Safe Water System

Water disinfection with dilute sodium hypochlorite (bleach)

Safe water storage

Social marketing and community mobilization

NewEnergy
Safe Water System Results

• Reduces diarrheal disease risk 25-85% in randomized, controlled, published studies

• Liquid sodium hypochlorite
  – Produced locally
  – Shelf life of 1 year

• Successfully implemented in many countries
Sodium Dichloroisocyanurate (Chlorine Tablets)

- Alternative to sodium hypochlorite
  - Effective microbicide
  - Emergency use for years

- Potential advantages over liquid chlorine
  - Tablets are easy to ship
  - Shelf life of 5 years

- Field trials show acceptability and microbiological effectiveness
  - Lack of published health impact studies
Objectives

• Assess the acceptability of chlorine tablets

• Determine impact of chlorine tablets
  – Stored water quality
  – Diarrhea incidence
Tamale, Ghana

- Northern Ghana
  - Peri-urban population

- History of seasonal cholera outbreaks in the rainy season

- Compounds with multiple families
  - With at least one child <5 years old
Typical Compound
Study Design

- Randomized, double-blinded, placebo-controlled trial
- Baseline survey: Aug 2006
  - Census and demographics
  - Water, sanitation, and hygiene practices
- Twice weekly visits over 12 weeks during rainy season: Aug-Nov 2006
  - Asked about diarrhea and tested for free chlorine residuals
- Microbiological water quality testing
  - Random sample of 20% of compound drinking water samples for *E. coli* at baseline, midpoint, and end
  - Source water testing at the end
Study Intervention

- Compounds randomized into intervention and control groups
- All received standard 20L plastic vessel with metal spigot
Study Intervention

- Intervention group received chlorine tablets

- Control group received placebo tablets in identical packaging

- Neither study participants or investigators knew which tablets were chlorine vs. placebo
Instructions for Use

• Provided verbal and pictorial instructions

• Instructed compounds
  – Use vessel provided
  – Add one tablet to water
  – Wait 30 minutes before drinking

• No further information on water treatment or handling, sanitation, and hygiene was provided
Microbiological Water Quality Testing

• Compound water samples collected and transported to lab within 6 hours
  – Incubated at 35°C for 18-24 hr

• Tested undiluted, 1:10, 1:100 dilutions using Colilert®

• Estimated the most probable number of \( E. \, coli \) colonies per 100ml
Baseline Compound and Individual Characteristics

• Enrolled 240 compounds
  – 3240 individuals (median 12 persons; range 2-42)

• Median age of individuals was 18 years
  (range 1 month-95 years)

• 550 (17%) were children < 5 years of age

• 51% were female

• The two groups did not differ
## Baseline Water Handling and Sanitation Practices* (N=240)

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Percent (n=240)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Water source</strong></td>
<td></td>
</tr>
<tr>
<td>Water tap</td>
<td>95%</td>
</tr>
<tr>
<td><strong>Water storage</strong></td>
<td></td>
</tr>
<tr>
<td>Clay pot</td>
<td>72%</td>
</tr>
<tr>
<td><strong>Water treatment</strong></td>
<td></td>
</tr>
<tr>
<td>Sieving thru cloth</td>
<td>29%</td>
</tr>
<tr>
<td>Using alum</td>
<td>23%</td>
</tr>
<tr>
<td><strong>Sanitation</strong></td>
<td></td>
</tr>
<tr>
<td>Public latrines</td>
<td>84%</td>
</tr>
<tr>
<td>Open ground</td>
<td>42%</td>
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</tbody>
</table>

* More than one answer was possible
Percentage of Intervention and Control Compounds with $\geq 0.2$ g/ml of Free Chlorine by Surveillance Visit (N=240)
Source Water

- 99% of compounds used tap water throughout the study period
- Microbiological water quality testing on source water showed no contamination
## Percent of Water Samples with E. coli and Median E. coli Colony Counts in Control and Intervention Compounds (N=240)

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* Wilcoxon 2-sample Test
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* Wilcoxon 2-sample Test
Crude Diarrhea Incidence in Control and Intervention Compounds

- Diarrhea incidence = \( \frac{\text{Diarrheal episodes}}{\text{Total observations}} \times 100 \)

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<th>Total observations</th>
<th>Diarrheal episodes (%)</th>
<th>Control</th>
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<th>Diarrheal episodes (%)</th>
<th>( P )</th>
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<tr>
<td></td>
<td>40,751</td>
<td>441 (1.1)</td>
<td></td>
<td>40,252</td>
<td>490 (1.2)</td>
<td>0.71</td>
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Diarrheal Incidence Rates for Intervention and Control Groups by Visit Number (N=3,240)
Diarrheal Incidence Rates for Intervention and Control Groups by Visit Number (N=3,240)
Summary

• Adherence during the study period was high

• Use of chlorine tablets was associated with a significant decrease in *E. coli*

• Use of chlorine tablets not associated with a health impact

• Diarrhea rates were much lower than expected
Limitations

• Exclusive use of improved water sources specifically tap water due to heavy rains
  – No detectable contamination
  – Periodic chlorination

• All compounds given safe storage vessels
  – May have served as a water quality intervention in both groups

• Twice weekly visits may have improved hygiene practices in both groups
Conclusions

• Chlorine tablets are a promising method of household water treatment
  – Adherence high
  – Microbicidal effect

• Lack of demonstrated health impact

• Further study of health impact is warranted
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