Willingness to pay for quality of drinking water

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Abstract

This paper presents households behavior of willingness to pay for quality of drinking water of Hyderabad city. The multinomial logit model is estimated for averting behavior to water contamination. Measures of awareness and households' wealth are incorporated into the model to account for joint production of utility. The study finds out that measures of awareness such as different levels of formal education of decision-makers and their informal exposure to mass media have statistically significant effects on willingness to pay for the averting behavior like home purification methods for drinking water. Furthermore, it also finds out willingness to pay for better quality of drinking water is much higher than the richest household of the sample, if the decision-maker having the highest level of education.

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Introduction

Willingness-to-Pay to avoid risks has long been recognized as an important response to perceived environmental and health hazards. The existence of consumer averting behavior in response to potential water contamination has been documented by Abdalla, Roach and Epp (1992), while Musser et al., Smith and Desvouges, Courant and Porter were among the first to provide a theoretical framework of averting behavior in response to pollution. They estimated that averting behavior formed a lower bound willingness-to-pay for reduction in pollution under certain conditions. Brensnahan and Dichie identify that under which joint production exists are not met for many averting behaviors, including bottled water and filter purchases.
In developing countries willingness-to-pay (WTP) and demand for quality of drinking water is often low. The major causes are lack of awareness regarding the contamination of drinking water and low level of households' income. Primary data of households has been collected from Hyderabad city with known history of polluted water. Multinomial Logistic regression is used to analyze the effects of awareness and wealth as a proxy of households' income on safe drinking water practices among households. By using estimated probabilities, cost of the different methods of purification has been calculated WTP. The estimated results show that education of female decision maker compared to male has more significant effect in using any or even more expensive method of purification. On average education level of decision makers is more important factor contributing to WTP for safe drinking water than the wealth of households.
The objectives of this paper are a) to estimate the effects of formal and informal awareness on the joint production of utility or on demand for the home purification methods b) on the basis of predicted probabilities to drive the estimates of WTP for safe drinking water practices. To accomplish these objectives we have develop a theoretical framework of households water purification practices by incorporating the wealth and awareness.

Theoretical Framework

The traditional demand functions, besides income and consumption pattern are also depending on the several other factors capturing preference structure of households like demographic composition, educational levels, profession and residential status of households [See Deaton (1980)], while the budget allocation decision making of households is best described as a multi-stage budget process. In our context the budget will first be allocated to food, health and other categories. Then at the second stage the food expenditure will be allocated to clean drinking water and on other items, while health expenditure will be allocated to curing of diarrhea and other waterborne diseases along with other items. At any stage of budget allocation, the size of given budget, prices and preference structure of household does matter. Engel has observed that the nature of preferences is such that income-consumption curves are skewed, that is, as income level (budget size) increases the budget share of luxuries tends to rise and that of necessities tends to decline. This implies that rich households are more likely to allocate a larger share of their budget to more expensive water purification devices. In a typical averting behavior model developed by Courant and Porter, water purification practices enter into the utility function through the production of health. For instance, utility function of health, H and all other goods Y is $U = U[Y, H(v, \alpha)]$, where v is the awareness regarding the contamination and risk averting activities, v enter through the production of health. Here we assume that households' get utility through the drinking safe water and indirectly through the health.

$$U = U(X_j, Z, \pi, H)$$

Where X_j is the practices to make water safe, J=1,2,3,4 for electric filter, ordinary filter, use of chlorine tablets and boiling, Z is the Marshallian composite good, π is the perceived risk from water contamination (however perceived risk may be different from the actual risk) and H is the health level. Further, households chooses between X and Z subject to budget constraint. $Y = Z + P_1X_1 + P_2X_2 + P_3X_3 + P_4X_4 + C$ where Y is income P_j is the price of water alternative and C is the average cost of filter. The conditional demand for water practices can be solved as a function of wealth as proxy of income, awareness (formal and informal), i.e.,

$$\overline{X_j} = \overline{X_j}(Y, q_i)$$

By substituting this conditional demand function into utility, we can drive the conditional indirect utility function. The households will choose water purification alternative j, if and only if $V_j > V_k$ for all $K \neq J$, (if a household's uses two purification methods we have chosen one that is best).

$$\overline{V_j} = \overline{V_j}(Y, q_i, \pi)$$

Willingness to pay for the safe drinking water or reducing the risk π for contamination, holding other things constant, is deducted from household's income.

$$\overline{V_j} = \overline{V_j}(Y, q_i, \pi) = \overline{V_j} = \overline{V_j}(Y - WTP, q_i, \pi^*)$$

Econometric Specification

The estimation of conditional indirect utility function unconditionally may produce misleading results because the explanatory variables are correlated with each other and utility function is not completely observable, thus V_j has two parts, deterministic and random. The probability that household may choose water purification method j will be

$$\theta_j = \Pr(\overline{V_j} - \overline{V_k} > \varphi_{jk})$$

where $\varphi = \varepsilon_k - \varepsilon_j$, now the household chooses any one method of purification out of four then, this will be rewritten as,

$$\theta_j = \Pr(\overline{V_j} - \overline{V_k} > \varphi_{jk})$$
$$= \Pr(\delta_j = 1).$$

The probability of choosing a particular water purification method by the households is

$$P(\delta_i = 1) = \frac{e^{V_j}}{1 + \sum_{j=1}^{4} e^{V_j}}$$

$$P(\delta_i = 0) = \frac{1}{1 + \sum_{j=1}^{4} e^{V_j}}$$

To estimate willingness to pay for the safe drinking water we use the predicted probabilities of each choice from multinomial logit model and multiplied by cost of adopted water purification device. The cost of adopting a purification device is estimated as the annual cost reported by the surveyed households.

Let C_{ij} be the actual cost associated with jth method of purification for ith household. The (WTP_i) by ith household is given by

$$WTP_i = C_0 * P(\delta_i = 0) + C_1 * P(\delta_i = 1) + C_2 * P(\delta_i = 2) + C_3 * P(\delta_i = 3) + C_4 * P(\delta_i = 4)$$

$P(\delta_i = j)$ j = 0, 1, 2, 3, 4, is the estimated probability of the adoption of a purification method j by ith household from the multinomial model. Now from policy perspective, it is important to determine how this WTP will be affected by the changes in the explanatory variables. For this we will regress this WTP on the explanatory variables by Ordinary Least Square (OLS) method as:

$$WTP_i = \beta_2 x_i + \varepsilon_i$$

From this willingness to pay we will calculate the mean willingness to pay.

Survey Data

The data used in this study are collected by researcher themselves from Hyderabad city in the year 2006. The stratified random sampling technique was used to collect the information of 514 households, which consists of 3796 household members. The population of each stratum was taken form *District Census Report 1998*, which shows that Hyderabad city, is administratively divided in four parts, i.e., three *Tehsils* (Hyderabad city, Latifabad and Qasimabad) and one cantonment. The total population of the city according to the Census is 1.473 million. The distribution of the sample is based on the population and number of Union Councils of the area. Nine households were chosen randomly from the union councils of city *Tehsil*, while ten households were chosen form rest of the union councils. Administratively cantonment has not been further divided into union councils, however, its population is much higher than average population of the union council, so authors made their own convenience strata based on number of households in the area. The same treatment is made for the remaining areas of the city.

The sample characteristics are given in table 1

Table 1: Sample Profile

Name of Area (*Tehsils*)	Population of Area (million)	Number of Union Councils	Average Population of Union Councils	Number of Households Chosen from the Area	Household Members	Average household size of sample
City	0.518	20	0.0259	180	1,404	7.80
Latifabad	0.556	20	0.0278	200	1,424	7.12
Qasimabad	0.114	4	0.0285	40	282	7.05
Cantonment	0.085	3*	0.0283	30	181	6.03
Remaining Parts of City	0.200	7*	0.0286	64	505	7.89
Total	1.473			514	3,796	7.39

* *District Census Report* does not classify these areas in Union Councils. The numbers given above are the most probable ones if the areas were classified into union councils.

Table 2: Sample Characteristics

Age distribution of household Members	Sex		Male Education					Female Education				
	Male	Female	Illiterate	1-8 Years	9-12 Years	13-15 Years	16 + Years	Illiterate Years	1-8 Years	9-12 Years	13-15 Years	16 + Years
0-5 years	206	177	172	34				157	20			
6-10 years	209	172	14	195				24	148			
11-20 years	612	470	40	155	346	71		58	136	210	66	
21-30 years	388	376	30	26	122	115	95	51	15	109	125	76
31-40 years	293	235	36	30	72	60	95	63	25	85	38	24
41-50 years	188	167	22	24	62	36	44	49	25	51	27	15
51-60 years	114	84	15	13	28	26	32	29	18	20	11	6
61 & + years	52	52	16	14	9	6	7	35	9	5	2	1
Total	2,062	1,733	345	491	639	314	273	466	396	480	269	122
%	54.33	45.67	16.73	23.81	30.99	15.23	13.24	26.89	22.85	27.70	15.52	7.04

Geologically, the city is a plat-topped with subtropical, semi desert type. The main source of drinking water of the city is surface water, which is served by five water supply systems. Since long the quality of drinking water of Hyderabad has been poor. Mukesh and Zeenat (2001) estimated the content of metals in drinking water of Hyderabad city by taking 18 water samples from different locations. The results of the study reveal that water quality in the city is poor against the standard health values.
The sample shows that out of 514 households, 35.02% households are not treating their drinking water, while remaining 64.98% households are using some water purification device with 23.68% are using the boiling technique, 5.64% chlorine tablets, 11.87% ordinary filter and 14.78% electric filter at their homes. This is shown in table 3.
For estimation, education will be used as a proxy for health awareness of households regarding the drinking water contamination. Five categories of education have been made: no education, 1-8 years of education, 9-12 years of education, 13-15 years of education and 16 years of education or above. Out of 65 illiterate decision-makers of households, 70.77 percent do not purify drinking water, while 16.92 percent used to boil water and only 1.54 percent is using most expensive method of water treatment that is electric filter. The percentage of no purification reduces to 15.2 percent as decision-makers gets the highest level of education, while for the same educational level, the percentage of boiling increases to 31.2 percent and for electric filter it is 29.6 percent.

Table 3: Distribution of Purification Adoption Rates by Education Level

	No Purification	Purification				Total
		Boiling	Chlorine Tablets	Candle Filter	Electric Filter	
	%	%	%	%	%	No.
Education level of decision maker						
No Education	70.77	16.92	7.69	3.08	1.54	65
1-8 years	54.24	32.21	8.47	1.69	3.39	59
9-12 years	34.81	41.77	6.33	8.86	8.23	158
13-15 years	26.17	30.84	3.74	17.76	21.49	107
16 or above years	15.20	31.20	4.00	20.00	29.60	125
All households	35.02	32.68	5.64	11.87	14.79	514

The second indicator of awareness is taken as mass media exposures. We collected the information whether a household member who reads a newspaper, watches television, or listens radio. After collecting the data, for simplicity these variables are made binary. Table 4 shows that 350 decision-makers almost never listen radio and 164 decision-makers listen at least once in a week. Out 514 decision-maker 469 watches television at least once in a week and out of which only 31.34 percent decision-makers do not purify drinking water at their homes, while out of 335 decision-maker who read newspaper at least once in a week only 26.28 do not purify the water.

Table 4: Distribution of Purification Adoption Rates by Other Household Characteristics

		No Purification	Purification				
			Boiling	Chlorine Tablets	Candle Filter	Electric Filter	Total
		%	%	%	%	%	No.
Media exposures of decision maker							
Radio habit	Almost Never	34.29	34.00	6.57	10.85	14.29	350
	At least once a week	36.59	29.88	3.66	14.02	15.85	164
TV habit	Almost Never	73.34	17.78	0.00	4.44	4.44	45
	At least once a week	31.34	34.12	6.18	12.58	15.78	469
Newspaper Habit	Almost Never	51.39	30.73	6.15	5.03	6.70	179
	At least once a week	26.28	33.73	5.37	15.52	19.10	335
Household wealth							
Least Wealth Quartile		33.33	40.31	5.43	11.63	9.30	129
Lower Middle Wealth Quartile		24.03	42.64	8.53	17.05	7.75	129
Upper Middle Wealth Quartile		31.54	34.62	3.85	9.99	20.00	130
Top Wealth Quartile		51.59	12.70	4.76	8.73	22.22	126
Children aged 0-5 years suffered from Diarrhea							
	No	35.87	27.72	4.35	11.41	20.65	184
	Yes	34.55	35.45	6.36	12.12	11.52	330
Sex of decision maker							
	Male	46.95	23.15	5.79	9.00	15.11	311
	Female	16.75	47.29	5.42	16.25	14.29	203
Occupation of decision maker							
	Non medical professional	36.51	33.20	6.02	11.41	12.86	482
	Medical Professional	12.50	25.00	0.00	18.75	43.75	32
All households		35.02	32.68	5.64	11.87	14.79	514

The correct information on consumption, income, or wealth of households cannot be collected accurately. However, the survey collects information on households' ownership of various assets and different characteristics of household dwelling. The wealth index is calculated from the given information by using first principle component. Appendix A provides the formula for the wealth index. For the ease of interpretation, wealth quartiles are created from the wealth index rather than actual wealth index for the analysis. Households of the least wealth quartile correspond to the poorer units of the sample. The Table 4 also shows the relationship of wealth and other characteristic of household with water purification practices.

It is expected that female decision-makers may have more willingness to adopt safe drinking water practices than male decision-makers. The data show that among the male decision-makers 46.95 percent do not purify water, while this proportion reduced to only 16.75 percent among the female decision-makers. The boiling of water has been done at homes mostly by female household members; data shows that among the female decision-makers 47.29 percent female use boiled water, which reduces around 14.29 percent for the expensive methods like electric filter. It is common perception that any member of a household belongs to medical profession has more stock of knowledge regarding the water contamination. Our sample represents decision-makers who practice medical profession only by 32 households 6.23 percent, but among them only 12.50 percent do not purify potable water at their homes.

Results and Discussion

Results from multinomial logistic model are shown in table 5, the dependent variable has five categories i.e., no purification, boiling, use of chlorine/alum tablets, ordinary filter and electric filter. The no purification method is taken as the base category. The marginal probability coefficient of the first educational level (1-8 years) of decision-maker is significant only for boiling method. On average 23 percent higher will be the probability that a household boils water for drinking if the decision-maker of that household is educated from 1-8 years of schooling compared to illiterate decision-maker. The marginal probability of boiling technique reduces as decision-makers become more educated. The marginal probability of a better-educated households (16 or above years) turns to be 40 percentage points higher for most expensive technology (electric filter) than an illiterate household. Among the media exposure variables radio listening habit of decision-maker is statistically insignificant for water purification techniques, while television-watching habit is only significant for the use of chlorine tablet for water purification. The newspaper reading habit of decision maker has significant influence on all the water treatment methods.

The wealth quartiles have insignificant effect on the households' purification behavior except third and fourth wealth quartiles for the most expensive technique that is electric filter. The estimated marginal probability coefficients show that on average 21.1 and 25.8 percentage points higher will be the probability of using electric filter to purify drinking water, if households belongs upper middle and top wealth quartiles respectively compared to the lowest wealth quartiles.

Other variables included in the estimation are occurrence of diarrhea among 0-5 years old members of the house, sex and occupation of decision makers. Sex of the decision makers is highly significant for all the methods of purification. On average female decision-makers are 36, 12 and 3 percentage points more likely to use boiling, ordinary filters and electric filters at their home respectively as compared to the male decision-makers.

Based on predicted probabilities of various purification methods from multinomial logit model, we have calculated WTP. To relate this WTP to household wealth, education, and media exposures, we have estimated a linear regression equation by OLS. The results are reported in Table 6. The two higher levels of education are statistically significant at 5 percent level of significance and the top educational level has the maximum WTP. On average, if a decision maker is educated 16 and above years of schooling then his willingness to pay for quality of drinking water will be 215.18 rupees higher than an illiterate decision maker and 46.85 rupees higher willingness to pay than those decision makers who are educated 13-15 years of schooling.

Table 5 Marginal Effects of Multinomial Logit Regression

Explanatory Variables	Probabilities of purification methods Boiling	 Chlorine/Alum Tablets	 Candle Filter	 Electric Filter
Education of decision maker; 1-8 years	0.230*	-0.001	-0.085	0.087
	(0.006)	(0.351)	(0.903)	(0.215)
Education of decision maker; 9-12 years	0.107*	-0.001	0.003	0.173*
	(0.005)	(0.725)	(0.207)	(0.046)
Education of decision maker; 13-15 years	-0.046*	-0.002	0.037*	0.369*
	(0.002)	(0.821)	(0.018)	(0.002)
Education of decision maker; 16 years or above	-0.031*	-0.002	0.045*	0.396*
	(0.000)	(0.562)	(0.007)	(0.000)
Radio habit of decision maker	0.009	-0.001	0.036	-0.017
	(0.708)	(0.295)	(0.288)	(0.862)
TV habit of decision maker	0.010	0.012*	0.038	0.074
	(0.417)	(0.000)	(0.360)	(0.135)
Newspaper habit of decision maker	0.087**	0.000	0.101*	0.042*
	(0.010)	(0.163)	(0.001)	(0.030)
Second wealth quartile	0.055	0.001	0.021	0.036
	(0.147)	(0.220)	(0.218)	(0.234)
3rd wealth quartile	-0.057	0.000	-0.019	0.211*
	(0.366)	(0.583)	(0.551)	(0.001)
Top wealth quartile	-0.205	-0.001	-0.032	0.258*
	(0.175)	(0.641)	(0.631)	(0.004)
Diarrhea	0.108*	0.000	0.017	-0.032
	(0.047)	(0.283)	(0.229)	(0.963)
Sex of decision maker	0.357*	-0.001*	0.117*	0.029*
	(0.000)	(0.019)	(0.000)	(0.000)
Occupation decision maker	-0.026	-0.015	0.030	0.069
	(0.854)	(0.780)	(0.568)	(0.327)
Log likelihood	-596.172			
Number of observations	514			

Probability of critical values are reported in parentheses
* Indicates significance at 5% level
** Indicates significance at 10% level

Among the media exposure variables, only newspaper habit of decision makers is statistically significant, and on average 69.14 rupees higher will the WTP, if household decision-maker reads newspaper at least once in a week. The top two wealth quartiles are statistically significant at 5 percent level of significance and on average 86.8 and 176.11 rupees higher willingness to pay of those households who belong to upper-middle and topmost wealth quartiles. Other variables include occupation of decision makers that is highly significant and it has the second highest WTP than education. 203.3 rupees higher will be the willingness to pay for those households who belong to medical profession compared to those household decision makers who belong to non-medical profession. Sex of decision makers is also significant and 100.59 rupees on average higher willingness to pay if a decision maker is female compared to a male decision maker. The only variable has unexpected sign and significant that is diarrhea.

Table 6: Estimated Parameters of the Willingness-to-pay Equation (in Pak rupees)

Explanatory Variables	**Coefficients**
Constant	-249.95
	(0.00)
Education of decision maker 1-8 years	24.34
	(0.54)
Education of decision maker 9-12 years	42.90
	(0.21)
Education of decision maker 13-15 years	168.33*
	(0.00)
Education of decision maker 16 or above years	215.19*
	(0.00)
Radio habit of decision maker	15.44
	(0.46)
TV habit of decision maker	53.19
	(0.13)
Newspaper habit of decision maker	69.14*
	(0.01)
Second wealth quartile	3.89
	(0.89)
3rd wealth quartile	86.81*
	(0.00)
Top wealth quartile	176.11*
	(0.00)
Diarrhea	40.06*
	(0.05)
Sex of decision maker	100.59*
	(0.00)
Occupation decision maker	203.31*
	(0.00)
Number of observations	514
F(13, 500)	19.29
Prob > F	0.000
R-squared	0.334
Adj R-squared	0.3167
Root MSE	213.78

Probability of critical values are reported in parentheses
* Indicates significance at 5% or lower

The results lead us to conclude that the educational attainment of decision makers has the highest influence on willingness to pay, which is much higher than those households who belongs to even topmost wealth quartile.

Summary and Conclusion

Averting costs that have been used as expenditures on goods that reduce risk and increase utility. The study measures WTP for safe drinking water practices among the households in Hyderabad district, Sindh, Pakistan. The sample size is 514 households, which consists of 3796 household members. The study estimates that there are statistically significant and quantitatively non-negligible effects of formal education on better quality of safe drinking water. The study also finds that there is a strong effect of informal education like electronic and print media on the water purification behavior of households. The WTP of a better-informed household is more than an uninformed people, while study finds that WTP of a better-educated person is 784 percentage pinots more than an uneducated person, which is even higher than the richest household of the sample. Thus better level of formal and informal education, especially the women education, about health hazards of contaminated drinking water may prevent waterborne diseases, rather than focusing other strategies, further paper also demonstrate that female decision-makers are more likely for WTP and to adopt some water purification device than male decision-makers.

References

Abdalla, C.W., B.A. Roach, and D.J. Epp (1992) "Valuing Environmental Quality Changes Using Averting Expenditures: An Application to Groundwater Contamination." *Land Economics* 68(May 1992): 163-169.

Bresnahan, B.W., and M. Dickie (1998) "Averting Behavior and Policy Evaluation." *Journal of Environmental Economics and Management* 29(November 1995): 378-392

Bruce, A. Larson, and E. Gnedenko, (1998), "Avoiding Health Risks from Drinking Water: Theory and Moscow Study Results." Harvard Institute for International Development. (Development paper No: 619-1998.)

Courant, P.N., and Porter, R.C. (1998) "Averting Expenditure and the Cost of Pollution." *Journal of Environmental Economics and Management*. 8(December 1981): 321:329

Dasgupta, P. (2001), "Valuing Health Damages from Water Pollution in Urban Delhi, India: A Health Production Function Approach." Institute of Economic Growth. (Working Paper Series No. E-210-2001.)

Deaton, A., and J. Muellbauer (1980), *Economics and Consumer Behavior,* Cambridge, M.A: Cambridge University Press.

Eatzaz, A. and A. Sattar (2007) "Awareness and the Demand of Safe Drinking Water Practices. Pakistan Institute of Development Economics (Working Pare Series No. 21)

Jyotsna, J., E. Somanathan, and S. Choudhuri, (2003), "Awareness and Demand for Environmental Quality: Drinking Water in Urban India." South Asian Network for Development and Environmental Economics. (Working Paper Series No: 4-2003.

McConnell, K.E., and M.A. Rosado (2000), "Valuing Discrete Improvements in Drinking Water Quality through Revealed Preferences." *Water Resources Research*. 36(6): 1575-82.

Mukesh, M. and K. Zeenat (2001), "Content of Metals in Drinking Water of Hyderabad." *Pakistan Journal of analytical chemistry* 2(2): 34-48.

Musser, W.N., L.M. Musser, A.S. Laughland, and J.S. Shortle (1992) "Contingent Valuation and Averting Costs Estimates of Benefits of Public Water Decisions in a Small Community." Agriculture Economics and Rural Sociology. (Publication No. 238, Pennsylvania State University, 1992a)

Nils, Rosemann (2005) *"Drinking Water Crises in Pakistan and the Issue of Bottled Water: The Case of Nestle's Pure Life"*. Actionaid Pakistan.

Richard, T.C., and R.C. Mitchell, (2000), "Public preferences Toward Environmental Risks: The Case of Trihalomethanes", Department of Economics, University of California, San Diego. (Discussion paper No:21-2000.)

Sattar, A. and E. Ahmad (2007) "Households Preferences for Safe Drinking Water" *International Journal of Human Development.* 3(1): 23-36

Smith, V.K. and W.H. Desvouges (1986) "Averting Behavior: Does It Exits?" *Economics Letters* 20, No. 3 (1986): 291-96

World Health Organization (2004) *The World Health Report 2002.* Geneva: WHO, Switzerland.

Appendix "A"
The Wealth Index

The Wealth Index for the ith household is defined as

$$W_i = \sum_{j=1}^{22} f_j \left[\frac{a_{ij} - m(a_j)}{S_j} \right] \quad \forall_i = 1, \ldots\ldots n$$

where

a_{ij} = 1 if ith household has asset a_j
0 otherwise

$$m(a_j) = \frac{\sum_{i=1}^{n} a_{ij}}{N}$$

$$S_j = \sqrt{\frac{\sum_{i=1}^{n} a^2{}_{ij}}{N} - [m(a_j)]^2}$$

And f_i is the "scoring factor" for the jth asset, that is, (f_1 …………… f_{32}) maximizes the variance of W subject to the constraint $\sum_{j=1}^{22} f_j^{\,2} = 1$.