Relative benefits of piped water supply over other "improved" sources: a case study from rural Vietnam

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IWA-4245: Singapore International Water Week, 29 June 2010

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Abstract

Access to improved water sources is rapidly expanding in rural central Vietnam. We examined one market-based, NGO-led, piped water supply program to assess the drinking water quality and health impacts of piped water systems where access to "improved" water sources (protected wells and rainwater harvesting) is already good. This longitudinal, prospective cohort study included 300 households in seven project areas in Da Nang province, Vietnam: 224 randomly selected households who paid to connect to one of seven piped water systems and 76 control households from the same areas relying primarily on "improved" water sources outside the home. The four-month study was intended to specifically measure the impact of the NGO-led water programs on households' drinking water quality and health and to evaluate system performance. Other observed water use and handling practices, including point-of-use water treatment by boiling, were also examined for possible associations with household drinking water quality and health. We found that: (i), households connected to a piped water supply had consistently improved drinking water quality over those relying on other, non-piped sources, despite inadequate centralized treatment; (ii), individuals in households with access to a piped water connection were at reduced risk of diarrheal diseases compared with households without a piped water connection (RR: 0.65, 95% CI 0.46 – 0.90); (iii), households paid less per month for water and reported greater satisfaction with the service over available alternatives; and (iv), boiling, while widely practiced, was not an effective household water quality intervention due to limited effectiveness in reducing *E. coli* (mean <90%) and no evidence of reduced diarrheal disease. Although a connection to a piped water supply offers measurable benefits to households at relatively low cost, maintaining water quality and ensuring consistent operation and maintenance represent ongoing challenges to local service providers.

Introduction

Overview of EMW GPOBA program
- World Bank supported scheme providing capital to finance community piped water projects (GPOBA)
- Purpose: to rapidly expand **safe** drinking water supplies
- System costs are offset by community participation
- **Full or near full cost recovery through tariffs** (metered connections)
- Managed by either community boards or for-profit cooperatives, O&M from tariffs
- Latrine construction financed by EMW with 15% rebate
- **30,000 households connected with 112 gravity-flow water systems so far**
  - 80% initial subsidy to systems
  - 200 or more households required
- People's committee (CPC) governance & oversight
- Village selection based on **demand and needs assessment** – areas targeted where per capita income <US$1 per day

Stated goal: **"To improve the overall living environment, and decrease the number of waterborne diseases"**

224 randomly selected households who paid to connect to one of seven piped water systems and 76 control households from the same areas relying primarily on "improved" water sources outside the home, primarily protected wells. The four-month study was intended to specifically measure the impact of the NGO-led water programs on households' drinking water quality and health and to evaluate system performance. Systems were constructed with community involvement.

Methods

- Random selection of eligible households connected to piped water and controls
  - Minimum group size for health impact study = 75 households to detect 30% difference in outcomes
  - Controls selected on basis of water source, SES, location
- Random selection of additional system households for stratification of water quality and other data across system types
- Total of **four visits** to each household, last visits in Sept 2009
  - Extensive first interview, brief follow-up surveys for changing covariates
- Extensive SES/other covariates
- System performance data, household water management
- Longitudinal data to estimates differences in disease between groups – diarrhea and other symptoms
  - 7 day recall
- Household water quality over time – *E. coli*, total coliforms, turbidity, free chlorine residual

Results

- No chlorine residuals detected at the household level (detection limit: 0.1 mg/l);
- Households connected to a piped water supply had consistently improved drinking water quality over those relying on other, non-piped sources, despite inadequate centralized treatment, occasional intermittent service, and limited monitoring;
- Individuals in households with access to a piped water connection were at reduced risk of diarrheal diseases compared with households without a piped water connection (RR: 0.65, 95% CI 0.46 – 0.90), most of whom used protected wells or rainwater harvesting;
- Connected households had greater access to water, paid less per month for water, and reported greater satisfaction with the service over available alternatives; and
- Boiling, while widely practiced, was not an effective household water quality intervention due to limited effectiveness in reducing *E. coli* (mean <90%) and no evidence of reduced diarrheal disease when compared with those who did not regularly practice boiling.

	Piped water	**Control**
Untreated household water (all sources)		
Mean *E. coli* per 100ml (cfu)	16 (13 – 18)	63 (47 – 84)
Mean TC per 100ml (cfu)	310 (260 – 370)	1,600 (1,200 – 2,100)
Arithmetic mean turbidity, all sources (NTU)	2.1 (1.9 – 2.3)	2.2 (1.0 – 3.3)
Boiled household water (all sources)		
Mean *E. coli* per 100ml (cfu)	11 (8.4 – 16)	17 (9.7 – 28)
Mean TC per 100ml (cfu)	50 (38 – 66)	100 (63 – 170)
% with boiled water in household at time of visit	91%	92%
Mean LRV of boiling, *E. coli*	0.71 (0.63 – 0.78)	1.1 (1.0 – 1.3)
Mean LRV of boiling, TC	1.5 (1.3 – 1.6)	1.9 (1.7 – 2.1)
% reporting intermittent service	100%	-
Residual chlorine in water	0%	0%

Diarrheal disease longitudinal prevalence, GEE	**Piped water**	**Control**
All people	0.026 (0.023 – 0.029)	0.034 (0.028 – 0.040)
Under 5s	0.066 (0.053 – 0.077)	0.029 (0.016 – 0.042)
Male	0.024	0.051
Female	0.020	0.021

Recommendations and next steps

Safeguarding water quality may result in greater health gains associated with small water systems. Possible next steps to address problems associated with water quality might be:
- A Water Safety Plan (WSP) approach to protecting water quality in piped systems;
- Exploration of alternative centralized treatment options, including NaDCC disinfection technologies;
- Exploration of household water treatment options, including point-of-entry filters;
- Increased monitoring by CPC and addition of water quality criteria to service agreements with operators.

The authors gratefully acknowledge funding support from USAID-RDMA and the input from collaborators at East Meets West Foundation, the University of Alabama, and the University of North Carolina – Chapel Hill.