

**Awareness of Water Pollution as a Problem and the Decision to Treat Drinking Water
Among Rural African Households with Unclean Drinking Water: South Africa 2005**

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Abstract

Factors related to household perception of water pollution as a problem, treatment of drinking water and choice of chemical treatment are examined for rural African households in South Africa in 2005 that use an unclean drinking water source. Only 19% of these households ever treat their drinking water. The less clean the water and the more distant the water source, the more likely the household is to perceive water pollution as a problem; education of household members does not matter. Households with less clean water, more educated household members, and that perceive water pollution as a problem are more likely to treat their water. Boiling and chemicals are the most common treatment methods. These are not good choices. Households on average spend 8 hours a week fetching water and 6 hours a week fetching wood or dung. Boiling decreases water volume and requires fuel. Chemicals cost money that many households can ill afford. Households with less clean water, with more educated members, with higher overall expenditures and with a more distant water source are more likely to chemically treat their water than to use another treatment option. Provision of free or subsidized treatment chemicals would likely lead to a much higher percent of households treating their drinking water.

Countries throughout the world are concerned with the effects of unclean drinking water because water-borne diseases are a major cause of morbidity and mortality (c.f. Clasen et al. 2007; WHO 2010). Clean drinking water is important for overall health and plays a substantial role in infant and child health and survival (Anderson et al. 2002; Fewtrell et al. 2005; Ross et al. 1988; Vidyasagar 2007). The World Health Organization (2005) estimates that worldwide about 1.8 million people die from diarrheal diseases annually. Persons with compromised immune systems, such as those with AIDS, are especially vulnerable to water-borne infections, even those which are not typically threatening to healthy individuals (Kgalushi, Smits and Eales 2004; Laurent 2005: 6).

The people most vulnerable to water-borne diseases are those who use an unclean drinking water source. Throughout the less developed world, the proportion of households that use an unclean drinking water source has declined, but it is extremely unlikely that all households will have a clean drinking water source in the foreseeable future (c.f. Mintz et al. 2001). UNICEF (2010: 7-9) reports that in 2010, 884 million people in the world use an unimproved drinking water source, and estimates that in 2015, 672 million people will still use an unimproved drinking water source. Thus it is important to understand what leads a household with an unclean water source to treat its drinking water.

Using data for rural African¹ households in South Africa that use an unclean drinking water source, this paper addresses the following questions: (1) What factors are related to whether a household with unclean drinking water considers water pollution a problem? (2) What factors are related to whether a household with unclean drinking water ever treats that water? (3) What factors are related to whether households that treat their water choose chemical treatment?

Prevalence of Households with an Unclean Drinking Water Source in South Africa

South Africa has made progress in extending clean drinking water to an increasing proportion of its population. Figure 1 shows the percent of all South African households and of rural African households that used an unclean drinking water source in every year, 1998-2006.²

¹ In South Africa, members of Bantu-language African ethnic groups are considered to be Africans. In South Africa in 2005, 77% of households were African, and 96% of rural households were African. Forty-three percent of all African households are rural.

² These results are based on data in the 1998-1999 October Household Surveys, the 2000-2001 Labour Force Surveys and the 2002-2006 General Household Surveys.

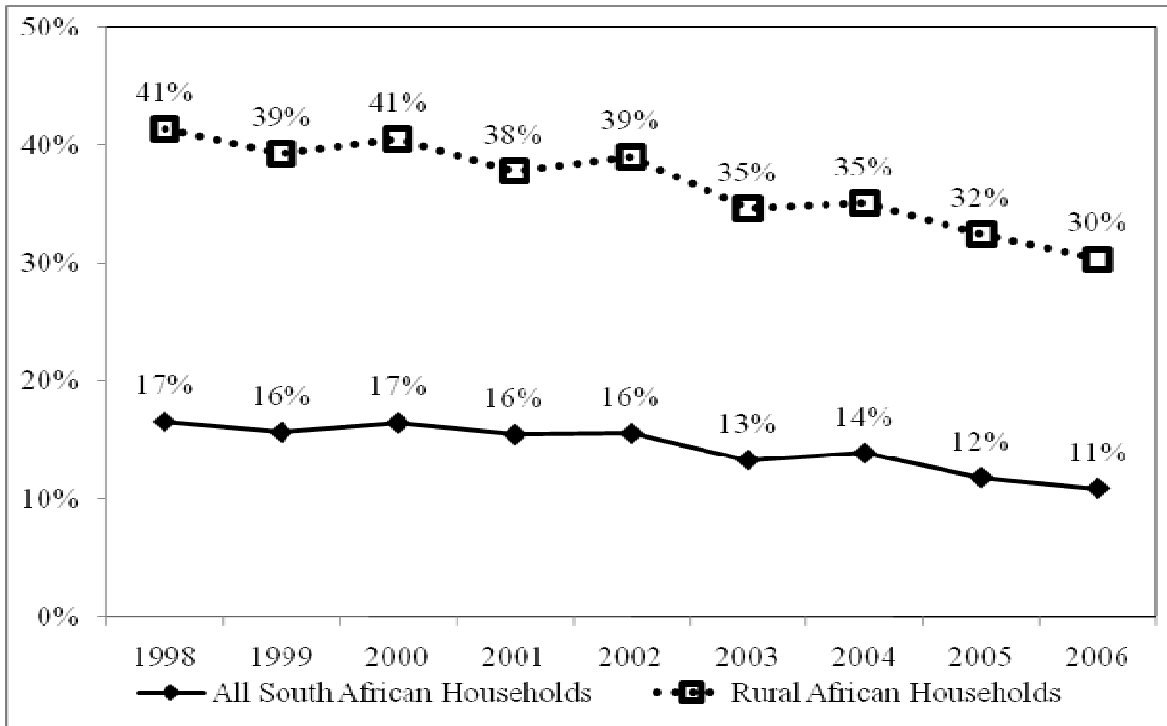


Figure 1. Percent of All South African Households and of Rural African Households that Used an Unclean Drinking Water

In 2005, 12% of all South African households and 32% of rural African households used an unclean drinking water source. Thus a considerable portion of South African households continue to use an unclean drinking water source, and in 2005 an unclean drinking water source was used by almost 1/3 of all rural African households.

Data Source

We use data from the 2005 South Africa General Household Survey.³ This is a hierarchal survey which asks some questions about the household as a whole and some questions about each household member. We use both types of information in this study. In the General Household Surveys, questions about perception of whether water pollution is a problem and about perceived quality of the household's drinking water are asked in the household section. Households have characteristics, such as the type of roofing, but households do not have perceptions; individuals have perceptions. Although the survey interviewer records the person number of the individual who responds to the household questions, for 2005 this was not coded by Statistics South Africa. Thus, we cannot analyze whether characteristics of the person answering the household questions, such as the respondent's

³ For more information about the 2005 South African General Household Survey see Statistics South Africa (2006).

age or gender, are related to the perception of water pollution as a problem. The 1998 October Household Survey also included the person number of the person answering the household questions, and that was coded. In that survey, either the head of household or the spouse of the head of the household usually responded to the household questions.

Table 1 shows some characteristics of households in the 2005 survey.⁴ We restrict the analysis to rural African households that use an unclean drinking water source. If the household has clean drinking water, there is little health necessity to treat it. In 2005 over 91% of all households without clean drinking water are rural African households; more than 30% of these households use an unclean drinking water source. Only a small minority of rural African households that use an unclean source of drinking water ever treat their drinking water (18.5%), and a minuscule percent of these households (6.4%) always treat their drinking water. Thus we use as the indicator of household water treatment whether the household ever treats its drinking water.

Table 1. Some Characteristics of Households in the 2005 South Africa General Household Survey

Unweighted number of households	28,128
Unweighted number of rural African households with an unclean water source	3965
Weighted percent of all households with unclean water that are rural African	91.4%
Percent of weighted rural African households with an unclean water source	32.4%
Percent of weighted rural African households with an unclean water source that ever treat their drinking water	18.5%
Percent of weighted rural African households with an unclean water source that always treat their drinking water	6.4%

Definition of a Clean Drinking Water Source

Statistics South Africa (2001: 75) defines a water source as clean if water is from a tap (regardless of whether the tap is in the residence, in the yard or is a public tap) or if it is from a water tanker. All other sources of water are considered not clean.

Of course, water sources that are considered clean can become contaminated between when water is taken from the source and when it is used in the household (c.f. Wright, Gundry and Conroy 2004; Montgomery and Elimelech 2007), and water can become contaminated if treatment is not carried out properly. Improper treatment was one source of a cholera outbreak in KwaZulu-Natal in 2001 (DWAF 2001). We do not address water

⁴ Throughout this paper, we use the 2005 General Household Survey household weights. For the statistical analysis in Tables 6 and 7, these weights are scaled to yield the actual number of rural African households that used an unclean drinking water source.

contamination between the source and household use or the issue of whether water from supposedly “clean” sources is unclean due to improper treatment.

Column 1 of Table 2 shows the distribution of sources of drinking water among rural African households that do not have a clean drinking water source. The main sources are flowing water (such as a stream), a borehole offsite and a spring. Only 3% of households use the worst drinking water source -- a dam, pool or stagnant water. Table 2 also shows for each source of drinking water the percent of households that think their water is safe, who report that the water is clear, that the water tastes good and that it does not smell bad (Columns 2-6). There is a high level of consistency across these indicators. Table 2 shows that the sources of drinking water are ordered from the best water quality to the worst water quality.

Table 2. Relation of Cleanness of Drinking Water to Perception of Qualities of Drinking Water, Rural African Households that use an Unclean Drinking Water Source, 2005

	Perception of Drinking Water				
	% dist	% Water safe	% Water clear	% Water tastes good	% Water does not smell bad
	(1)	(2)	(3)	(4)	(5)
Borehole on site	9.0	94.7	92.5	88.7	92.1
Rainwater tank on site	1.8	85.2	90.6	74.1	83.3
Borehole offsite	22.2	82.1	82.9	70.8	78.2
Well	6.6	34.9	42.8	48.5	50.0
Spring	19.5	32.6	36.1	34.2	40.3
Flowing water stream	37.9	22.2	29.6	30.7	33.3
Dam pool stagnant water	3.0	19.1	24.7	27.3	22.7
All	100.0	45.9	50.1	47.4	51.6

The definition of clean water used in this study differs from that used elsewhere. United Nations agencies often refer to “improved drinking water sources.” The World Health Organization (2007) reports:

“Improved drinking water sources are defined in terms of the types of technology and levels of services that are more likely to provide safe water than unimproved technologies. Improved water sources include household connections, public standpipes, boreholes, protected dug wells, protected springs, and rainwater collections.”

The 2006 World Development Report writes (UNDP 2006: 81):

“For international reporting purposes people are classified as enjoying access to water if they have available at least 20 litres a day of clean water from a source less than 1 kilometre from their home.”

A limitation of the WHO definition is some vagueness, especially the lack of clarity of how it is determined whether a water source is “protected.” In the UNDP definition, access to clean water (not defined) is combined with

amount of water available and proximity of the water source. Easterly (2008:62) notes that exactly what is meant by clean water is often unclear. An advantage of the definition employed in this paper is that it is clear.

Types of Household Water Treatment

Table 3 shows the distribution of types of treatment among rural African households with unclean drinking water that ever treat their water. Boiling and chemical treatment are the most commonly used methods. Less than 7% of households that treat their water use a water filter or some other treatment method.

Table 3. Distribution of Types of Water Treatment Used Among Rural African Households with an Unclean Drinking Water Source who Ever Treat Their Water, 2005

Boiling	51.3%
Chemical	42.3%
Filtering	6.1%
Other	.3%
Total	100.0%

For poor households, neither boiling nor chemical treatment are good options. Both are costly in either time or money. Boiling substantially reduces the amount of water, and chemicals to treat water cost money.

In 2005, 60% of rural African households with unclean water use wood as their main source of fuel. Someone needs to gather the wood. This is especially time-consuming in fuel-short areas (de Konig, Smith and Last 1985; Gilman and Skillicorn 1985), which characterizes most of South Africa. Kirkland, Hunter and Twine (2007) report that time spent collecting wood for fuel among rural South Africans has increased in recent years. In the 2005 data, households on average spend 8 hours a week fetching water and six hours a week fetching wood, a considerable expenditure of time and energy. Also, although boiling for an adequate length of time kills bacteria boiled water can easily become recontaminated (Luby et al. 2000). Based on the 2005 data, on average rural African households that do not have a clean drinking water source use an average of 59 liters of water a day. A liter of water weighs 2.2 pounds. In 2005, in 59% of households it took 15 minutes or longer to walk to the drinking water source (30 minutes or more round-trip). Thus, with the weight of water and the time it took to fetch water, there would be understandable reluctance to increase the amount of water fetched.

Mean household size is 4.8, and the median household size is 5. A general recommendation for a basic level of water consumption is 20 liters per person (Carter et al. 1997; WELL 1998; WHO 2003: 13). Water consumption by these households is already low, likely related to the labor involved in obtaining water. Thus, reluctance to boil water is very understandable.

Chemical treatment of water also has drawbacks. Chemicals for treatment must be purchased. Since expenditure is involved (for purchase of chemicals), economic factors are likely to be important in the decision to chemically treat water. The least expensive treatment chemical is *Jik*, a liquid bleach sold in South Africa. Water is treated through adding a teaspoon of *Jik* to 20 liters of water and letting the water stand for at least 90 minutes. The cost of enough *Jik* to treat 60 liters of water a day for a month is about R12.

Table 4 shows the distribution of rural African households that use an unclean drinking water source by expenditure level. Table 4 also shows within each expenditure level the monthly household expenditures in South African Rand⁵ on food, housing, transportation, clothing, personal items, and other purposes. This average is shown for each expenditure level, as well as the average sum of reported expenditures. Table 4 (Column 9) also shows average monthly expenditures once the amounts expended for food, housing and transportation have been removed. Column (10) shows the percent of total expenditures that are devoted to food. In the lowest expenditure category, households on average spend only R52 on items other than food, housing or transportation. These poor households devote 69% of all expenditures for food. Thus, for these poorest households, R12 per month (\$1.50) is a non-trivial expense. Foundation for Water Research (2001) cites the expense of *Jik* or water treatment tablets as a major impediment to water treatment in South Africa. Thirty-three percent of rural Africa households that use an unclean drinking water source report they are in the lowest expenditure category (<R400 per month).

Table 4. Reported Monthly Expenditures of Rural African Households that use an Unclean Drinking Water Source

Expenditure group	Food	Housing	Transportation	Clothing	Personal items	Other expenditures	Sum of expenditures	Expenditures without food, housing or transportation	% of total expenditures on food
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
							(2)+(3)+(4)+(5)+(6)+(7)	(8)-(2)-(3)-(4)	(2)/(8)
0-R399	192	6	27	25	16	12	277	52	69.4%
R400-R799	372	13	53	34	36	37	543	106	68.5%
R800-R1199	499	34	108	110	59	79	886	245	56.3%
R1200+	725	227	274	334	106	298	1960	734	37.0%
Total	361	33	71	67	39	58	630	165	57.2%

Earlier Work on Environmental Perceptions and Behaviors in the Less Developed Region

Social scientists have studied the role of socio-economic status and individual characteristics in the formation of environmental perceptions and actions taken to protect the environment for several years (Van Liere and Dunlap 1980; Dunlap and Scarce 1991; Hunter, Strife and Twine 2009; Jacobs 2002; White and Hunter 2009).

⁵ In 2005, the exchange rate was about eight South African Rand per one US dollar, R8=\$1

Early work by Inglehart (1995) and others (Franzen 2003) argued that concerns about the environment and its protection were more likely to be found in developed societies where populations enjoyed a higher socio-economic status. Others have challenged this position, contending that environmental awareness is not confined to those in more developed societies. Some researchers have found that individuals in less developed settings not only express concerns about environmental conditions, but also differentiate among these conditions and actions regarding environmental matters (Anderson et al. 2007; Dunlap, Gallup and Gallup 1993; Dunlap and York 2008; Jacobs 2002; White and Hunter 2009). Some researchers have also found that high socio-economic status is not important for environmental awareness (Anderson et al. 2007; Blake, Guppy and Urmetzer 1997; Hohm 1976; Murch 1971).

Contributing to this perspective is the role of the specific environmental conditions in which individuals find themselves. Analysis of perceptions of water pollution in South Africa found that “those most directly affected by water pollution were also most likely to see it as problem” (Anderson et al. 2007: 157). White and Hunter (2009: 980) concluded from their examination of environmental issues in Ghana that “residents of less-wealthy nations also often prioritize environmental issues”. Hunter and her associates found in their study of environmental perceptions of rural South Africans that “there may actually be more commonality than differences with regard to social and environmental concerns” among people and communities around the world than previously believed (Hunter et al. 2009: 20). Analysis of data for all South African households found that education of the head of household was not important for concern with water pollution, but it was important for whether the household treated drinking water (Anderson et al. 2007).

Bivariate and Multivariate Analysis

Factors considered in this paper as influencing the three dependent variables include: (1) the danger from unclean drinking water, (2) educational attainment of household members, (3) ability to afford the cost of water treatment, and (4) difficulty involved in obtaining drinking water. In the analysis of whether the household treats drinking water and the choice of type of treatment, whether the household perceives water pollution as a problem is also a factor considered.

Table 5 shows the variables considered in this analysis. Categories have been defined to yield a reasonable distribution of cases across categories of each variable. For example, flowing water sources and stagnant water sources were merged since only 3% of rural African households with an unclean drinking water source used a stagnant water source.

**Table 5. Coding of Variables in Analysis and Distribution of Values:
Rural African Households that Used an Unclean Drinking Water Source**

Variable	Codes	Percent Distribution
Water pollution a problem	0=Water pollution not a problem in the community	67%
	1=Water pollution a problem in the community	33%
Ever treats drinking water	0=Household never treats drinking water	81%
	1=Household ever treats drinking water	19%
Chemical treatment	0=Treats water, but not with chemical treatment	57%
	1=Household chemically treats water	43%
Degree of water uncleanness	1=Borehole or rainwater tank onsite,	11%
	2=Borehole offsite	22%
	3=Well or Spring	26%
	4=Flowing or stagnant water	41%
Highest educational attainment Among household members	1=0-4 years	13%
	2=5-8 years	28%
	3=9-11 years	39%
	4=12 years or more	20%
Monthly household expenditures	0=0-R399	33%
	1=R400+	77%
Time to water source	1=0 - <2 minutes	5%
	2=2 - <5 minutes	16%
	3=5 - <15 minutes	21%
	4=15 - <30 minutes	21%
	5=30 - <45 minutes	16%
	6=45 - <60 minutes	9%
	7=60 minutes or more	13%

The 2005 General Household Survey includes various indicators of the degree of uncleanness of drinking water. As shown in Table 2, perceptions of water uncleanness accord well with the ordering we use for the degree to which various sources of drinking water are unclean. We do not use subjective perceptions of drinking water as independent variables in this analysis. When members of households who treated their water answered questions about drinking water characteristics, we cannot be certain whether they were answering based on the water characteristics before or after treatment. For example, there is a significant negative Spearman correlation between water having a bad odor and households that treat their water choosing chemical treatment. Chemical treatment can remove odors, so the negative relation between a bad odor in water and choice of chemical treatment could be because the chemical treatment removed the odor rather than the lack of odor leading to choice of chemical treatment.

Much of the literature has suggested that poor health related to water is a result both of unclean drinking water and of inadequate sanitation (c.f. Carter, Tyrrel and Howsam 1997; Fewtrell et al. 2005). Anderson, et al. (2007) in an analysis of data for all South Africa households found that having worse sanitation was significantly

related both to perceiving water pollution as a problem and to treating drinking water. However, we do not include sanitation type in this analysis. When we look at rural African households without a clean drinking water source, type of sanitation is unrelated to water treatment (Spearman correlation = -.021). We speculate that sanitation type is not important for this analysis because the drinking water source is typically quite distant from the residence and thus quite distant from where human waste is disposed of.

As an indicator of educational attainment of household members, we calculated the educational attainment of the most educated person in the household. It is perhaps surprising that in these very poor, households, 20% of households included a member with 12 years or more of education. The education of the most highly educated household member seemed a better choice than education of head of household. Educational attainment has increased over time, and younger adult household members tend to have higher educational attainment than the household head. Also, preliminary analysis showed that educational attainment of head of household and educational attainment of most educated household member were significantly positively related. Multicollinearity concerns preclude the inclusion of both education variables in a multivariate analysis.

Regarding ability to afford the cost of water treatment, various indicators were tried, including the entire range of categories of household monthly expenditures. Although the full range of household expenditures is statistically significant in the analysis of use of chemical treatment, a simple division of monthly expenditure into more and less than R400 per month has a stronger relation. This is probably because extreme poverty is important deciding not to chemically treat water.⁶

Various indicators were also available for the difficulty of obtaining water. Time to walk to the water source is the indicator chosen. The 2005 General Household Survey includes for each household member whether he or she spent at least an hour the previous week fetching water and if so how many hours were spent in this activity. Similarly the survey asks for each household member whether at least an hour was spent the previous week fetching wood or dung and, if so, how many hours were spent. However, a household might choose not to boil

⁶ The results in Tables 5-7 are based on the responses to monthly household expenditures in categories rather than by summing reported expenditures over the 6 categories of expenditures shown in Table 4. Using the sum of expenditures gives very similar results to using reported categories of total expenditures. However, total expenditures are likely reported more accurately through the response in categories rather than through summing the responses to expenditures in the six categories.

water because doing so would entail many more trips to the water source. Similarly, the household might choose chemical treatment to avoid the water loss entailed in boiling.

The poverty of the rural African households that use an unclean drinking water source is striking. As seen in Table 5, 33% spent less than R400 a month, and 79% spend less than R800; 59% take fifteen minutes or more to reach the drinking water source. Fifty-three percent of the heads of household are female. For 46% of households the main source of income is pensions or grants, and for 22% of the households, the main source of income is remittances. For only 25% of the households is the main source of income salaries or wages.

Table 6 shows the Spearman correlations between the independent variables from Table 5 and the three dependent variables. The less clean the drinking water source and the longer it takes to reach the water source, the more likely the household is to perceive water pollution as a problem. Neither education of household members or monthly household expenditures is significant. Thus, households do not need to be well-educated or relatively well-off to recognize water pollution as a problem. Rather the objective threat from drinking water and the difficulty of obtaining that water are important.

Table 6. Spearman Correlations Between Factors Related to Perception of Water Pollution as a Problem, Treatment of Drinking Water and Whether Chemical Treatment is Used and Three Dependent Variables: Rural African Households that Used an Unclean Drinking Water Source

* p < .05, ** p < .01, two-tailed tests	Water pollution a problem	Ever treats drinking water	Chooses chemical treatment
Degree of uncleanness of water source	.277**	.193**	.035
Highest educational attainment of HH member	-.024	.047**	.104*
Monthly household expenditures > R400	.007	.012	.151**
Time to drinking water source	.216**	.058**	.147**
Water pollution a problem	--	.144**	.018

Households with a less clean water source, with a more educated household member, and with a more distant water source are more likely to treat their water. Household expenditures are not important for whether the household treats water at all. Households that perceive water pollution as a problem are much more likely to treat their water than households that do not view water pollution as a problem.

For choice of chemical treatment (among households that ever treat their drinking water), the longer it takes to reach the water source, the more likely the household is to use chemical treatment. The more distant the water source, the more extra labor boiling water necessitates. Also, the more educated a household member, the more likely the household is to choose chemical treatment, suggesting that chemical treatment is viewed as more desirable

than boiling. This could be partially because chemically treated water remains resistant to contamination even after treatment, while boiled water can easily become contaminated before consumption. If the household spends more than R400 per month, that household is much more likely to choose chemical treatment. This is probably because, as discussed earlier, for the poorest households, purchase of even the least expensive chemical for treatment consumes a substantial portion of the household's disposable income. In the correlations, the degree of uncleanness of the water source is not related to choice of chemical treatment. Also, perception of water pollution as a problem is not related to choice of chemical treatment.

Table 7 shows the results of logistic regression analyses of the three dependent variables with the same independent variables considered in Table 6. The results for the analysis of perception of water pollution as a problem and to whether the household ever treats drinking water are identical in Table 6 and Table 7. The results in the correlation and the regression analysis for choice of chemical treatment are also identical, except that in the multivariate analysis, the more unclean the water source, the more likely the household is to choose chemical treatment.

Table 7. Logistic Regression of Factors Related to Perception of Water Pollution as a Problem, Treatment of Drinking Water, and Whether Chemical Treatment is Used: Rural African Households that Used an Unclean Drinking Water Source

* p < .05, ** p < .01, two-tailed tests	Water pollution a problem	Ever treats drinking water	Chooses chemical treatment
Degree of uncleanness of water source	.462**	.291**	.178*
Highest educational attainment of HH member	-.006	.207**	.201*
Monthly household expenditures >R400	.048	-.022	.665**
Time to drinking water source	.180**	.000	.150**
Water pollution a problem	--	.508**	-.179
Constant	-6.043	-5.053	-3.740
Chi Square	365.6**	136.6**	35.1**
n	3522	3522	591

There is a high degree of rationality in the perceptions and behaviors examined. The less clean a household's water source, the more likely the household is to perceive water pollution as a problem and the more likely the household is to treat its drinking water. Also, the higher a household's overall expenditures, the more likely is a household that treats its water to use chemicals. As indicated by the significant positive coefficient for education of most educated household member, chemicals seem to be viewed as more effective or desirable than boiling for water treatment.

Education of household members is not related to perceiving water pollution as a problem. However, the more educated a household's members, the more likely the household is to treat its water and the more likely the household is to choose chemical treatment. Education is related to efficacy in organizing the household to take an action – water treatment.

Concluding Comments

What is most striking is how *rarely* households treat their drinking water. However, it is important to keep in mind that households do not have good alternatives for water treatment. Boiling needs an increased amount of water and fuel, which requires additional household labor to fetch these materials, and chemicals cost money, in a situation where households are very poor. In a water-short setting, and in a situation where on average it takes more than 15 minutes to walk to the drinking water source,, chemical treatment is more desirable than boiling, if the household can afford to purchase the chemicals.

The sensitivity of choice of chemical treatment to a household's expenditures suggests that the cost of chemicals is a substantial barrier to chemical water treatment. Free or subsidized chemicals could substantially increase the percentage of households that treat their water. With chemicals, an increase in the percentage of households treating water would not be accompanied by large increases in the expenditure of household members' time to collect water and fuel.

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