HOUSEHOLD PERCEPTIONS OF THE QUALITY OF DRINKING WATER IN UGANDA

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ABSTRACT

This paper reports results from a survey questionnaire of water quality and avoidance measures used by households in Uganda. Each of the 487 respondents indicated their opinion of the quality of drinking water at the tap and the types of avoidance measures undertaken to improve drinking water quality to manage the potential health risks. Three main types of avoidance measures were examined: boiling, filtering, and buying bottled water. Filters and bottled water are two higher-cost options whereas boiling is customary and essentially a low-cost option. The questionnaire also collected information about household characteristics. Data were analyzed using a simultaneous probit equation. Strong relationships were found between household characteristics, opinions of water quality and the use of avoidance measures. Particularly, the finding that boiling reduces the likelihood of households buying bottled water, but buying bottled water does not reduce the likelihood of boiling as an avoidance measure. In relation to public water supply and quality management, the results indicate the need to recognize the importance of avoidance behavior for both the final level of risk and the least-cost approaches to reducing such risks.

***Key words*:** Health, risk, water quality, survey, simultaneous probit

INTRODUCTION

Safe drinking water has long been a key public health and environmental issue (Putnam & Wiener, 1995). Recognition of the importance of water quality to health dates back to ancient times: Sanskrit writings advocated heating and filtering of water as early as 2000 B.C. (Baker & Taras, 1981). Throughout history, water was known to be an essential element for survival and was hailed as the "scarce elixir of life". With the advent of germ theory and greater understanding of the role of water in spreading infectious disease in the nineteenth century (Watts, 1997), attention increasingly focused on the protection and purification of drinking water supply. As early back as the nineteenth century, health minded American communities began to separate drinking water and delivering to users from reservoirs and wells (Putnam & Wiener, 1995). Today however, many people in developing countries still do not have separate drinking water and sewer systems.

In Uganda for instance, over 54 percent of the population is without access to clean drinking water and adequate sanitation (AMREF, 2002; Howard, 2001). A test carried out on most spring water sources in the capital city, Kampala, revealed the presence of *Escherichia coli* in water samples, an indication of fecal contamination (Howard & Luyima, 1999; Kyambadde, Kansiime, Gumaelius & Dalhammar, 2004). Although the raw water in Kampala is treated to international standards at Gaba I and Gaba II water works, it is polluted at the Murchison Bay as a result of domestic sewerage effluent, untreated effluent, storm water run off and the poor maintenance of the sewer and water systems (Howard & Luyima, 1999).

Casual observations suggest that, based on their perceptions of water quality at the tap, households in Kampala undertake various measures (such as boil, filter or buy bottled water) to improve water quality and reduce apparent risks at the tap. These measures are called avoidance

measures or averting actions, while the money spent on such actions is termed defensive expenditures (Courant & Porter, 1981; Hartford, 1984). If avoidance measures are inexpensive, widely available, and widely used, actual health risks from water consumed may be substantially different from apparent risks at the tap. To date, however, there has been no empirical analysis of such avoidance behavior in Uganda, which is surprising given concerns over health risks from tap water and the number of cities in Uganda that are financing or attempting to finance water infrastructure improvement projects designed in part to improve water quality at the tap. To fill this void, we collaborated with researchers at Makerere University, Uganda to investigate the types of avoidance measures that are used by households in Kampala to adjust the quality of drinking water in Kampala. Thus, the specific objective here is to determine if avoidance measures are actually used by residents in Kampala, and to what degree, to affect water quality prior to consumption.

DATA AND MODEL

Economists have developed several ways of estimating the value consumers place on possible reductions in health risks associated with the products they consume. These include values revealed by market prices, values measured by expenditures on related goods or services, and values obtained directly from consumers through surveys. When consumers cannot directly observe safety attributes of food and drinking water, market prices cannot be used as a guide in assessing the value of safer food and drinking water. However, expenditures on related goods and services may provide insight into how consumers value reduction of health risks in food and drinking water. Following in this tradition, the current analysis uses household avoidance

expenditures. The data were collected using a survey questionnaire administered to 487 households in four Divisions of Kampala district: Makindye, Nakawa Kawempe and Rubaga.

Respondents were selected at random and interviewed in person by trained professional interviewers during the weekend and evening hours (December 2004 through January 2005). The sampling approach (selecting random sample of Parishes in each Division) was based on a previous pilot surveillance project (Howard, Teuton and Luyima, 2001). The questionnaire asked respondents about their behaviors and opinion on the quality of tap water. Particularly, three main types of avoidance measures were included in the questionnaire: boiling, filtering, and buying bottled water. Filters and bottled water are two higher cost options whereas boiling is customary and essentially a low-cost option for households. Respondents were also asked to indicate the level of their household income, and other household characteristics such as family size, apartment location, education, sex and age. The margin of error for the overall survey results is +2.8 points at the 95% confidence interval. The margin of error for demographic and attitudinal subgroups of the sample will be larger, depending on the size of the subgroup.

Table 1 reports the summary results of the survey for the three avoidance measures. Respondents report that they are generally satisfied with the quality of their tap water (about 68 percent from the total sample). As for self-reported total household income, which was designed to capture all types of formal and informal income, about 63 percent report household incomes less than 0.3 million shillings per month (a little less than $200), about 32 percent report income between 0.3 and 1 million shillings per month (about $200 to $500), and a little over 5 percent report income levels over 1 million shillings.

Table 1. The use of Avoidance Measures in Kampala (Percentage)

Variable	Kawempe N=118	Makindye N=139	Rubaga N=124	Nakawa N=106	Total Sample N=487
Pop. Density Kampala: 4581.3	916.26	1099.51	1053.70	824.63	
BOILING WATER					
1-always	86	93.0	88.6	84.9	89.1
2-most of the time	6.5	4.0	0.9	8.6	4.9
3-some of the time	5.6	2.0	2.6	5.4	4.2
4-never	1.9	1.0	7.9	1.1	1.8
BOTTLED WATER					
1-always	13.9	9.0	23.2	8.6	13.7
2-most of the time	19.4	28.0	26.2	18.6	28.1
3-some of the time	44.4	53.0	41.5	42.7	40.6
4-never	22.3	10.0	9.1	30.1	17.6
FILTERING WATER					
1-always	0.9	2.0	4.0	0.0	1.8
2-most of the time	1.9	4.0	0.0	0.0	1.6
3-some of the time	11.1	1.0	5.1	4.3	5.2
4-never	86.1	93.0	90.9	95.7	91.4

The income distribution obtained in this survey is very consistent with income information reported by the 2002 national population and housing census. About 71 percent of the sample lives in two room apartments whereas over 67 percent of the sample pays 150,000 shillings or less per month (less than $100) for their apartments, which is relatively half of total household income. In terms of demographics, about 79 percent of respondents were female. About 73 percent of respondents were less than 50 years old, with an average age of about 38 for

the complete survey. Looking at education, about 73 percent of the respondents completed at least secondary education.

The survey did ask questions in an ordered-categorical form (never, sometimes, most of the time, always). These categorical responses formed the basis for econometric analysis of the various avoidance measures. Given the four choices for each question, a new binary variable was created for each measure, defined as 1 if the response was always or most of the time and 0 if the response was sometimes or never. The probability that a given respondent uses a specific avoidance measure[1] (i.e. boil water, buy bottled water or a combination) was estimated using a simultaneous equation system to allow the possibilities of substitution across individual avoidance options (i.e. boiling water and buying bottled water as well):

$$\begin{aligned} \text{BOIL} = {} & \gamma_0 + \gamma_1 \text{Income} + \gamma_2 \textit{Quality} + \gamma_3 \text{Re}\,\textit{sidence} + \gamma_4 \textit{Education} \\ & + \gamma_5 \textit{Household size} + \gamma_6 \textit{Age} + \gamma_7 \textit{Bottle} + \varepsilon_1 \end{aligned} \tag{1}$$

$$\begin{aligned} \text{BOTTLE} = {} & \varphi_0 + \varphi_1 \text{Income} + \varphi_2 \textit{Quality} + \varphi_3 \text{Re}\,\textit{sidence} + \varphi_4 \textit{Education} \\ & + \varphi_5 \textit{Householdsize} + \varphi_6 \textit{Age} + \varphi_7 \textit{Boil} + \varepsilon_2 \end{aligned} \tag{2}$$

The two equation system (equations 5 and 6) was estimated in LIMDEP using the simultaneous probit regression approach (Greene, 1995).

[1] The third avoidance measure (filter) was not modeled because the survey results indicated that filtering was not a commonly used avoidance measure among Kampala residents.

RESULTS

Table 3 provides results for the estimated simultaneous probit model for avoidance measures, where income, education, presence of children under 18 years in the household, opinion on quality, location of household, and the endogenous variables are included as explanatory variables. All explanatory variables in the model are zero/one variables. Thus, the base case represented by the constant is for low income households, living in Rubaga division, who consider their water quality to be good. The estimated parameter coefficients show the change in the probability of choosing an avoidance measure as this base case changes in terms of income (from low to medium and high), location (from Rubaga division to Makindye, Nakawa, or Kawempe division), education (from low to medium or high), children in household (from no child to at least one child below 18 years), and overall opinion of water quality (from good quality to either OK or bad quality).

For purchasing bottled water (BOTTLE), Table 3 shows that while the parameters for income medium and income high have the expected positive sign, only the parameter for income high is statistically different from zero at the 1% level, and the marginal effect coefficient for income high is greater than that for income medium as would be expected by economic theory. Noting that marginal effects enable the isolation of the effect of a change in one variable given that all others remain constant, the marginal effect for income high imply that a 1% increase in income high category is associated with 69% increase in the likelihood that a respondent will buy bottled water to avoid the potential health risks associated with tap water.

Table 2. Simultaneous Probit equations Results for water quality survey model

	BOIL		BOTTLE	
Variable	Coefficients	Marginal Effects	Coefficients	Marginal Effects
Constant	-0.633* (0.349)	-0.425** (0.139)	-1.026** (0.069)	-1.164** (0.415)
Income high	-0.362* (0.191)	-0.526* (0.263)	0.562** (0.209)	0.687** (0.181)
Income medium	0.269 (0.189)	0.471 (0.357)	0.161 (0.115)	0.261 (0.193)
Education high	0.278** (0.028)	0.616* (0.302)	0.246* (0.010)	0.474* (0.238)
Education medium	0.172* (0.081)	0.483* (0.242)	0.175 (0.127)	0.476 (0.323)
Children in household	0.098** (0.038)	0.443* (0.221)	-0.088* (0.047)	-0.308* (0.138)
Quality Ok	-0.220 (0.306)	-0.462 (0.314)		
Quality bad	0.621* (0.318)	0.631** (0.153)		
BOTTLE	0.283** (0.099)	0.422* (0.208)		
BOIL			-0.556** (0.055)	-0.861** (0.192)
Kawempe			-0.162** (0.027)	-0.506** (0.142)
Nakawa			-0.094** (0.036)	-0.631** (0.215)
Makindye			-0.073* (0.032)	-0.525** (0.175)
Log-L	-72.692		-68.911	
Chi-squared	48.204		39.354	
Model Prediction[a]	73%		68%	
N	474		474	

Notes: 1= use measure all the time or regularly, 0= use measure never or seldom.
*, ** denote significance at 1 and 5 percent levels; standard errors in parenthesis.
[a] The predicted percentages are calculated as (predicted/total sample)*100.

For boiling water (BOIL), the parameter for income medium is not statistically significant, as expected because boiling does not involve any significant cost so that the income constraint is not a binding factor in the choice of boiling. However, the parameter for the highest level of income (income high) is statistically significant at the 1 percent level and is negative. These results indicate that boiling water has the characteristics of an 'inferior' good, and high income households tend to buy bottled water anyway, which reduces the need for boiling. The marginal effect in the BOIL equation, though statistically significant, is relatively smaller than the coefficient for bottled water, showing the importance of income as a key factor in the choice of buying bottled water.

Education promotes good hygiene and therefore, one would expect education to be a binding factor in the use of avoidance measures. It is not surprising therefore that the coefficients for education high and education medium are statistically significant in the BOIL equation. For bottled water, the coefficient for education is surprisingly not significant, but the size of its marginal effect is relatively large. In communities faced with water contamination, the presence of children demands special emphasis because children are at greater risk than are adults from certain kinds of exposure to water-borne illnesses. The coefficients for the variable capturing the presence of children less than 18 years in the household are significantly different from zero at the 1 percent level in the BOIL equation and at the 5 percent level in the BOTTLE equation.

For boiling water, the variable has a positive sign and relatively large marginal effect, meaning, that the presence of children in a household is associated with a 44 percent increase in the likelihood that a respondent will boil water to avoid potential health risks at the tap. On the other hand, the sign of the coefficient for the presence of children in the household is negative for purchasing bottled water. This result is not surprising in light of the observation that about 63

percent of household fall under the low income category, and bottled water is a relatively high cost option. Another possible explanation for this result might be that as family size increase, households switch from high cost to low cost defensive measures.

Basic opinion of water quality is related to boiling decisions; and from theory, one would expect more avoidance behavior when tap water quality is considered to be worse by residents. These expectations are validated by the relatively high and statistically significant marginal effect for bad water quality. This result suggests that a 1 percent decrease in water quality is associated with a 62 percent increase in the likelihood that a respondent will boil water to avoid health risk. Although the coefficient for quality ok is not statistically different from zero at the 5 percent level or higher, the coefficient has a negative sign, meaning, that as basic opinion of water quality changes from bad to ok, there will be less avoidance in the form of boiling water. But again, quality is subjective since household never have clear, objective facts on water quality.

While the basic assumption is that a given respondent uses a specific avoidance measure, the analysis allows possibilities of substitution across individual avoidance measures. The general premise was that there can be substitution across individual avoidance measures (i.e. boiling water and purchasing bottled water), with the decision to boil leading to lower bottled water purchases and *vice versa*. Although both endogenous variables (BOIL and BOTTLE) are statistically significant, results from the simultaneous model do not support the general hypothesis. The results suggest that while the decision to boil water reduces the likelihood of purchasing bottled water the reverse is not true. Rather, the decision to purchase bottled water increases the likelihood of boiling drinking water. One possible explanation for this finding is that since bottled water is a high cost option and most of the respondents fall in the low income

category, only a small percentage of household's drinking water needs can be sustained by bottle water purchases. For low income household it is a complementally issue rather than a substitution issue and *vice versa*. Lastly, bottled water purchase decisions were expected to differ markedly between locations in the district. The estimated coefficients for Nakawa, Makindye and Kawempe locations are statistically significant and the signs on the parameters are negative, indicating that there are less bottled water purchases across the different locations. This finding is not so surprising given that only 13.7 percent of the sample indicated bottled water purchase on a daily basis and also 63 percent of the sample reported incomes in the lower category.

CONCLUSION

This paper analyzed self-reported opinions on water quality and defensive measures used by households in Uganda to avoid potential health risks from tap water. The results confirm the existence of strong relationships between household characteristics, opinions on water quality and the use of avoidance measures. Of imporatnce is the finding that boiling reduces the likelohood of household buying bottled water but purchase of bottled water does not reduce the use of boiling as an avoidance measure. Because people's values and preferences for avoiding different risks and their abilities to afford alternatives to the choice of risk management, strategies for drinking water may need to be made at the local rather than national level. In any case, we need to weigh all of the risks of drinking water in a thoughtful, sensible manner and search for solutions that reduce the overall risk.

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