©*The Pakistan Development Review*
46 : 4 Part II (Winter 2007) pp. 767–777

Willingness to Pay for the Quality of Drinking Water

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1. INTRODUCTION

Willingness-to-Pay to avoid risks has long been recognised as an important response to perceived environmental and health hazards. Abdalla, *et al*. (1992) have documented the existence of consumer averting behaviour in response to potential water contamination, while Musser, *et al*. (1992) Smith and Desvouges (1986) and Courant and Porter (1998) were among the first to provide a theoretical framework for the averting behaviour in response to pollution. All these studies estimated that averting behaviour formed a lower bound willingness-to-pay for reduction in pollution under certain conditions.

In developing countries willingness-to-pay and demand for the good quality drinking water is often low. The major causes are lack of awareness regarding the contamination of drinking water and low levels of household incomes.

The objectives of this paper are (a) to estimate the effects of formal and informal awareness of households on the demand for the home purification methods and b) to estimate willingness to pay for the safe drinking water. To accomplish these objectives we develop a theoretical framework of households' water purification behaviour by incorporating the wealth and awareness indicators of households.

For this study primary data of households are collected from Hyderabad city with known history of polluted water. Multinomial Logit regression is used to analyse the effects of awareness and wealth on safe drinking water practices among households. By using estimated probabilities, costs of the different methods of purification are calculated to arrive at the estimates of willingness to pay for the safe drinking water. The estimated results show that the education level of female decision-makers compared to that of male decision-makers has more significant effect in using any or even more expensive method of purification. Furthermore, on average education level of decision makers is more important factor contributing to willingness to pay for safe drinking water than the wealth of households.

2. THEORETICAL FRAMEWORK

The traditional demand functions are dependent on, besides income and prices, several other factors capturing preference structure of households like demographic composition, educational levels, profession and residential status of households [see Deaton (1980)]. In cross section data all consumers face the same set of prices and,

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therefore, the variations is prices paid by different consumers do not represent genuine price variations; these may be due to quality differentials and the differences due to locations The budget allocation decision of households in our context may be understood as a multi-stage budgeting process. For example, at the upper stage budget is allocated to food, health and other categories. Then at the lower stage the food expenditure is allocated to clean drinking water and other food items, while the lower-stage stage health expenditure is allocated to curing of diarrhea and other waterborne diseases along with other health items. Engel's law observes that the nature of preferences is such that income-consumption curves are skewed, that is, as 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 as compared to poor households. In a typical averting behaviour model developed by Courant and Porter (1998), water purification practices enter into utility function through households' production function of health. Thus denoting the quantities of composites goods health and 'all other goods' by *H* and *Y* respectively, the utility function of a consumer can be written as

$$U = U\,[Z, H(A, \pi)] \quad \dots \quad \dots \quad \dots \quad \dots \quad \dots \quad \dots \quad \dots \qquad (1)$$

where *Z* is the Marshallian composite good, *H* is a measure of health level, *H*(.) is the production function for health, *A* is the set of averting activities, π is an indicator of the perceived health-risk associated with drinking contaminated water. It is assumed that $U_A > 0$ and $U_\pi < 0$. Here we have assumed that households get utility through the drinking safe water and indirectly through the health. We consider four water purification devices, which are electric filter, ordinary filter, use of chlorine tablets and boiling. If a household's uses two purification methods, we consider the one that is the most effective, where effectiveness follows the order: electric filter (most effective), ordinary filter, use of chlorine tablets and boiling (least effective).

Further, household chooses between *A* and *Z* subject to budget constraint. $Y = Z + P_1 A_1 + P_2 A_2 + P_3 A_3 + P_4 A_4 + C$, where *Y* is income P_i is the price of water alternative and C is the average cost of filtered water. The price of the composite good is set equal to unity. Given that the consumer chooses water alternative *j*, the conditional demand for water practices can be solved as a function of wealth (a proxy of permanent income), awareness (formal and informal) and other variables like sex and occupation of decision-maker and occurrence of diarrhea among 0–5 age members of the household. That is,

$$A_j = A_j\,(P_j, Y, M, O) \quad \dots \quad \dots \quad \dots \quad \dots \quad \dots \quad \dots \qquad (2)$$

where *M* is the set of awareness variables and *O* is the set of other variables.

To estimate willingness to pay for the safe drinking water we first obtain the predicted probabilities of each choice from multinomial logit model that determines the decision to adopt one of the four methods of purifying drinking water *vis-à-vis* no water purification. The equation for the multinomial regression model is given by

$$P\left(Y_i = j \mid X_i\right) = \frac{\exp\left(\beta_j X_i\right)}{1 + \sum_{m-1}^{4} \exp\left(\beta_m X_i\right)} \qquad j = 1, \dots, 4 \qquad \dots \quad \dots \qquad (3)$$

The predicted probabilities of each choice are then multiply by the 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 *j*th method of purification for *i*th household and $P(A_i = j)$ be the probability of the adoption of a purification method *j* by *i*th household predicted from the estimated multinomial model. Then the (WTP_i) by *i*th household is given by

$$WTP_i = C_1 P(A_i = 1) + C_2 P(A_i = 2) + C_3 P(A_i = 3) + C_4 P(A_i = 4) \quad \ldots \quad (4)$$

Now from policy perspective, it is important to determine how this *WTP* is affected by changes in various explanatory variables. For this purpose we regress estimate *WTP* on a set of explanatory variables by Ordinary Least Square (OLS) method, that is;

$$WTP_i = ß X_i + \varepsilon_i \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad (5)$$

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

Since there are four choices for water purification, the multivariate logit model takes the form:

$$P(Y_i = j | X_i) = \frac{\exp(\beta_j X_i)}{1 + \sum_{m-1}^{4} \exp(\beta_m X_i)} \qquad j = 1, \ldots, 4$$

3. SURVEY DATA

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

Geographic distribution of population and the randomly drawn sample are shown in Table 1, which also shows average size of households taken from each region. Table 2 shows the distribution of sampled households with respect to age, gender, and education levels of members of the sampled households.

Table 1

Sample Profile

Name of Area (*Tehsil*)	Population (Thousand)	Number of Union Councils	Average Population of Union Council	Number of Households Chosen	Average Household Size
City	518	20	25.9	180	7.80
Latifabad	556	20	27.8	200	7.12
Qasimabad	114	4	28.5	40	7.05
Cantonment	85	3*	28.3	30	6.03
Remaining Areas	200	7*	28.6	64	7.89
Total	1.473	54	27.3	514	7.39

**District Census Report* does not classify the total area into Union Councils in these regions. The numbers are obtained on the basis of the average size of a union council in the district. The numbers shown are those retained after discarding some of the sampled households due to incomplete and/or sketchy information.

Table 2

Education Profile of the Sample

Age in Years	Number of Males with Education					Number of Females with Education				
	Illiterate	1-8	9-12	13-15	16 +	Illiterate	1-8	9-12	13-15	16 +
0-5	172	34				157	20			
6-10	14	195				24	148			
11-20	40	155	346	71		58	136	210	66	
21-30	30	26	122	115	95	51	15	109	125	76
31-40	36	30	72	60	95	63	25	85	38	24
41-50	22	24	62	36	44	49	25	51	27	15
51-60	15	13	28	26	32	29	18	20	11	6
Above 60	16	14	9	6	7	35	9	5	2	1
Total	345	491	639	314	273	466	396	480	269	122
Percentage	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 flat-topped with subtropical, semi desert type conditions. 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 in Hyderabad has been poor. Mukesh and Zeenat (2001) estimated the contents 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 statistics shown in Table 3 indicate that out of 514 households, 35.02 percent households are not treating their drinking water, while remaining 64.98 percent households are using some water purification device with 32.68 percent using the boiling technique, 5.64 percent chlorine tablets, 11.87 percent ordinary filter and 14.79 percent electric filter at their homes.

For estimation, education will be used as a proxy for health awareness of households regarding the drinking water contamination. Education is classified into five categories, which are no education, 1-8 years of education, 9-12 years of education, 13-15 years of education and 16 years of education or above. Table 3 shows that out of 65 illiterate decision-makers of households, 70.77 percent do not purify drinking water, while 16.92 percent boil water and only 1.54 percent use the most expensive method of water treatment, that is, electric filter. The percentage of households who do not purify drinking water 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 to 29.6 percent.

The survey also collected the information on whether household members read newspapers, watch television or listen to radio on regular or irregular basis. Table 4 shows that decision-makers in 350 of the 514 households almost never listen to radio and among them 36.59 do not purify their drinking water. Further, decision-makers in 469 of the 514 households watch television at least once in a week, out of which only 31.34 percent do not purify drinking water at their homes. Likewise decision-maker in 335 households read newspaper at least once in a week and out of these households only 26.28 do not purify drinking water.

It is expected that female decision-makers have greater willingness to adopt safe drinking water practices than male decision-makers because females are in general more intensively involved in the food related household activities. 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 most commonly adopted device for safe drinking water among the female decision-makers appears boiling of water. Data show that among the female decision-makers 47.29 percent female use boiled water, which reduces to 14.29 percent for the expensive methods like electric filter.

One can also expect that the members of a household belonging to medical profession have better stock of knowledge regarding water contamination. The data in Table 3 show that among the 32 households in which the decision makers are working in medical profession, only 12.50 percent do not purify drinking water at their homes, while 43.75 percent use the most expensive and most effective device, that is, electric filter.

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. A wealth index is then calculated from the given information by using first principle component.[1] For the ease of interpretation, the analysis is carried out on the basis of wealth quartiles rather than the actual wealth index. Households of the lowest wealth quartile correspond to the poorest units of the sample, while those belonging to the highest quartile represent the richest units. Table 3 also shows the relationship of water purification practices with the four wealth quartiles. This relationship indicates some correlation between the two attributes. In particular, households belonging to the lowest wealth quartile tend to rely on the cheaper water purification device of boiling, while among those belonging to the two upper wealth quartiles, a larger percentage is found to use electric filters.

[1]Consider a data matrix A consisting of m columns (variables) and n rows (observations) on the m wealth indicators. Denote the eigenvector associated with the largest eigenvalue of the variance-covariance matrix of *A* by *v*. Then $v'A = \sum_{i=1}^{m} v_i a_{ij}$ is the defined to be the first principal component of the matrix *A*. The first principal component is a linear combination of the variables in the matrix *A* that captures the maximum common variation in these variables.

Table 3

Distribution of Purification Adoption Rates (Percentages) by Households' Characteristics

Household Characteristics	Number of households	No Purification	Boiling	Chlorin/Alum Tablets	Candle Filter	Electric Filter
Education Level of Decision-maker						
No Education	65	70.77	16.92	7.69	3.08	1.54
1-8 Years	59	54.24	32.21	8.47	1.69	3.39
9-12 Years	158	34.81	41.77	6.33	8.86	8.23
13-15 Years	107	26.17	30.84	3.74	17.76	21.49
16 Years or Above	125	15.20	31.20	4.00	20.00	29.60
Media Exposures of Decision-maker						
Listening to Radio						
Almost Never	350	34.29	34.00	6.57	10.85	14.29
At least Once a Week	164	36.59	29.88	3.66	14.02	15.85
Watching TV						
Almost Never	45	73.34	17.78	0.00	4.44	4.44
At least Once a Week	469	31.34	34.12	6.18	12.58	15.78
Reading Newspaper						
Almost Never	179	51.39	30.73	6.15	5.03	6.70
At least Once a Week	335	26.28	33.73	5.37	15.52	19.10
Sex of Decision-maker						
Male	311	46.95	23.15	5.79	9.00	15.11
Female	203	16.75	47.29	5.42	16.25	14.29
Occupation of Decision-maker						
Non Medical Professional	482	36.51	33.20	6.02	11.41	12.86
Medical Professional	32	12.50	25.00	0.00	18.75	43.75
Household Wealth						
Bottom Quartile	129	33.33	40.31	5.43	11.63	9.30
Lower Middle Quartile	129	24.03	42.64	8.53	17.05	7.75
Upper Middle Quartile	130	31.54	34.62	3.85	9.99	20.00
Top Quartile	126	51.59	12.70	4.76	8.73	22.22
All Households	514	35.02	32.68	5.64	11.87	14.79

4. RESULTS AND DISCUSSION

Results from multinomial logit model are shown in Table 4, the dependent variable consists of 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 the probability that households with 1-8 years of schooling boils water for drinking is 23 percentage points higher as compared to the households with illiterate decision-maker. The marginal probability of boiling technique reduces as decision-makers become more educated. The probability that the households with the most educated decision makers (16 or above years) adopt the most expensive technology (electric filter) turns to be 40 percentage points higher than the households with illiterate decision-makers.

Among the media exposure variables radio listening habit of decision-makers 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 the probability of adoption of all the water treatment methods.

The wealth quartile dummies have insignificant effect on the households' purification behaviour except for the third and fourth quartiles for the most expensive technique that is electric filter. The estimated marginal probability coefficients show that on average the probability of using electric filter to purify drinking water among the third and the fourth wealth-quartile (richest) households is respectively 21.1 and 25.8 percentage points higher than the first wealth-quartile (poorest) households.

Other variables included in the set of explanatory variables are the 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.

Table 4

Marginal Effects of Multinomial Logit Regression

	Probabilities of Purification Methods			
Explanatory Variables	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			

Note: The probabilities values of the marginal effects are reported in parentheses. The marginal effects significant at 5 percent and 10 percent levels are indicated by * and ** respectively.

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 5. These results show that 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 has 16 and above years of schooling then his willingness to pay for quality of drinking water will be 215.18 rupees higher than that of an illiterate decision maker and 46.86 rupees higher than that of a decision-makers who has 13-15 years of schooling.

Table 5

Parameters Estimates 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-statistic	19.29*
R-squared	0.334

Note: The statistics significant at 5 percent and 10 percent levels are indicated by * and ** respectively.

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. The households who belong to upper-middle and topmost wealth quartiles have on average 86.8 and 176.11 rupees higher willingness to pay than the households belonging to the bottom wealth quartile.

Another variables included in the analysis is the dummy for occupation of decision- makers, which is highly significant and shows that households in which the decision makers belong to medical profession are willing to pay 203.3 rupees more for safe drinking water than the households in which decision-makers belong to non-medical profession.

Sex of decision-makers is also significant and indicates that the female decision makers are willing to pay on average 100.59 rupees more than the male decision makers. The only variable with an unexpected sign of its regression coefficient, which is also statistically significant, is diarrhea.

5. SUMMARY AND CONCLUSION

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 the 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 behaviour of households. The willingness to pay of a better-informed household is more than an uninformed people, while study finds that the willingness to pay of a better-educated person is 784 percentage pinots higher than that of an uneducated person. Thus better level of formal and informal education, especially among the women, about health hazards of contaminated drinking water may prevent waterborne diseases, rather than focusing other strategies. Further, the study also finds that female decision-makers are willing to pay more and are more likely to adopt some water purification device than male decision-makers.

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